Cogn Process (2015) 16 (Suppl 1):S1–S113
DOI 10.1007/s10339-015-0732-7

PROCEEDINGS

Space and Situated Cognition: Proceedings of the Sixth International Conference on Spatial Cognition (ICSC 2015)

Edited by Thomas Hünefeldt and Marta Olivetti Belardinelli

ICSC 2015 is kindly sponsored by:
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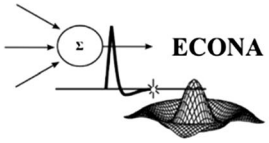

SAPIENZA
UNIVERSITÀ DI ROMA

1. Schematic Conference Program

	September 7			September 8				Sep-09				September 10				September 11			
	Aula 3	Aula 4	Aula 7	Aula 3	Aula 4	Aula 7		Aula 3	Aula 4	Aula 7		Aula 3	Aula 4	Aula 7		Aula 3	Aula 4	Aula 7	
8:30-8:50	FROM 9:00 WELCOME DESK			SYMPOSIUM 3	SYMPOSIUM 4	SYMPOSIUM 5		SYMPOSIUM 10	SYMPOSIUM 11	SYMPOSIUM 12		SYMPOSIUM 15	SYMPOSIUM 16	SYMPOSIUM 17		SYMPOSIUM 22	SYMPOSIUM 23	TALKS 11	
8:50-9:10																			
9:10-9:30																			
9:30-9:50																			
9:50-10:10																			
10:10-10:40				COFFEE BREAK				COFFEE BREAK				COFFEE BREAK				COFFEE BREAK			
10:40-11:00																			
11:00-11:20				SYMPOSIUM 6	SYMPOSIUM 7	TALKS 5		SYMPOSIUM 13	TALKS 7	TALKS 8		SYMPOSIUM 18	SYMPOSIUM 19	TALKS 9		SYMPOSIUM 24	TALKS 12	TALKS 13	
11:20-11:40																			
11:40-12:00	OPENING CEREMONY																		
12:00-12:20	KEYNOTE 1			POSTERS 1	POSTERS 2	POSTERS 3		KEYNOTE 3				KEYNOTE 5				POSTERS 4	POSTERS 5	POSTERS 6	
12:20-12:40																			
12:40-13:00																			
13:00-13:20																			
13:20-15:00	INAUGURAL BUFFET			LUNCH BREAK				LUNCH BREAK				LUNCH BREAK				LUNCH BREAK			
15:00-15:20																			
15:20-15:40	TALKS 1	TALKS 2	TALKS 3	KEYNOTE 2				KEYNOTE 4				KEYNOTE 6				KEYNOTE 7			
15:40-16:00																			
16:00-16:20																			
16:20-16:50	TEA BREAK			TEA BREAK				TEA BREAK				TEA BREAK				TEA BREAK			
16:50-17:10								SYMPOSIUM 14	ECONA MEETING	FILM				TALKS 10					
17:10-17:30																			
17:30-17:50	SYMPOSIUM 1	SYMPOSIUM 2	TALKS 4	SYMPOSIUM 8	SYMPOSIUM 9	TALKS 6						SYMPOSIUM 20	SYMPOSIUM 21			SYMPOSIUM 25	SYMPOSIUM 26	SYMPOSIUM 27	
17:50-18:10																			
18:10-18:30																			
18:30-18:50								20:30 SOCIAL DINNER											
18:50-19:10																			

KEYNOTES

KEYNOTE 1	O'Regan	Constructing space: A theoretical basis for how naïve artificial or biological agents can construct spatial notions
KEYNOTE 2	Gallese	Embodied simulation and the space around us: The perspective of cognitive neuroscience
KEYNOTE 3	Bao	Spatial attention is eccentricity dependent: Where something is, matters!
KEYNOTE 4	Goldin-Meadow	How our hands help us spatialize
KEYNOTE 5	Gallagher	Intersubjective relations in lived space and instituted space
KEYNOTE 6	Gepshtein	Solid field of sensitivity: perceptual structure of immersive space
KEYNOTE 7	Clancey	Spatial Conception of Activities: A Socio-Cognitive Perspective for Simulating Work Practices

SYMPOSIA

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SYMPOSIUM 2	Belardinelli & Butz	Anticipatory object interaction: perceptual and motor aspects
SYMPOSIUM 3	Stefanucci	Individual differences in spatial cognition using virtual objects and environments
SYMPOSIUM 4	Bhatt	Human Behavior, Design, and the Built Environment. The Case of Visuo-Spatial Cognition and Computation
SYMPOSIUM 5	Bao & Pöppel	No here without now: Temporal situatedness
SYMPOSIUM 6	Weisberg	Individual Differences in Navigating
SYMPOSIUM 7	Candidi & Bufalari	Situated cognition in the space of social interactions: from the bodily-self to shared spatial representations.
SYMPOSIUM 8	Gianelli	Motor perspectives on social interaction
SYMPOSIUM 9	Lugli & Winter	How do numbers move mentally? The interplay between numerical cognition and multiple dimensions of space
SYMPOSIUM 10	Simione & Gigliotta	Neurocomputational Approaches to Spatio-temporal Attention
SYMPOSIUM 11	Papadopoulou et al.	Computing Embodied Architectures
SYMPOSIUM 12	van der Ham et al.	Individual differences in wayfinding
SYMPOSIUM 13	Zlatev & Fagard	Fictive Motion" and Situated Cognition: How to Resolve the Tension?
SYMPOSIUM 14	Gentner	Spatial Language and Spatial Cognition
SYMPOSIUM 15	Fazzaglia	"Architectural psychology and inhabited spaces: A multidisciplinary approach to improve quality of life"
SYMPOSIUM 16	Vickers	The Quiet Eye As an Objective Measure of Situated and/or Spatial Cognition
SYMPOSIUM 17	Forbus	Multimodal perspectives on spatial cognition
SYMPOSIUM 18	Reboul & Guelton	Situated cognition in the arts
SYMPOSIUM 19	Nikolaev & van Leeuwen	Eye movement-related brain activity in visuospatial information processing
SYMPOSIUM 20	Iachini	Situated spatial cognition and social processing: body, emotions and interactions in space
SYMPOSIUM 21	Dolins & Garber	Should We Stay Or Should We Go? Evidence from Lab and Field Studies of Convergent Strategies in Spatial Decision-Making by Nonhuman Primates
SYMPOSIUM 22	Hartmann & Fischer	Numbers in the eye of the beholder: What eye movements reveal about numerical cognition
SYMPOSIUM 23	Serino & Pasqualini	Embodied space in architecture and neuroscience: measures and mechanisms
SYMPOSIUM 24	Arend & Ashkenazi	Number-space association: Insights from developmental, clinical and neuropsychological perspectives
SYMPOSIUM 25	Borghi & Tummolini	Language, action and space
SYMPOSIUM 26	Riemer	The body in space
SYMPOSIUM 27	Richardson & Orgs	Synchronous movement, Cooperation and the Performing Arts

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TALKS 2	Navigation 1
TALKS 3	Emotion and Space
TALKS 4	Spatial memory
TALKS 5	Language and Space
TALKS 6	Space concepts
TALKS 7	Body and Space 1
TALKS 8	Spatial Frames and Perspectives 2
TALKS 9	Navigation 2
TALKS 10	Attention and Perception
TALKS 11	Body and Space 2
TALKS 12	Affordances
TALKS 13	Spatial skills and techniques

POSTERS

POSTERS 1	Attention & Perception 1
POSTERS 2	Representation & Memory 1
POSTERS 3	Movement, Action, & Navigation 1
POSTERS 4	Attention & Perception 2
POSTERS 5	Representation & Memory 2
POSTERS 6	Movement, Action, & Navigation 2

2. Detailed Conference Program

Conference site: *Faculty of Medicine and Psychology, Via dei Marsi 78, 00185 Rome*

MONDAY, SEPTEMBER 07

From 9:00 **REGISTRATION** (Entrance Hall)

11:40–12:00 **OPENING CEREMONY** (Aula Magna)

12:00–13:20 **KEYNOTE LECTURE** (Aula Magna):

Kevin O'Regan: ***Constructing space: A theoretical basis for how naive artificial or biological agents can construct spatial notions***

13:20–15:00 **INAUGURAL BUFFET**

	TALK SESSION 1 (Aula III): ***Spatial Frames and Perspectives 1***	**TALK SESSION 2** (Aula IV): ***Navigation 1***	**TALK SESSION 3** (Aula VII): ***Emotion and Space***
15:00–15:20	Cerles & Rousset: *Recollecting words while processing space: an interference paradigm*	Arkin et al.: *Using visual information for spatial advice giving in a primate-inspired autonomous robot*	Kumoğlu & Olguntürk: *The effects of correlated colour temperature on wayfinding performance and emotional reactions: a study in a virtual airport environment*
15:20–15:40	Freundlieb et al.: *Evidence for spontaneous visuospatial perspective-taking during social interactions*	Epstein et al.: *Spatial abstraction for autonomous robot navigation*	Liang et al.: *Effects of emotional states on temporal order thresholds*
15:40–16:00	Papadopoulou: *The architect's perspective on the tour and map perspective*	Macagno et al.: *Using 3D immersive virtual environments to monitor human navigation in a human analog of the morris water navigation task: the VE-HuNT system*	Luce & Carter: *Positive it is this way? The role of mood on global versus local landmark use within virtual environments*
16:00–16:20	Sugimoto et al.: *The effect of understandability on wayfinding through survey- and route-based expressions*	Pouliquen-Lardy et al.: *Virtual collaboration: effect of spatial configuration on spatial statements production*	Marmolejo-Ramos, Correa et al.*: The place of joy, surprise and sadness in vertical space*

16:20–16:50 **TEA BREAK** (Aula VIII)

	SYMPOSIUM 1 (Aula III): ***Situated cognition and the philosophy of place*** Convenors: Hünefeldt & Schlitte	**SYMPOSIUM 2** (Aula IV): ***Anticipatory object interaction: perceptual and motor aspects*** Convenors: Belardinelli & Butz	**TALK SESSION 4** (Aula VII): ***Spatial memory***
16:50–17:10	Gallagher: *Situating interaction in peripersonal and extrapersonal space: phenomenology, social psychology and neuroscience*	Farnè: *Seeing to feel: anticipating contact in hand-objects interactions*	Azanon et al.: *Prototype effects on the retrieval of spatial location*
17:10–17:30	Tversky: *Thinking in and out of place*	Foerster & Schneider*: Anticipatory eye movements in sensorimotor actions: on the role of guiding fixations during learning*	Bochynska & Laeng: *Tracking down the path of memory: eye scanpaths facilitate retrieval of visuospatial information*
17:30–17:50	Clancey: *Projecting ourselves into space: the embodied experience of exploring Mars through robotic laboratories*	Belardinelli & Butz: *Action in the eye of the beholder: goal-oriented gaze strategies*	Delogu & McMurray: *Do we forget where the sounds come from?*
17:50–18:10	Seamon: *Human-immersion-in-place: phenomenology, body-subject, and environmental embodiment*	Herbort & Butz: *Planning grasps for object interaction: the role of motor simulation*	Engemann et al.: *How language impacts memory of motion events in English and French*
18:10–18:30	Trigg: *A sense of (non-)place: a phenomenological analysis*	Himmelbach: *It takes two: knowing tools and understanding tools*	Holmes et al.: *Remembering where: effects of perspective change and object rotation on spatial memory*

18:30–18:50	Malpas: *Place and placedness*	Koester & Schack: *Grasping interacts with word meaning: neurophysiological evidence*	Murcia-Lopez et al.: *Preliminary findings on the effect of scale transformations on spatial memory in immersive and desktop virtual environments*

TUESDAY, SEPTEMBER 08

	SYMPOSIUM 3 (Aula III): ***Individual differences in spatial cognition using virtual objects and environments*** Convenor: Stefanucci	**SYMPOSIUM 4** (Aula IV): ***Human behavior, design, and the built environment. The case of visuo-spatial cognition and computation*** Convenor: Bhatt	**SYMPOSIUM 5** (Aula VII): ***No here without now: temporal situatedness*** Convenors: Bao & Pöppel
8:30-8:50	Shelton et al.: *Spatial Learning Profiles: Using Virtual Environments to Dissociate Preference from Prowess*	Bhatt: *Architectural Design Cognition and Computation - I*	Miyake et al.: *Co-creation of the present: effects of voluntary movements on simultaneity perception*
8:50–9:10	Stefanucci et al.: *An investigation of mobility and spatial anxiety on spatial memory in a virtual environment*	Tversky & Chou: *Thinking with things in design*	Wang et al.: *Subjective present: a window of temporal integration*
9:10–9:30	Creem-Regehr et al.: *Effects of spatial abilities, cue-types, and scale on spatial memory in virtual natural landscapes*	Kalay et al.: *Simulating agents' spatial and social cognition by means of a distributed artificial intelligence mechanism*	Zhou et al.: *Situational context is important: Perceptual grouping modulates temporal perception*
9:30–9:50	Meilinger, Takahashi et al.: *Spatial orientation as a social cue: the case of objects and avatars*	Portugali & Haken: *Information adaptation in urban design*	Zaytseva et al.: *Episodic memory: a connection between the past and the present*
9:50–10:10	Hegarty et al.: *Individual differences in spatial abilities across different scales of space*	Schultz: *Architectural design cognition and computation—II*	Avram: *Time sentience may vary according to perspective in moral judgments*
10:10–10:40	**COFFEE BREAK** (Aula VIII)		
	SYMPOSIUM 6 (Aula III): ***Individual differences in navigating*** Convenor: Weisberg	**SYMPOSIUM 7** (Aula IV): ***Situated cognition in the space of social interactions: from the bodily-self to shared spatial representations*** Convenors: Candidi & Bufalari	**TALK SESSION 5** (Aula VII): ***Language and space***
10:40–11:00	Weisberg & Newcombe: *It's not can but how: navigation aptitude and strategy*	Lenggenhager: *The bodily self in shared and social space: a neurological perspective*	Catricalà & Guidi: *Onomatopoeias and ideophones: a new study about the interface between space, image schemas and phoneme clusters*
11:00–11:20	Chen & McNamara: *Individual differences in cue combination during navigation*	Chakrabarti: *The role of reward in simulative processes: insights from and for autism*	Cerqueglini: *Spatial frames of reference in traditional Negev Arabic: language-to-cognition correlation*
11:20–11:40	Negen & Nardini: *When do people use path integration to build metric maps of space?*	Sebanz et al.: *Spatial perspective taking in the context of joint action*	Schick et al.: *Language cues in the formation of hierarchical representation of space*
11:40–12:00	Marchette et al.: *Navigation ability predicts the spatial organization of free recall*	Pezzulo: *Shared Action Spaces: (How) does the brain merge the co-actors' spatial representations during social interactions?*	Yagi: *Spatiality of shared intentionality and language universals: a philosophical reflection*
12:00–13:20	**POSTER SESSION 1** (Aula III): ***Attention and Perception 1***	**POSTER SESSION 2** (Aula IV) ***Representation & Memory 1***	**POSTER SESSION 3** (Aula VII) ***Movement, Action & Navigation 1***
	1. Balconi et al.: *Environment impact based on functional and aesthetical features: What is their influence on spatial features and rewarding mechanisms?*	1. Borgo & Stufano: *Understanding architectural types*	1. Bennett & Giudice: *Developing compensatory augmentations for aging and navigation*
	2. Bourrelly et al.: *Does posture or gravity influence the perception of affordances?*	2. Cavallina et al.: *The effects of space and time interactions on the corsi block tapping test: an investigation of the motor aspects of the task*	2. Cogné et al.: *Contextual auditory stimuli are helpful on virtual spatial navigation in patients with visual neglect*

	3. Conti et al.: *A cognitive robotics approach for the study of unilateral spatial neglect*	3. Cerles et al.: *An implicit spatial memory alignment effect*	3. Corveleyn et al.: *Effect of central vision deficit in reach and grasp task*
	4. Fini et al.: *The "Near extrapersonal space" (NES): a subjective space affected by the individual's physical and personality characteristics*	4. Dutriaux & Gyselinck: *Posture and imagery in the memory of manipulable objects*	4. Frankenstein: *Imagined and actual movement through the environment and the reference frame orientation in survey knowledge recall*
	5. Imbir: *Duality of emotion approach in case of flanker task performance: An attempt to understand emotion-cognition interactions from new perspective*	5. Georges et al.: *The link between number-space associations and visuospatial abilities depends on cognitive style*	5. Lemieux et al.*: Gender differences when manipulating confidence during a first-person virtual maze learning task*
	6. Manca & Fornara: *Confirmatory factor analysis for indicators of perceived environmental quality of the stadium (IPEQS)*	6. Janyan et al.: *Remember down, look down, read up: Does a word modulate eye trajectory away from remembered location?*	6. Mukawa et al.: *The effect of repetition priming on spatial memory during backtracking in a novel environment*
	7. Morgado et al.: *The effect of body posture on power and space perception*	7. Kluss et al.: *Representation of impossible worlds in the cognitive map*	7. Palmiero et al.: *Situated navigational working memory: the role of positive mood*
	8. Pedale et al.: *The impact of emotional stimuli in biasing attentional selection during visual search in natural scenes*	8. Li & Zhao: *The choice of intrinsic axis under multi-cue conditions*	8. Redhead: *Conditioned inhibition within a real and virtual water maze task*
	9. Thomas et al.: *Looking up and down: semantic meaning automatically directs vertical attention*	9. Lilla & Delogu: *Where was it? Object location memory depends on sensory modality*	9. Sahai et al.: *Space influences evocation of structural and functional object-related gestures*
	10. Uiga et al.: *Mechanisms underlying reinvestment by older adults during walking*	10. Maier et al.: *Cultural spatial biases: number generation is influenced by reading direction*	10. Seepanomwan et al.: *The role of intrinsic motivation in the development of tool use: a study in infant robots*
	11. von Stülpnagel: *Configurational salience of landmarks: an analysis of sketch maps using space syntax*	11. Quinton & Smeding: *When abstract concepts get bound together through time and space: a case study on implicit stereotypes*	11. Spataro et al.: *Do pointing movements facilitate the recall of serial positions in visuospatial working memory?*
	12. Yang et al.: *Spatial orienting around the fovea: exogenous and endogenous cueing effects*	12. Ruotolo et al.: *The way people represent spatial information depends on the characteristics of the task: effects of delay and stimuli manipulability*	

13:20–15:00 **LUNCH BREAK** (Aula VII & VIII)

15:00–16:20 **KEYNOTE LECTURE** (Aula Magna):
Vittorio Gallese: ***Embodied simulation and the space around us: the perspective of cognitive neuroscience***

16:20–16:50 **TEA BREAK** (Aula VIII)

	SYMPOSIUM 8 (Aula III): ***Motor perspectives on social interaction*** Convenor: Gianelli	**SYMPOSIUM 9** (Aula IV): ***How do numbers move mentally? The interplay between numerical cognition and multiple dimensions of space*** Convenors: Lugli & Winter	**TALK SESSION 6** (Aula VII): ***Space concepts***
16:50–17:10	D'Ausilio et al.: *Sensorimotor information flow in interacting partners*	Göbel: *Up or down? Reading direction influences counting direction: a cross-cultural comparison*	Dal Pian: *Measuring land in agriculture and calculating area in Euclidean Geometry: an encounter of liminal spaces*
17:10–17:30	Sartori et al.: *Complementary actions: Novel perspectives*	Lachmair et al.: *When words meet numbers: spatially grounded associated response codes?*	Holischka: *Virtual places as real places: about the distinction between fiction and interactive virtuality*
17:30–17:50	Quesque et al.: *Perceiving social intention in motor actions at the second-person perspective*	Lugli et al.: *Moving through the space: how arithmetical calculations are involved*	Jonietz & Timpf: *On the relevance of Gibson's affordance concept for geographical information science (GISc)*
17:50–18:10	Reader & Holmes: *Keeping social interaction social: new kinematic methods and analyses for improving validity*	Winter et al.: *Gesture space corresponds to mental number space: evidence from "tiny" and "low" numbers*	Nitsche: *Images of situated cognition: involvement and location*

18:10–18:30	Letesson et al.: *Eye contact during action observation triggers allocentric action representation*	Shaki: *Spatial biases in mental arithmetic without spatial responses? Operational momentum revisited*	Zaman et al.: *Being the body: a computational approach to human experience of space*
18:30–18:50		Lourenco: *Probing the mental number line: a between-task analysis of spatial-numerical associations*	Zaman & Litman-Cleper: *Space first: a spatial inference model for multi-sensory perception*

WEDNESDAY, SEPTEMBER 09

	SYMPOSIUM 10 (Aula III): ***Neurocomputational approaches to spatio-temporal attention*** Convenors: Simione & Gigliotta	**SYMPOSIUM 11** (Aula IV): ***Computing embodied architectures*** Convenors: Papadopoulou et al.	**SYMPOSIUM 12** (Aula VII): ***Individual differences in wayfinding*** Convenors: van der Ham et al.
8:30–8:50	Akyürek: *Temporal integration in the context of computational models of the attentional blink*	Ackermann: *Displaced, detached, disembodied: perpetually connected yet [mostly] out of touch*	Nardini & Negen: *Individual differences in the development of spatial frames of reference*
8:50–9:10	Bowman: *Attention increases the acuity of conscious perception: all-or none percepts, temporal variance and the simultaneous type/ serial token model*	Gün: *(e)Scapes (for) bridging visual-making and computing*	O'Malley et al.: *Do you still know how to get there? Effects of cognitive ageing on route memory*
9:10–9:30	Raffone: *Modelling consolidation and selection for encoding in visual working memory*	Mavros: *A neuropsychological perspective of spatial experience*	Meneghetti & Bonvento: *Learning through "orienteering": Comparing the visuospatial abilities and environment representations of individuals with and without orienteering experience*
9:30–9:50	Simione & Nolfi: *Selection-for-action emerges in neural networks trained to learn spatial associations between stimuli and actions*	Ntzani: *Enchanting spaces of time-past: investigating the effects of reading metaphors on public engagement with archaeological remains*	van der Ham & van Stralen: *Left right confusion: effects of strategy*
9:50–10:10	Gigliotta et al.: *Neuromodelling based on Evolutionary Robotics: on the importance of motor control for spatial attention*	Paloma Gonzalez Rojas: *Motion metrics and mental maps*	Meilinger, Rebane et al.: *The acquisition of survey knowledge through navigation*
10:10–10:40	**COFFEE BREAK** (Aula VIII)		
	SYMPOSIUM 13 (Aula III): ***"Fictive Motion" and Situated Cognition: How to Resolve the Tension?*** Convenors: Zlatev & Fagard	**TALK SESSION 7** (Aula IV): ***Body and Space 1***	**TALK SESSION 8** (Aula VII): ***Spatial Frames and Perspectives 2***
10:40–11:00	Pajunen & Itkonen: *Eliciting different perspectives upon fictive motion: evidence from Finnish*	Grade, D'Ursel et al.: *The influence of body posture and action observation priming on reachability judgment and distance estimation*	Alacam et al.: *Switching reference-frame preferences during verbally assisted haptic-graph comprehension*
11:00–11:20	Stosic et al.: *Does the road go up the mountain? Fictive motion between linguistic conventions and cognitive motivations*	Ruggiero, Senese et al.: *I feel like you when you come close to me: motor simulation and inter-bodies distances*	Avraamides et al.: *Sensorimotor interference in reasoning from imagined perspectives*
11:20–11:40	Blomberg & Zlatev: *Non-actual motion: phenomenological analysis and linguistic evidence*	Thair & Newport: *The effects of spatial discrepancy on peri-personal space in virtual environments*	Cooperrider et al.: *Spatial frames of reference in gesture: evidence from bilingual Mexico*
11:40–12:00	Ekstrom et al.: *The expression of non-actual motion in Swedish sign language*	Wignall et al: *Body schema, size and gender: a motor imagery study*	Gramann: *Neural correlates of mental rotations for different reference frame proclivities*
12:00–13:20	**KEYNOTE LECTURE** (Aula Magna): **Yan Bao*: Spatial attention is eccentricity dependent: Where something is, matters!***		
13:20–15:00	**LUNCH BREAK** (Aula VII & VIII)		

15:00–16:20 **KEYNOTE LECTURE** (Aula Magna):
Susan Goldin-Meadow*: How our hands help us spatialize*

16:20–16:50 **TEA BREAK** (Aula VIII)

	SYMPOSIUM 14 (Aula III): ***Spatial language and spatial cognition*** Convenor: Gentner	**ECONA MEETING** (Aula IV, 17:00)	**FILM** (Aula VII, 17:00): ***Personality in mental space***, by Gerrit A. C. Derks
16:50–17:10	Gentner et al.: *Spatial language and spatial comparison combine to support children's learning*		
17:10–17:30	Majid et al.: *Spatial relations in closely related languages*		
17:30–17:50	Levine et al.: *Variations in parents' spatial language predict children's spatial skill*		

20:30 **SOCIAL DINNER** (Ristorante "Consolini", Via Marmorata 28)

THURSDAY, SEPTEMBER 10

	SYMPOSIUM 15 (Aula III): ***Architectural psychology and inhabited spaces: A multidisciplinary approach to improve quality of life*** Convenor: Pazzaglia	**SYMPOSIUM 16** (Aula IV): ***The Quiet Eye As an Objective Measure of Situated and/or Spatial Cognition*** Convenor: Vickers	**SYMPOSIUM 17** (Aula VII): ***Multimodal perspectives on spatial cognition*** Convenor: Forbus
8:30–8:50	Pazzaglia: *New challenges for architectural psychology*	Causer et al.: *Developing spatial cognition through the identification and training of visual attention in surgical skills*	
8:50–9:10	Bonaiuto & Fornara: *Urban environment and well-being*	Klostermann et al.: *The quiet eye and information processing: facilitation of stimulus identification and response selection*	Cohn: *Learning about space, time and activities from a robot perspective*
9:10–9:30	Siviero: *Footbridges as elements for urban rehabilitation and renewal*	Wilson et al.: *"Use your illusion II": Influencing spatial cognition and action*	Freksa: *Computational problem solving in spatial substrates*
9:30–9:50	Culatti: *Bridges in the landscape: qualitative aspects*	Gonzales et al.: *Quiet eye duration in expert and novice archers: a task complexity dichotomy*	Pustejovsky: *Affordances and the functional characterization of space*
9:50–10:10	O'Malley et al.: *Reducing spatial disorientation for older adults with memory difficulties: towards dementia-friendly architecture*	Vine et al.: *Blink and you might miss it: blinks may reflect an inward shift of attention, during the performance of a skill*	Forbus: *Sketching our way to spatial learning*

10:10–10:40 **COFFEE BREAK** (Aula VIII)

	SYMPOSIUM 18 (Aula III): ***Situated cognition in the arts*** Convenors: Reboul & Guelton	**SYMPOSIUM 19** (Aula IV): ***Eye movement-related brain activity in visuospatial information processing*** Convenors: Nikolaev & van Leeuwen	**TALK SESSION 9** (Aula VII): ***Navigation 2***
10:40–11:00	Reboul: *Decoupling, situated cognition and immersion in art*	Pannasch: *Eye movement-related brain activity in free visual exploration*	Burgmanis et al.: *The influence of travel behavior on cognition of urban environment*
11:00–11:20	Trentini: *Immersion as an embodied cognition shift: Aesthetic experience and spatial situated cognition*	Nakatani et al.: *Perceivers' internal state tags fixation-by-fixation visual information: an EEG-eye movement co-registration study*	Claessen et al.: *The effect of instruction on the spatial and temporal aspects of route knowledge*
11:20–11:40	Ganczarek et al.: *Intersection of reality and fiction in art perception*	Ossandon et al.: *Predictions of visual content across eye movements and their modulation by inferred information*	Nardi et al.: *More on the ability to use slope for navigation: evidence from children*

11:40–12:00	Guelton: *"Hupareel": Experiences and immersions in an hybrid reality game between Paris–Shanghai–Montreal*	Nikolaev & van Leeuwen: *Encoding of visuospatial information in free viewing*	Smith et al.: *Developmental trajectories of path integration: the influence of concurrent task*
12:00–13:20	**KEYNOTE LECTURE** (Aula Magna): **Shaun Gallagher:** ***Intersubjective relations in lived space and instituted space***		
13:20–15:00	**LUNCH BREAK** (Aula VII & VIII)		
15:00–16:20	**KEYNOTE LECTURE** (Aula Magna): **Sergei Gepshtein:** ***Solid field of sensitivity: perceptual structure of immersive space***		
16:20–16:50	**TEA BREAK** (Aula VIII)		
	SYMPOSIUM 20 (Aula III): ***Situated spatial cognition and social processing: body, emotions and interactions in space*** Convenor: Iachini	**SYMPOSIUM 21** (Aula IV): ***Should we stay or should we go? Evidence from lab and field studies of convergent strategies in spatial decision-making by nonhuman primates*** Convenors: Dolins & Garber	**TALK SESSION 10** (Aula VII): ***Attention and perception***
16:50–17:10	Saulton et al.: *The interaction of social and spatial cognitive processes in naturalistic social interactions*	Garber & Bicca-Marques: *Experimental field study of social and spatial foraging strategies in wild tamarins*	Holloway & Smith: *Probability cueing in virtual environmental search*
17:10–17:30	Tajadura-Jimenez: *The Hearing Body: Influences of audition on body and space representations*	Howard et al.: *Spatial and temporal nodes in the paths of bearded capuchin monkeys (Sapajus libidinosus) and the effects of landscape*	Nicholls & Lew: *Numerical spatial cognition and time: the association may be a product of response bias*
17:30–17:50	Coello et al.: *The motor encoding of peripersonal space and its role in social interactions*	Teichroeb: *The role of competition on individual routing decisions: lessons from foraging experiments on wild vervet monkeys*	Quetard et al.: *Detecting a pedestrian in the fog: the role of target expectation and visual exploration in perceptual decision making under uncertainty*
17:50–18:10	Lloyd & Koutsopoulou: *Situational awareness and interpersonal spatial processing in martial artists*	De Lillo & Kirby: *Monitoring of spatio-temporal patterns of resource availability by humans in a virtual reality foraging task*	
18:10–18:30	Balconi & Crivelli: *The "emotional" and "interpersonal" body in spatial cognition*	Dolins et al.: *Chimpanzee goal-directed foraging and navigation in a virtual environment: spatial knowledge, distance, or sight of goal as prioritizing factor?*	
18:30–18:50	Frassinetti et al.: *The effect of perspective-taking and personal space regulation in autism*	Kirby & De Lillo: *Visual cues, predictive of food location, do not override the acquisition of spatial information in humans in a virtual reality foraging task*	
18:50–19:10	Iachini, Pagliaro et al.: *I do not have a good impression: moral information and spatial behavior in virtual interactions*		

FRIDAY, SEPTEMBER 11

	SYMPOSIUM 22 (Aula III): ***Numbers in the eye of the beholder: What eye movements reveal about numerical cognition*** Convenors: Hartmann & Fischer	**SYMPOSIUM 23** (Aula IV): ***Embodied space in architecture and neuroscience: measures and mechanisms*** Convenors: Serino & Pasqualini	**TALK SESSION 11** (Aula VII): ***Body and Space 2***
8:30–8:50	Van 't Noordende, van Hoogmoed et al.: *Using eye tracking to measure number line estimation strategies in children with mathematical difficulties*		Hugues et al.: *Long lasting reduction of postural asymmetry by prism adaptation after right brain lesion. A pilot study*
8:50–9:10	Reinert et al.: *Strategies in unbounded number line estimation? Evidence from eye-tracking*	Gattara & Gallese: *The space around our workplace. The notion of embodiment within the everyday office environment*	Muffato et al.: *Age-related differences in pointing accuracy in new and familiar environments*

9:10–9:30	Burr et al.: *Serial dependencies cause logarithmic-like compression of the numberline*	Rooney et al.: *Peripheral extension and central projection: two forms of embodiment through the dorsal and ventral streams of vision*	Ruiz Fernandez et al.: *Flex to the left, extend to the right: disambiguating motor and spatial influences on valence judgements*
9:30–9:50	Hartmann & Fischer: *Spatial biases during mental arithmetic: evidence from eye tracking*	Vecchiato et al.: *Neurophysiological correlates of embodiment and motivational factors during the perception of virtual architectural environments*	Stevens et al.: *Thoughts in space: on quantifying the impact of environmental surround on cognitive processing*
9:50–10:10	Myachykov & Chapman: *The interplay between remembered affordances and the perceived numbers: an eye-tracking study*	Pasqualini et al.: *Bodies and objects: biofeedback response from architectonic experience*	Szpak et al.: *Too close for comfort: the effect of interpersonal proximity on spatial attention*
10:10–10:40	**COFFEE BREAK** (Aula VIII)		
	SYMPOSIUM 24 (Aula III): ***Number-space association: insights from developmental, clinical and neuropsychological perspectives*** Convenors: Arend & Ashkenazi	**TALK SESSION 12** (Aula IV): ***Affordances***	**TALK SESSION 13** (Aula VII): ***Spatial skills and techniques***
10:40–11:00	Van't Noordende, Kroesbergen et al.: *The relation between early match skill, memory and non-symbolic number-space mapping*	Belardinelli & Butz: *Planning with the eyes: end state comfort effects in gaze behaviour*	Escobar et al.: *An operational method to integrate cognitive and actual distances in a GIS street network*
11:00–11:20	Ashkenazi: *Domain-specific and domain-general effects on arithmetic: evidences from typical and atypical development*	Kostov & Janyan: *Reversing the affordance effect: negative stimulus-response compatibility observed with images of graspable objects*	Kornkasem & Black: *Formation of spatial thinking skills through different training methods*
11:20–11:40	Rinaldi: *Situating numbers on an experienced space*	Saccone et al.: *Abstract spatial coding and affordance influences on the object handle orientation effect*	Luini et al.: *Socio-spatial intelligence: social media and spatial cognition for territorial behavioral analysis*
11:40–12:00	Arend: *Number-space association in synaesthesia: an FMRI investigation*	Vishton et al.: *How preparation to touch or grasp alters visual size perception*	Moritz et al.: *Adapting map organization to task requirements: how epistemic action facilitates map use*
12:00–13:20	**POSTER SESSION 4** (Aula III): ***Attention and Perception 2***	**POSTER SESSION 5** (Aula IV): ***Representation & Memory 2***	**POSTER SESSION 6** (Aula VII): ***Movement, Action & Navigation 2***
	1. Bourrelly et al. : *Perception of affordances during long-term exposure to weightlessness in the International Space Station*	1. Fiori et al.: *The right TPJ plays an active role in maintaining an internal representation of verticality: an interferential continuous theta burst stimulation study*	1. Bortolotti et al.: *Case study in rehabilitation with SAM method (sense and mind): a proposal and analysis*
	2. Churches et al.: *Perceptual biases in the horizontal and vertical dimensions are driven by separate cognitive mechanisms*	2. Gerard et al.: *Architecture and spatial cognition to enhance learning*	2. Cortesi et al.: *Execution, observation and mental simulation of upper limb gesture for transitive and intransitive action: a fNIRS study*
	3. Di Luca & Schiltz: *Contextual versus numeric visuo-spatial reorientation during cancellation tasks*	3. Kasek: *Visual expertise in immediate spatial localisation tasks*	3. Dudschig & Kaup: *To fly or not to fly? The automatic influence of negation on language-space associations*
	4. Iachini, Ruggiero et al.: *The influence of anxiety and personality factors on comfort and reachability space: A correlational study*	4. Kojima: *Prior knowledge of character locational stereotypes and representations during text comprehension*	4. Kirby & De Lillo: *Chunking by food type and spatial constraints in a virtual reality search task*
	5. Le Bigot & Postollec: *Effect of nearby hand on visual processing in a 3D virtual environment*	5. Li et al.: *Memory and visual search in immersive environments*	5. Lopez et al.: *Coupled filtering in visual and motor spaces for reaching and grasping*

	6. Marichal et al.: *Embodiment of peripersonal space perception: Does the level of phobia influence reachability judgments?*	6. Marmolejo-Ramos, Montoro et al.: *The mapping of emotion words onto space: a cross-modal study*	6. Ngo et al.: *The relation between navigation strategy and associative memory: an individual differences approach*
	7. Nagy: *Differences between right and left brain-damaged patients in perception of body position*	7. Palleschi et al.: *The ability of visuospatial orientation: similarities and differences*	7. Quinton & Lengagne: *Abstract planning over control primitives for robotic manipulation*
	8. Nikitatis et al.: *Sustained attention in smart transformable environments*	8. Ruggiero, Ruotolo et al.: *Switching frames of reference: congenital blindness limits the allocentric to egocentric translation*	9. Redhead & Allison: *Effects of gender stereotypic threat on a spatial orientation task in a real and virtual environment*
		9. Sikl & Svatonova: *Long-term memory for aerial photographs and maps*	9. Sameer & Bhushan: *Route Memory in an Unfamiliar Homogenous Environment* 10. Sosson et al.: *Does body motion influence arithmetic problem solving?* 11. Spinelli et al.: *Is error monitoring a graded or an all-or-none process? An EEG study in immersive virtual reality*

13:20–15:00 **LUNCH BREAK** (Aula VII & VIII)

15:00–16:20 **KEYNOTE LECTURE** (Aula Magna):
William J. Clancey: ***Spatial conception of activities: A socio-cognitive perspective for simulating work practices***

16:20–16:50 **TEA BREAK** (Aula VIII)

	SYMPOSIUM 25 (Aula III): ***Language, action and space*** Convenors: Borghi & Tummolini	**SYMPOSIUM 26** (Aula IV): ***The body in space*** Convenor: Riemer	**SYMPOSIUM 27** (Aula VII): ***Synchronous movement, cooperation and the performing arts*** Convenors: Richardson & Orgs
16:50–17:10	Diessel: *Linguistic relativity or semantic universals of space? A fresh look at spatial frames of reference*	van der Ham: *Human navigation in real and virtual environments: the role of locomotion*	Richardson: *Behavioural coordination*
17:10–17:30	Coventry: *Spatial demonstratives and perceptual space*	Riemer & Wolbers: *First person perspective: a methodological constraint for path integration studies?*	von Zimmermann: *Collective speech and coordinated action*
17:30–17:50	Borghi: *Perspective and bodily space in language comprehension*	Trojan: *Body and space: theoretical concepts and controversies*	Cohen & Tarr: *Synchrony, exercise and social bonding*
17:50–18:10	Knoeferle: *Actions and spatially informative cues in spoken language comprehension: evidence from eye tracking*	Torta & Trojan: *Prismatic lenses and pain*	Stevens & Leach: *Distributed cognition and creativity: effects of collaboration and familiarity on improvising Contemporary Dance*
18:10–18:30	Volterra et al: *Spatial agreement in Italian sign language*	Fuchs: *Spatial perception of artificial hands and phantom limbs*	Vicary & Orgs: *Aesthetic perception of movement synchrony in dance*
18:30–18:50	Cangelosi: *Embodied language learning in humanoid robots*	Maselli: *Self-location and its relation to body ownership in full body illusions*	

3. Abstracts of Keynote Lectures

Abstracts are listed alphabetically according to the author's last name.

Spatial attention is eccentricity dependent: Where something is, matters!

Yan Bao

Department of Psychology, Peking University, People's Republic of China

The human visual field is characterized by an interesting paradox. On the one hand, homogeneity is suggested as the subjective brightness for supra-threshold stimuli remains constant throughout the visual field. On the other hand, inhomogeneity is indicated by various observations such as the different sensitivities as measured by light-difference thresholds, different saccadic programing modes and distinct visual pathways for the perifoveal and peripheral visual field. In recent years, new observations have been made using spatial cueing paradigms, pointing towards a functional subdivision of attentional control in the visual field. In this talk, I will focus on the converging evidence of our recent observations based on both behavioral and imaging measurements. The initial discovery of an eccentricity effect of spatial attention comes from an inhibition of return (IOR) study, which demonstrates a stronger inhibitory processing at the periphery relative to the perifoveal visual field. This eccentricity effect is confirmed later by various spatial cueing paradigms and is shown to be independent of cortical magnification factor. Further studies using ERP, fMRI and MEG technologies have revealed different neural mechanisms of spatial attention in the two regions of the visual field. Moreover, by using the circadian rhythm as a tool, the two types of spatial attention have been successfully disentangled, i.e., one peaks in the morning and the other peaks in the evening. Thus, our recent studies have provided strong evidence showing that spatial attention in the visual field is not homogeneous, but eccentricity dependent—the perifoveal and peripheral regions underlie a functional dissociation of attentional control.

Spatial conception of activities: A socio-cognitive perspective for simulating work practices

William J. Clancey

Florida Institute for Human and Machine Cognition, Pensacola, FL, USA

People conceive their everyday affairs (their practices) as social actors in activities, in which they perceive, infer, move, manipulate objects, and communicate in some physical setting (e.g., going to the grocery to buy dinner). These behaviors are conceptually choreographed in an ongoing, usually tacit understanding of "what I'm doing now," encapsulating *roles* ("who I'm being now"), *norms* ("what I should be doing"; "how I should be dressed/talking/sitting"), and *progress appraisals* ("how well I'm doing"). Activity motives and modalities vary widely (e.g., waiting in line, listening to music, sleeping), all of which require time and occur in particular settings. Brahms is a multiagent work systems design tool for modeling and simulating activities, used extensively to design aerospace work systems. For example, the Generalized Überlingen Model (Brahms-GÜM) simulates air transportation practices, focusing on how pilots and air traffic controllers interact with automated systems in safety–critical, time-pressured encounters. Spatial cognition is pervasive: Scanning displays of multiple workstations, coordinating airspaces and flight paths, while timing interventions to maintain aircraft separations. Brahms-GÜM demonstrates how events may become unpredictable when aspects of the work system are missing or malfunctioning, making a routinely complicated system into one that is *cognitively complex* and thus out of human control. Normally asynchronous processes become coupled in space and time, leading to difficulty comprehending the situation ("what is happening now") as a familiar multi-modal flow of events. Such examples illustrate the dynamics of spatial cognition inherent in our *conceptually situated* experience—our consciousness—of who we are and what we are doing.

Intersubjective relations in lived space and instituted space

Shaun Gallagher

Department of Philosophy, University of Memphis, USA

Based on developmental and phenomenological studies, I'll explicate the concept of the kind of lived space that characterizes primary and secondary intersubjectivity where there is face-to-face interaction, joint attention and joint action. I'll then suggest that one can design institutional space that either preserves or destroys that intersubjective space, and I'll explore this issue by looking at empirical examples.

Embodied simulation and the space around us: The perspective of cognitive neuroscience

Vittorio Gallese

Department of Neuroscience, University of Parma, Italy

The notion of space will be addressed within the broader notion of "embodied simulation", discussing the multimodal properties of the motor system relevant to an embodied account of the space around us. The same motor circuits that control the motor behavior of individuals' bodies also map the space around them, and the objects at hand in that very same space, thus defining and shaping in motor terms their representational content. The notion of space, although unitary when examined introspectively, is not represented in the brain as a single multipurpose map. Different and parallel parieto-premotor cortical networks create internal representations of bodily actions. The space around us is thus defined by the motor potentialities and confinements of our body, meaning also that perception always requires action.

Solid field of sensitivity: Perceptual structure of immersive space

Sergei Gepshtein

Center for Neurobiology of Vision, Salk Institute for Biological Studies, La Jolla, CA, USA

Much of our knowledge about the perceptual structure of space rests on studies where space is represented cinematically, using images and movies rendered on flat screens and viewed by static observers. How well does the cinematic understanding of space predict the experience of immersive space by individuals surrounded by objects in physical and virtual environments? Recent studies attempted to translate models of spatial and temporal forces that shape visual experience in the cinematic mode to models of visual structure of immersive space. I will review these efforts and describe the perceptual structure of immersive space in terms of a "field of sensitivity." The field is made up of solid regions which contain different visual information and which may overlap or nest in one another.

How our hands help us spatialize

Susan Goldin-Meadow

Department of Psychology, University of Chicago, USA

The spontaneous gestures that people produce when they talk have been shown to reflect a speaker's thoughts—they can index moments of cognitive instability and reflect thoughts not yet found in speech. Gesture can go beyond reflecting though to play a role in changing that thought—the gestures we see other produce can change our thoughts, and the gestures we ourselves produce can change our thoughts. In this talk, I consider whether gesture effects these changes because it itself is an action and can thus bring action into our mental representations. But gesture is a special kind of action—it spatializes ideas, even ideas that are inherently non-spatial, and it is representational and thus more abstract than direct action on objects. Gesture's representational properties may thus allow it to play a role in learning by facilitating the transition from action to abstraction.

Constructing space: A theoretical basis for how naive artificial or biological agents can construct spatial notions

J. Kevin O'Regan

Laboratoire Psychologie de la Perception, CNRS, Université Paris Descartes, Paris, France

The brain sitting inside its bony cavity sends and receives myriads of sensory inputs and outputs. A problem that must be solved either in ontogeny or phylogeny is to extract the particular characteristics within this "blooming buzzing confusion" that signal the existence and nature of physical space, with structured objects immersed in it, among them the agent's body. I shall show how a biological (or artificial) agent with arbitrary sensors can discover the existence of one important aspect of space, namely rigid displacements, without any prior knowledge about the structure of its sensors, its body, or of the world. Following an idea of Henri Poincaré, the method involves examining the compensable relations between the sensorimotor contingencies linking sensory and motor variables. Once acquired, the notion of rigid displacement will allow the agent to manifest apparently spatial knowledge in its behaviours.

4. Abstracts of Symposia

For each symposium, the general abstract of the symposium is followed by the abstracts of the single contributions listed in the order requested by the convenor(s).

SYMPOSIUM 1: Situated cognition and the philosophy of place

Convenors: Thomas Hünefeldt[1,2] and Annika Schlitte[2]

[1]ECONA – Interuniversity Center for Research on Cognitive Processing in Natural and Artificial Systems, Sapienza University, Rome, Italy; [2]Research Group on "Philosophy of Place", Catholic University of Eichstätt-Ingolstadt, Germany

Background: Over the last two decades, the complex problem of the situatedness of human experience and action has become an important topic of research and debate not only in cognitive science, but also in the social and cultural sciences. While in cognitive science this emergent, but also quite heterogeneous research movement is known under the heading of "situated cognition", the analogous research movement in the social and cultural sciences is sometimes referred to in terms of a "topological turn" or "topographical turn" and goes along with recent philosophical attempts to move the concept of "place" to the center of philosophical analysis and reflection. Given their convergent interest in and emphasis on the situatedness of human experience and action, it is significant and noteworthy that these different research movements seem largely to ignore each other.
Aim: Therefore, the aim of this symposium is to explore the possibilities and conditions of an interdisciplinary dialogue between these research movements in order to develop a more comprehensive understanding of the situatedness of human experience and action.
Approach: In order to realize this aim, we invited a philosopher, a psychologist, and a computer scientist associated with the "situated cognition" movement, and three representatives of the contemporary hermeneutic and phenomenological thought on place, hoping that the interdisciplinary exchange will provide deeper insights into the complex relationship between embodiment, situatedness and place.

Situating interaction in peripersonal and extrapersonal space: Phenomenology, social psychology and neuroscience

Shaun Gallagher

Department of Philosophy, University of Memphis, USA

Background: Our perception of the near and far space around our body is modulated by the presence of and our interaction with other people. I look at evidence from the neuroscience of the mirror system that shows that mirror neurons are activated differentially for the difference between actions perceived in near or peripersonal space and actions perceived in far or extrapersonal space. I argue that this evidence supports an enactivist rather than a simulationist interpretation of the mirror system.
Aims: To defend an enactivist (action-oriented) interpretation of space perception in the intersubjective context.
Method: Review of neuroscientific evidence; philosophical argument
Results: The presentation provides evidence and argument for the role of enactive perception in space perception in the context of social cognition.
Conclusions: The standard simulationist interpretation of the mirror system cannot explain the difference in mirror neuron activation; an enactivist interpretation explains the evidence more adequately.

Thinking in and out of place

Barbara Tversky

Columbia Teachers College and Stanford University, USA

Our bodies are grounded in place and in time (though we rarely stay still). Many accounts of spatial perspective-taking give primacy to our immediate position and orientation in space. Nevertheless, our minds can be elsewhere. In particular, we can take perspectives other than our own. Surprisingly there are situations in which we spontaneously take perspectives other than our own, even in the face of a conflicting actual perspective. We seem to do this by imagining another position in space, mapping our bodies to that position and orientation, and invoking our embodied skills for conceptualizing actual spaces. Thus perspective-taking is both disembodied and embodied. A range of empirical studies point to action understanding as a key factor in taking alternative perspectives.

Projecting ourselves into space: The embodied experience of exploring Mars through robotic laboratories

William J. Clancey

Florida Institute for Human and Machine Cognition, Pensacola, USA

Background: Since 2004 planetary scientists have been conducting field work on Mars using mobile robotic laboratories. "Rovers" are programmed to acquire and analyze samples, take photographs, and apply instruments for spectral molecular and atomic analysis. The rovers return data that is interpreted and used to plan ongoing investigation of the landscape. The missions require working through consensus in large groups, publicly and systematically studying a landscape over months and years—without personally being able to move, look about, and manipulate materials.
Aims: The objective of the study was to determine how the design of a robotic laboratory enables successfully doing field science on another planet without being physically present. How does the sociotechnical system of roles, tools, processes keep the scientists engaged and change the practice of field science?
Method: An ethnographic study of the Mars Exploration Rover science team, complemented with interviews and mission documents, was compared to observations of field expeditions on Earth.
Conclusions: The rover's design enables an experience of virtual presence on Mars and serves as a multidisciplinary collaboration tool. With stereo vision integrated with other instruments and sampling tools, the sociotechnical system is designed to facilitate the scientists'

imaginative projection into the body of the rover—an embodied experience of being on Mars. Rather than the "robotic geologist" replacing the scientists, the system design necessarily enables imagining possibilities for action (moving, analyzing, manipulating), which gives the scientists agency. The rover is a physical surrogate that augments human cognition, facilitating a new kind of field science.

Human-immersion-in-place: Phenomenology, body-subject, and environmental embodiment

David Seamon

Department of Architecture, Kansas State University, Manhattan, Kansas, USA

Background: This paper draws on phenomenologist Maurice Merleau–Ponty's discussion of perception and corporal sensibility to consider lived dimensions of everyday human actions and movements, including spatial behavior. The paper focuses on environmental embodiment—the various lived ways, sensorily and motility-wise, that the body in its pre-reflective perceptual presence engages and synchronizes with the world at hand, especially its spatial and environmental aspects.
Aims: This paper argues that an understanding of situated cognition must incorporate the lived significance of tacit, unself-conscious bodily awareness and intentionality—What Merleau–Ponty identified as body-subject. Body-subject can be defined as pre-reflective corporeal awareness manifesting through action and typically in sync with and enmeshed in the spatial and physical environment in which the action unfolds.
Method: The experiential context for generalization is a passage from Columbian novelist Gabriel García Márquez's One Hundred Years of Solitude (1967). This passage describes how a woman, coping with progressive blindness, manages her everyday environment, including bodily orientation, spatial behaviors, and daily household tasks.
Results: The paper demonstrates that the prepredicative intentionality of body-subject is spatially versatile and incorporates a wide range of environmental scales. The paper identifies more complex ensembles of body-subject extending over time and space and fashioning a wider lived geography. These bodily ensembles include: (1) body-routines—sets of integrated gestures, behaviors, and actions that sustain a particular task or aim; and (2) time–space routines—sets of more or less habitual bodily actions that extend through a considerable portion of time.

A sense of (non-)place: A phenomenological analysis

Dylan Trigg

Department of Philosophy, University of Memphis, USA

Background: The distinction between place and non-place has occupied research in both the philosophy of place and human geography for the last 20 years. In a distinction that stems from Marc Augé but is traceable to Edward Relph, "place" is thought as being relationally constructed, laden with meaning, and shaped by a broader history; home being emblematic of place. "Non-place," on the other hand, is taken to mean places divested of meaning, homogenous, and largely interchangeable; airports, supermarkets, and pre-fabricated office complexes being examples. Whilst this distinction has tended to be pervasive and influential in phenomenological accounts of place, critical analysis on the relation between place and non-place has been sparse.
Aims: (1) To delineate a nuanced analysis of the distinction, ambiguities, and tensions between place and non-place. (2) To question and interrogate what kind of difference is involved in this distinction. (3) To address the role intersubjectivity plays in the "sense of place."
Method: First-person phenomenological research in conjunction with conceptual analysis rooted in Merleau–Ponty's philosophy of the body.
Results: N/A
Conclusions: Through developing Merleau–Ponty's analysis of bodily intentionality, I make two claims: (1) Places are defined through our intersubjective relations, such that a place can be either imbued with meaningful or less meaningful depending on our relation with others. (2) The distinction between place and non-place is a distinction that needs to be situated in a broader analysis of the body's prepersonal and pre-thematic relation to place.

Place and placedness

Jeff Malpas

University of Tasmania, Australia; La Trobe University, Melbourne, Australia

Background: Place is a central concept in my approach to thinking about self and world, and my contribution will explore a key aspect of what the focus on place entails.
Aims: To explore and elaborate the difference between the notions of place and placedness.
Method: Within the topographical approach that characterizes much of my work, place is the primary concept, and that means that being-placed, as determinative of experience and cognition, has first to be understood in relation to place.
Results: Understanding the difference between place and placedness, and the role this distinction plays in a topographical approach, will provide a possible means to distinguish such a topographical approach, and approaches like it, from other approaches including those associated with situated cognition.
Conclusions: That the distinction between place and placedness is central to philosophical topography and part of what makes it distinctive.

SYMPOSIUM 2: Anticipatory object interaction: Perceptual and motor aspects

Convenors: Anna Belardinelli and Martin V. Butz

Computer Science Department, University of Tübingen, Germany

Background: Our refined ability to skillfully act in the environment and to interact with objects heavily relies on the prediction capabilities of our sensorimotor system. While often studied separately within cognitive science, vision and motor control are inherently tied

to each other. The fact that the interactions between vision and motor control usually take place in such a natural and flawless way overshadows to a large extent the complexity of the core cognitive processes involved. Attention, goal-orientedness, and anticipatory planning of both eye and effector movements coordinate and multiplex a rich spectrum of bottom-up information processing and top-down anticipation, hinging on separate but highly interactive cortical areas.
Aim: New studies are shedding light on the role of the interactions between perception and action in deeply structuring cognition. Especially natural tasks constituted by sequences of motor primitives, such as reaching, grasping, or moving objects for achieving multiple goals and tool use move into focus.
This symposium aims at bringing together experts from different disciplines, working on the neural, cognitive, and computational aspects involved in simple and complex interactions with objects.
Approach: Eye-tracking, brain imaging, behavioral studies, and computational modeling work will be presented and will serve as the basis for fruitful discussions and intellectual exchange to integrate perspectives and to consider the far-reaching consequences of the gathered insights, spanning clinical, robotics, and human factor applications.

Seeing to feel: Anticipating contact in hand–objects interactions

Alessandro Farnè

Lyon Centre of Neuroscience Research, Impact Team, INSERM, Lyon France

Background: The binding of visual information available outside the body with tactile information arising from the body surface allows for the representation of the space lying in between, which is often the theatre of our interactions with objects. The definition of what has become known as "peripersonal space" (PPS), originates from single-unit electrophysiological studies in monkeys, based on a class of multisensory, predominantly visual–tactile neurons. In such neurons, visual information is coded as 'tactile' in advance to the contact with the body (e.g., with hands), in a body-part centred reference frame.
Aims: I will first recall the behavioural and functional neuroimaging evidence that support the existence of a similar representation of the peripersonal space in humans, based upon a network of posterior parietal and premotor areas. My focus will then be on the question: what is the function of such a multisensory system?
Method: I will provide behavioural and electrophysiological evidence for the role of PPS in the planning and execution of both defensive (avoidance) and appetitive (reach-to-grasp) actions on nearby objects.
Results: I'll present results indicating that, similar to non-human primates, the peri-hand space in humans is represented in hand-centred coordinates. This evidence demonstrates how multi-sensory-motor systems may process hand-related visual inputs within just 70 ms following a sudden event, and before the execution of a grasping action.
Conclusions: Performing actions induce a fast remapping of the peripersonal space, thus supporting the hypothesis of a role for peripersonal space in the generation and control of rapid hand-centred avoidance and acquisitive actions.

Anticipatory eye movements in sensorimotor actions: On the role of guiding fixations during learning

Rebecca M. Foerster[1,2] and Werner X. Schneider[1,2]

[1]Neuro-cognitive Psychology, Bielefeld University, Germany; [2]Cluster of Excellence 'Cognitive Interaction Technology' (CITEC), Bielefeld University, Germany

Background: During object-based sensorimotor tasks, humans look at target locations for subsequent hand actions. These anticipatory eye movements or guiding fixations seem to be necessary for successful performance. By practicing a sensorimotor task, humans become faster and perform fewer guiding fixations (Foerster et al., 2011).
Aims: We aimed at clarifying whether this decrease in guiding fixations is the cause or the effect of faster task completion time. Participants may learn to useless visual input (fewer fixations) allowing shorter completion times. Alternatively, participants may speed up their hand movements (e.g., more efficient motor control) leaving less time for visual intake. The latter would imply that the number of fixations is directly connected to task speed.
Method: We investigated the relationship between number of fixations and task speed in a computerized version of the number connection task (Foerster & Schneider in press). Eye movements were recorded while participants clicked in ascending order on nine numbered circles. In 90 learning trials, they clicked the sequence as fast as possible. In the subsequent experimental phase, they should perform 30 trials again under high-speed instruction and 30 trials under slow-speed instruction.
Results: During slow-speed instruction, fixation rates were lower with longer fixation durations and more fixations were performed than during high-speed instruction. The results suggest that the number of fixations depends on both the need for visual intake and task completion time.
Conclusions: It seems that the decrease in anticipatory eye movements through sensorimotor learning is at the same time a result and a consequence of faster task performance.

Action in the eye of the beholder: Goal-oriented gaze strategies

Anna Belardinelli and Martin V. Butz

Computer Science Department, University of Tübingen, Germany

Background: Our eyes typically anticipate the next manual action, selecting the relevant object. Yet, if the final task and the way we intend to execute an action is reflected in early visual exploration has hardly been investigated.
Aims: In a series of experiments we considered how scan paths on real-world objects would be affected by different factors such as task, object orientation, familiarity, and low-level saliency.
Method: The experiments were conducted by means of a remote or a head-mounted eyetracker. Participants were asked to pantomimically act on objects presented on a screen or to act upon real objects. Eye fixation locations and durations as well as manual reaction and motion times were collected.
Results: In every experiment, eye fixations distribution differed significantly depending on the final task (e.g. lifting vs. opening).

Already from the second fixation prior to reaching the object, the eyes targeted the task-relevant regions. Familiarity had a significant effect when different tools were used as stimuli, with more fixations concentrating on the active end of unfamiliar tools. Object orientation (upright or inverse) determined the type of grasp, reflected also in the eyes' fixations, and the anticipation of the end state comfort determined the height of the fixations on the objects.
Conclusions: Scan paths dynamics can reveal how actions are planned, offering indirect insights into the structuring of complex behaviour and the understanding of how affordance perceptions, task considerations, and low-level feature biases determine eye saccades as well as manual motor control.

Planning grasps for object interaction: The role of motor simulation

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Background: Object interactions dependon a person's preferences (e.g. comfortable grasp) and the objects' shape (i.e. how an object can be grasped). Personal preferences have to be matched with the object's shape when planning to grasp an object.
Aims: We examined how grasps are planned. According to the simulation hypothesis, humans simulate object manipulationswith each of the grasps options to select the best grasp. According to the preference hypothesis, a preferred grasp is adjusted to comply with the objects' shape.
Method: Participants operated knobs that could be grasps with two, four, or an unconstrained range of grasps. If the simulation hypothesis was correct, reaction times should be shorter, when fewer grasps need to be simulated. If the preference hypothesis was correct, reaction times should be shortest when grasps are unconstrained and increase, the more difficult it is to match the object shape with the preferred grasp.
Results: Reaction times were shorter when the knob could be grasped with two grasps or when the grasp was unconstrained than when four grasps could be used. Nevertheless, grasp selections were comparable in all conditions.
Conclusions: When participants chose among discreet grasps options, planning time increased with the number of possible grasps, in linewith the simulation hypothesis. However, when graspswere unconstrained, planning times were short despite the multitude of potential grasps, suggesting another selection process in this case. As grasp choices were comparable regardless of the knob's shape, discreet and continuous grasp selections likely share a common mechanism.

It takes two: Knowing tools and understanding tools

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Background: Using objects as tools in everyday situations is usually based on previously acquired knowledge about the typical tools we use. However, when we do not have specific tools at hand or are confronted with new problems that we did not experience before, we have to understand the tool and the respective problem and think about mechanical solutions. Clinical tests in apraxia patients focus on practical demonstrations of typical tool knowledge through tool use pantomimes and real tool use but neglect mechanical thinking and reasoning.
Aims: Reveal deficits of mechanical reasoning in patients who showed tool-related disorders in standard tests of limb apraxia.
Method: We devised a large set of typically well known andusually unknown tools. We created combinations of tools and problems that were orthogonalised with respect to the factors familiarity and effectivity. Healthy adults and patients with apraxia were instructed to rate the familiarity and effectivity of tools relative to a given problem.
Results: As expected, patients with limb apraxia reliably identified well known typical tools and typical tool/problem combinations. Despite of this rather good performance based on tool knowledge, the patients showed an impairment in mechanical reasoning in comparison to healthy adult controls.
Conclusions: Deficits in tool understanding and mechanical reasoning represent an underdiagnosed component of apraxia. They might play a more important role than hitherto assumed. Investigations in patients with respective disorders can provide important insights into the neuronal implementation of this cognitive process.

Grasping interacts with word meaning: Neurophysiological evidence

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Background: Embodiment theories assume that abstract, cognitive representations such as the meaning of words partly overlap with concrete, sensory and motor representations and would predict that goal-oriented (i.e., intentional) complex movements and lexical-semantic representations interact if a task involves both types of representation.
Aims: Event-related potentials (ERPs) were used to test for neurophysiological interactions between grasping and implicit, abstract action representations (noun affordances).
Method: We manipulated the word meaning (referring to small or large objects) and the size of cube-like objects which required precision or powergrips. Hence, the grip type and the word meaning was congruent or incongruent with one another. In a go/no-go dual task, 26 participants performed a lexical decision task. Letter strings were presented in one of three positions on the screen. Only for words (German nouns), participants had to grasp and lift an object at the corresponding location on the table. In a control block, participants pointed at the objects instead of grasping them. The electroencephalogramme was recorded continuously.
Results: "Word size" affected only reaction times [$F(1,25) = 8.9$; $p < .01$], grip type affected only movement times [$F(1,25) = 91.5$; $p < .0001$]. Preliminary ERP analyses yielded the earliest interaction effects between "word size" and grip type at parieto occipital electrodes in the time range between 100 and 200 ms after word onset [$F(1,23) = 5.9$; $p < .05$]. The control block yielded qualitatively different ERP results.

Conclusions: The combined results suggest that lexical meaning representations (affordances) and movement information interact on the neurophysiological level and that the effects are specific for grasping in accordance with embodiment theories.

SYMPOSIUM 3: Individual differences in spatial cognition using virtual objects and environments

Convenor: Jeanine K. Stefanucci

University of Utah, USA

Background: What affects how we perceive and reason about spatial aspects of our environments? A large body of literature suggests that gender sometimes affects spatial abilities. For example, men perform better on mental rotation tasks and some virtual wayfinding tasks than women. However, women often have better object location memory than men. Other individual differences may affect spatial cognition as well.
Aim: In this symposium, we discuss other factors, such as anxiety, learning style, social context, training, mobility range, and strategy preference, which may influence a variety of spatial cognitive abilities. We propose that the magnitude of the effect of these factors on spatial cognition may change based on the scale of the environment being tested. Across all presentations, we aim to highlight the way that virtual environments and virtual objects can allow us to test for these individual differences in spatial abilities in a more controlled way, while also providing a tool for constructing novel objects and environments. Overall, we believe that a better understanding of these factors that relate to individual differences in spatial ability could allow us to apply our findings to training and performance in STEM (Science, Technology, Engineering, and Math) fields.
Approach: A variety of spatial abilities will be discussed in the context of individual differences in ability and scale of the virtual environment or objects tested. For example, we will present work that suggests that perceived distance to an object may be influenced by the object's orientation which potentially conveys a social context. Further, spatial abilities may influence tasks at multiple scales, including object (e.g., mental rotation), perspective (e.g., perspective taking) and environmental (navigation) scales of space. We also suggest that individual differences in measures of spatial learning (as assessed in desktop and immersive virtual environments) can provide indices of both success rate and learning style for navigation. The use of specific proximal and distal cues in different types of large-scale navigation tasks will also be discussed as they relate to gender, spatial abilities, and spatial memory. Finally, individual differences in mobility (home range and lifetime range) will be examined in the context of exploration of virtual environments and interaction with gender and anxiety.

Spatial learning profiles: Using virtual environments to dissociate preference from prowess

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Background: Individual differences in spatial learning often focus on empirical measures of success and/or rely on self-reports of preferences for different strategies. However, success is often defined by the effective use of a particular strategy, and self-reports require individuals to have explicit access to what drive their behavior.
Aims: We developed empirical measures of spatial navigation that can assess success and strategy independently by allowing different ways for participants to demonstrate successful navigation.
Method: Using desktop and visually immersive VR environments, our paradigms have individuals learn novel environments that allow multiple navigational solutions. After learning, participants navigate to targets, and we measure success rate and solutions used.
Results: Across a series of studies and two different paradigms, we are able to demonstrate that individual differences in success rate and specific solution use are large and generally independent of one another. In addition to finding that preference for one solution over another does not yield better performance, we found that preference is not related to whether individuals are capable of using a strategy when it is required. Finally, success rate and solution use are associated with different aspects of the individual's broader spatial/cognitive profile, suggesting that preference and ability are distinct.
Conclusions: With these paradigms, we have established the stability of an individual's bias to use certain navigational strategies and the relationship between bias and brain activation in spatial learning networks. These novel paradigms offer new tools for examining learning as an interaction of individual learning style, spatial skills, and situational/environmental factors.

An investigation of mobility and spatial anxiety on spatial memory in a virtual environment

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Background: Sex differences are often observed in spatial cognition, navigation, and home range size, possibly reflecting the need for males to travel far from home in search of mates. In contrast, females have much less to gain by traveling far from home.
Aims: Consistent with this work, we expected males and females to differ in their exploratory behavior of a novel, large-scale space.
Method: Participants explored a large virtual environment in search of five objects, returned to their starting location to point in the direction of each object, and then navigated back to the objects. Participants also completed self-report questionnaires on spatial anxiety, large-scale spatial navigation strategies, harm avoidance, and lifetime mobility range.
Results: During exploration females exhibited a higher proportion of time spent paused and revisited locations more often than males. Sex differences were also observed in both pointing accuracy and

navigation efficiency, and were completely mediated by the exploration behaviors.
Conclusions: The differences in exploratory behavior may be related to harm avoidance tendencies, possibly reflecting the differential fitness consequences associated with traveling far from home.

Effects of spatial abilities, cue-types, and scale on spatial memory in virtual natural landscapes

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Background: The Morris water maze is a task adapted from the animal spatial cognition literature, which uses different types of visual cues (close and far) to test a type of spatial memory that is vital for navigation. However, there are mixed findings with respect to individual or gender differences in virtual Morris water maze tasks, which may be attributed to variations in the scale of the space, the cues provided, and differences in spatial navigation experience and abilities.
Aims: We explored the influence of environmental scale, cue-context, and individual differences on spatial memory performance.
Method: Participants completed either a large (146 m) or small (36 m) outdoor virtual Morris maze on a desktop display, along with self-report measures of large-scale navigational abilities and lifetime mobility.
Results: Consistent with previous findings, preliminary results suggest a male advantage in the virtual Morris maze when presented with distal (far) cues but not proximal (close) cues. Additionally, the Santa Barbara Sense of Direction Scale and a measure of lifetime local travel may relate to memory performance in some conditions.
Conclusions: The results of this study suggest that there is a relationship between gender, spatial abilities, cue-types, and scale that merits further exploration.

Spatial orientation as a social cue: The case of objects and avatars

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Background: Humans naturally keep a larger distance to the front of other people than to their back.
Aims: Within three experiments we examined if such a front-back asymmetry is present already in perceived distances, and whether it extends to objects as well as to human characters.
Method: Participants watched through a head mounted display single photorealistic virtual characters moving on the spot (avatars) and moving or static virtual objects (i.e., cameras) located within an invisible cube. Avatars and objects were presented at different distances and were either facing the participants or facing away from them. Participants then estimated the perceived distance to cameras and avatars by moving a virtual object to the location of the avatar or the centre of the invisible cube containing the cameras.
Results: Both cameras and avatars facing participants resulted in shorter estimated distances than cameras and avatars facing away. This asymmetry was independent of the presented distance.
Conclusions: Together with similar findings from experiments with virtual cones these results point towards a fundamental perceptual effect of object orientation. This orientation asymmetry effect does not depend on movement or object form and might indicate a basic form of social processing.

Individual differences in spatial abilities across different scales of space

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Background: Spatial cognition research has distinguished between cognitive abilities at figural (e.g., mental rotation), vista (e.g. perspective taking) and environmental (navigation) scales of space.
Aims: This talk will review new research findings regarding individual and sex differences at each of these scales of space.
Method: Research on mental rotation examined the role of strategies in explaining differences in mental rotation tasks. Research on perspective taking (vista scale) examined how framing tasks as measuring spatial versus social abilities affected sexdifferences. Research at the environmental scale examined correlations between performance on the Allocentric heading task (Sholl et al., 2006) and measures of individual and strategy differences in various spatial tasks.
Results: In research on mental rotation males and females did not benefit differentially from a strategy of noticing foils that are structurally different (rather than mirror images) of the target figure. Participants of both genders and all ability levels performed better when the foils were structurally different. Research on perspective taking revealed sex differences that were eliminated when the task was framed as measuring social (empathy) ability. Research on the allocentric heading task revealed that performance and strategies on this task are predicted by measures of perspective taking ability and self-report measuresof navigation strategies, respectively.
Conclusions: This research highlights the importance of studying individual differences in spatial cognition broadly across different scales of space and of considering a comprehensive range of factors, including strategies and spatial anxiety, which might contribute to performance differences.

SYMPOSIUM 4: Human behavior, design, and the built environment. The case of visuo-spatial cognition and computation

Convenor: Mehul Bhatt

University of Bremen, Germany and The Design Space Group, Germany

Background: Spatial thinking, conceptualisation, and the verbal and visual (e.g., gestural, iconic, diagrammatic) communication of

commonsense as well as expert knowledge about the world—the space that we exist in—is one of the most important aspects of everyday human life. Philosophers, cognitive scientists, psychologists, linguists, psycholinguists, ontologists, information theorists, computer scientists, mathematicians, architects, and environmental psychologists have each investigated space through the perspective of the lenses afforded by their respective field of study.

Aim: This symposium focusses on human visuo-spatial cognition, and people or user-centered design processes involved in the conception, synthesis, engineering, and empirical analysis of spatial environments at multiple scales: large-scale building design, as well as geo and urban design. The symposium particularly addresses research challenges in the context of human behaviour and design cognition; we call for an interdisciplinary approach encompassing mutually complementary and synergising perspectives from:

- Visuo-spatial cognition and computation, and computational cognitive systems
- Cognitive psychology
- Architecture and urban design
- Geospatial science and human geography
- Spatial informatics in arcteciture and engineering design

Approach: Based on past research expertise and projects, and community-based scientific initiatives related to the theme of spatial cognition and design for architecture and urban planning, this symposium will create a platform to discuss the cognitive and computational foundations that can impact the development of next-generation design systems, design practices, and people-centred assistive frameworks and technologies encompassing the multi-faceted nature of professional spatial design.

Architectural design cognition and computation—I

Mehul Bhatt

University of Bremen, Germany and The Design Space Group, Germany

Background: Building designers (e.g., architects, planners) and stakeholder need access to assistive technologies—people-centred design systems—that manifest a basic understanding of human behaviour in spatial environments. Of particular interest are aspects pertaining to "visuo-spatial perception and cognition", "design semantics", and "design function" from the viewpoint of users, as well as design creators.

Aims: Our research on "people-centered spatial design" categorically addresses the question: How can cognitive modalities constitute the foundational building blocks of design education, discourse, systems, and the professional practice of spatial design for architecture? The broader goal is to identify how interdisciplinary application of knowledge may provide real benefit for the theory and professional practice of architecture design, and eventually, tangible benefit for the quality of everyday personal life and work.

Method: We have developeda people-centered model of design abstraction, formal modeling, and cognitive design computing for function-driven architecture design (assistance) systems. Our methods are founded at the intersection of artificial intelligence, spatial cognition and computation, and computational cognitive systems. Especially from the viewpoint of visuo-spatial cognition, of particular interest has been the integration of analytical methods for predictive analysis with empirically-driven evidence based (post-occupancy) analysis of large-scale built up spaces (e.g., airports, hospitals, museums).

Results: This talk presents an overview of our research methodology and deliverables along three dimensions: design conception, design computation, and design communication. We summarise basic research questions addressed, methodology adopted, deliverables produced, and industry transfer and real-world impact in the field of hospital design.

Thinking with things in design

Barbara Tversky and Juliet Chou

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Human behavior is both the input for designing the built environment and the goal of the built environment. The built environment is inherently spatial and so that designing it invites sketching. Sketches are by definition vague and ambiguous, so that they invite multiple interpretations and reinterpretations. In inspecting their own sketches, designers report making new discoveries, a productive interaction that leads to more sketching and more new ideas. We have captured this process in laboratory experiments that provide sketches and prompts to participants and asking them to generate new ideas for each. The results have shown positive effects of mindsets for expanding ideation and discovery.

Simulating agents' spatial and social cognition by means of a distributed artificial intelligence mechanism

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Background: Current approaches to human behavior simulation—like the ones used to simulate emergency egress—barely account for agents' social and spatial cognition. We attribute this shortcoming to the very nature of Agent-based systems, which advocate endowing agents with sensors that mimic real-world perception and cognition mechanisms. Such approach excessively increases both simulation complexity and computational costs, and therefore prohibits including in the simulation social and cultural factors.

Aims: Instead, we propose to reduce agents' complexity by transferring the responsibility for spatial and social awareness from the agents to the zones in which they operate.

Method: Zones are discrete spatial entities within a virtual setting (e.g. rooms, corridors, or their parts). During the simulation process, each zone is responsible for detecting the presence of agents within its boundaries, as well as the activities in which they engage and the objects they use. Zones can use that information to calculate environmental properties, such as people density, and noise levels. These values are stored in dynamic databases, called data-maps, that are updated at specific time intervals during the simulation, and that can be queried by agents to determine if the conditions required to perform some activities are met.

Results: The proposed methodology relieves agents from computational burdens associated with individually determining such spatial conditions, and allows simulating multi-agents' cognitive abilities by means of a simple and computationally efficient mechanism.
Conclusions: By simulating agents' spatial and social cognition within given spaces, it becomes possible to verify the impact of design choices on user behavior, and therefore to support the design of settings that better perform from a user perspective.

Information adaptation in urban design

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Background: The morphology of cities and their urban elements convey three forms of information that affect human behavior, design and the built environment: semantic information (SI) referring to what an urban entity is, pragmatic information (PI) referring to the action afforded by urban entities and Shannon information (SHI) that measures the quantity of information transmitted by the various urban entities. The same holds true for sketches, drawings and similar means planners and designers use. As can be seen, SI and PI are associated with meaning, while SHI with quantities. Recently we've (Haken and Portugali, 2015) shown that the quantitative SHI and the "meaning carriers" SI and PI condition each other as two aspects of a process of information adaptation (IA) the essence of which is interplay between SHI, and PI/SI.
Aims: To show that with respect to human behavior, design and the built environment, IA operates in the personal process of design, and in its impact on cities.
Method: Mathematical modelling and descriptive case studies.
Results: In terms of IA: (1) The designer starts with high SHI and many possible meanings, and gradually reaches a state of low SHI associated with a single meaning (SI/PI). (2) Design in cities implies adapting the information of a newly designed urban element to that of the environment.
Conclusions: Further questions: what counts as a good adaptation and thus Good City Form (Lynch 1981)? Is it one associated with 'information steady state' that conforms to the environment? Or, one associated with 'information phase transition' that adds new meanings to the city and thus sharply inflates its SHI?

Architectural design cognition and computation—II

Carl Schultz

Institute for Geoinformatics, University of Muenster, Germany and The Design Space Group

Background: People-centred evidence-based analysis of the interaction between people and the built-environment has been a crucial concern for many focus groups and research initiatives. Cross-domain studies led by environmental psychologists on user experience and behaviour abound. However, general-purpose evidence-based tools and standards that specifically target user behaviour and experience are missing in the community. In particular, there is a lack of support for data collection, data sharing, qualitative analysis, and communication of analytical results, within technical design systems.
Aims: Based on research within the DesignSpace Group (www.design-space.org), we report on the ongoing development of prototypical systems for conducting large-scale people experiments, with a specific focus on user wayfinding behaviour in the built environment.
Method: We focus on the manner in which analytical knowledge may be translated to formal specifications that can be applied within other kinds of design simulation systems. We adopt a case study-driven methodology. Specifically, we report on the application of our software systems and tools in wayfinding experiments that we have conducted in prominent large-scale public buildings including hospitals.
Results: We argue that formal methods in artificial intelligence and the resulting software tools and systems can greatly enhance the capacity for both (a) collecting user data and (b) deriving meaningful information *from* user data concerning the performance of building designs (ranging from conceptual design to pre- and post-occupancy).

SYMPOSIUM 5: No here without now: Temporal situatedness

Convenors: Yan Bao[1] and Ernst Pöppel[2]

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Background: Situatedness is both spatially and temporally defined, but the temporal component in situated cognition is a neglected topic. Previous research has shown that information processing is embedded in different time windows such as in the domain of some tens of milliseconds or a few seconds. The high frequency domain of some tens of milliseconds is related to the perception of simultaneity or temporal order; the time window of a few seconds which presemantically integrates sequential events is hypothesized to create the subjective present with the impression of "nowness"; longer time windows are related to our experience of durations and they provide operative frames for higher cognitive functions [see Pöppel E and Bao Y: Temporal windows as a bridge from objective to subjective time. In: Dan Lloyd and Valtteri Arstila (Eds.), *Subjective time: the philosophy, psychology, and neuroscience of temporality*, MIT Press, 2014, pp. 241–261].
Aim: By bringing together studies focusing on different time windows, we aim to address in more detail the temporal machinery of cognitive processing and raise some open questions for a better understanding of situated cognition, in particular temporal situatedness.
Approach: Both behavioral and neuroimaging paradigms are employed for a deeper understanding of temporal situatedness. Using for instance mismatch negativity (MMN) as an index, new experiments show that the human brain processes information preferentially in distinct time windows up to approximately three seconds supporting previous empirical evidence. In other studies in the higher frequency domain the importance of the situational context or of voluntary movements on temporal perception and simultaneity judgment is demonstrated; the underlying neural machinery provides the building blocks for cognitive processing. The link between past and present is shown in a single case study of a patient who after

50 years of acquired blindness still creates visual imagery in the present. In a study on moral judgment it is shown that judgments in the first person perspective are temporally embedded in the present, whereas such judgments in the third person perspective are characterized by an abstract temporal situatedness. Thus, empirical evidence with different experimental paradigms integrating information from different time scales indicate the importance of temporal situatedness.

Co-creation of the present: Effects of voluntary movements on simultaneity perception

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Background: Co-creation of the present is based on perceptual simultaneity especially for voluntary movements, with which people are interacting with the environment including other people in real time. However, only little is known about multi-modal temporal processing in voluntary movements.
Aims: In this study we tried to reveal effects of voluntary movements on the perception of simultaneity of auditory and tactile stimuli.
Method: The differences of subjective simultaneity (PSS) and the just noticeable difference (JND) were measured by temporal order judgment (TOJ) tasks under voluntary, involuntary, and no-movement conditions.
Results: The results showed that the PSS was significantly affected by voluntary movements compared to involuntary movements and no-movements. However, presumably because of the complexity in controlling the velocities of voluntary movements, there was no effect of voluntary movements on the JND in comparison to involuntary and no-movement conditions.
Conclusions: On the basis of the results, we conclude that it might be efference copy, e.g. a copy of the motor command, generated only in voluntary movements, rather than proprioceptive sensation both in voluntary and involuntary movements, which is responsible for the perceptual shift between auditory and tactile stimuli.

Subjective present: A window of temporal integration

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Background: It has been proposed that temporal perception is implemented in a 'time window' of approx. 3 s which we experience as 'present' (e.g., Pöppel and Bao, 2014). Mismatch negativity (MMN) is a brain reaction to oddball stimuli in a series of standard stimuli, i.e. a negative deflection of an ERP component peaking at 150–200 ms, when subtracting the ERP to frequent stimuli from that to deviant stimuli. MMN varies with the inter-stimulus intervals (ISI).
Aims: Using MMN, we tested the hypothesis whether a 3 s window is selective for pre-attentively detecting the violation of regularity in a stimulus sequence.
Method: 22 subjects (11 males) participated in this study. The standard and the deviant stimuli (20 % probability, randomly presented) were tones with 1000 and 1500 Hz, both with 100 ms duration; four ISI were selected, i.e., 1.5, 3, 4.5 and 6 s.
Results: In frontal midline areas (Fz and surrounding channels), we found ERP amplitudes for the two conditions 1.5 and 3 s ISI were significantly larger than for the conditions 4.5 and 6 s ISI. Surprisingly, male subjects show a much stronger effect in temporal modulation of the MMN. The slopes of responses show a positive correlation with amplitudes, allowing new insights into the gain function of neural mechanism.
Conclusions: Our results show MMN to be stronger up to 3 s, indicating that a 3 s time window might be selective for neuronal mechanisms to process deviant stimuli. It is suggested that temporal information processing is segmented, creating a "subjective present" (at least in males).

Situational context is important: Perceptual grouping modulates temporal perception

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Background: Subjective time of an event in the subsecond range is often compressed or dilated by the situational context created by preceding and succeeding stimuli. How such context distorts psychological time is still an open question.
Aims: Here, we pursued this issue by examining whether the perceptual grouping among successive visual stimuli modulates the perceived duration.
Method: Using a duration comparison task, we asked observers ($N = 12$) to judge the relative duration of a target (300 ms) and a comparison item (120–480 ms) and estimated the apparent duration of target from the corresponding psychometric function. The target was temporally flanked by a preceding item and a succeeding item (100 ms each). In different conditions, the target was more similar to either the preceding or the succeeding item in colour or shape, thus forming a perceptual group with either the preceding or the succeeding item.
Results: Results showed that grouping based on similarity modulated perceived duration. Specifically, when the target was grouped with the preceding item, its subjective duration was shorter than when it was grouped with the succeeding item. Interestingly, this pattern was observed when keeping the preceding item (a disc) and target (a square) constant while changing the succeeding item (a ring or a square), suggesting that the effect depends, to some degree, on the holistic perceptual grouping rather than on fragmented processes.
Conclusions: These results demonstrate that the situational context is an important factor in shaping temporal codes, thus bridging the seemingly independent perceptual feature processes and temporal representation.

Episodic memory: A connection between the past and the present

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Background: Autobiographical memory can be characterized as a subsystem of episodic memory that implies a rich recollective experience with an individual time axis. The complex of verbal and pictorial components of the episodic memory bridges the memory with the perceptual processing.
Aims: Assuming close relatedness between episodic memory and perceptual processing, we wondered if this connection remains in the individuals that experience a loss of the perceptive skills.
Method: Using fMRI we studied the neural processing of the individual recent and remote memories in the blind individual (female, 70 y.o.). Remote memories referred to the period when our case was able to see, hence to construct the pictorial images. The recent memories were based on experiences happening later on after becoming blind.
Results: We found the patterns of activations for the overall memory conditions similar to the previous reports, but additionally an activation of the visual cortex, specifically bilateral angular gyri. In the direct contrast, recent versus remote memories, we observed activations of the bilateral temporal middle and inferior gyri, bilateral frontal middle gyri, fusiform gyri. In the reverse contract, remote versus recent memories, no difference was found.
Conclusions: Despite the inability to see, the activation of visual cortex might indicate the preserved ability to reconstruct the visual images that constitute the memories. The situational images of the past, that are stored in memory, can be revisited in the present moment, that might be crucial for the confirmation of personal identity.

Time sentience may vary according to perspective in moral judgments

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Background: There appears to be an inconsistency in experimental paradigms used in fMRI research on moral judgments. As stimuli, moral dilemmas or moral statements/pictures that induce emotional reactions are usually employed; a main difference between these stimuli is the perspective of the participants reflecting either a first-person (moral dilemmas) or a third-person perspective (moral reactions).
Aims: The present study employed functional magnetic resonance imaging (fMRI) in order to investigate the neural correlates of moral judgments presented in either a first- or third-person perspective.
Method: Participants had to evaluate sentences withmoral content, presented in first- and third-person narrative.
Results: Our results indicate that different neural mechanisms appear to be involved in these perspectives. The so-called "actor–observer bias" affects moral evaluation. This attribution bias seems to be supported by a temporal aspect as well. 1PP presentations engage evaluative cognition, this type of processing being temporally related to the present, while the 3PP situation relies on abstract evaluations, which tend to be more time independent.
Conclusions: We posit that these findings demonstrate that first or third person perspectives in moral cognition involve distinct neural processes. Moreover, these distinct neural processes seem to rely upon distinct temporal perceptions.

SYMPOSIUM 6: Individual differences in navigating

Convenor: Steven M. Weisberg

University of Pennsylvania, USA

Background: Everyone navigates, but how navigation is accomplished varies widely within and between individuals. Long-standing debates over whether humans form cognitive maps have been recently informed by empirical data showing that some people do form cognitive maps while others may not. As a clearer picture of navigation behavior is emerging, the neural activity that correlates with specific navigation activities has been described in increasingly rich detail. The data from neuroimaging suggest that the metric information necessary for creating cognitive maps is indeed represented in the brain. But it is also becoming clear that individuals represent and use this information with varying accuracy. More recent work, to be highlighted in this symposium, explores individual differences in strategies used and aptitude for learning and recalling environments, and the way cues are combined during navigation to yield representations.
Aim: This symposium will describe the various properties along which individuals differ in the course of navigation. We do not endeavour to find individual difference variables (e.g., gender, race, etc.) which may correlate with navigation behavior, but rather how individuals vary along dimensions like navigational proficiencies, strategies, representations, and cue use. It is our aim to characterize more fully the range with which humans solve the problem of navigation.
Approach: We approach this topic from the standpoint that people differ widely in how and how successfully they navigate. The talks will cover studies that use behavioral and neuroimaging techniques to describe and relate individual differences in many properties of navigation. Steven Weisberg will describe a study in which navigation strategy and navigation proficiency are assessed, and described as distinct behavioral constructs. Timothy McNamara will show how individual differences in cue preference (visual vs. self-motion) relate to cue combination. James Negen will explore the role of individual differences in when graph-like or map-like representations are used in learning places. Finally, Steven Marchette will explain how individual differences in self-reported navigation ability correlate with representing familiar places spatially.

It's not can but how: Navigation aptitude and strategy

Steven M. Weisberg[1] and Nora S. Newcombe[2]

[1]University of Pennsylvania, USA; [2]Temple University, USA

Background: People vary in navigation strategy (e.g., on the Dual Solution Paradigm; Marchette et al., 2011). Some use a place-based strategy, in which distances and directions yield map-like representations, whereas others use a response-based strategy, in which scenes and turns yield stimulus–response representations. People also vary in accuracy (e.g., on Virtual Silcton; Weisberg et al., 2014). Some learn the layout of an environment exactly, while others commit large errors.
Aims: We explored the relation between navigation strategy and accuracy, using two virtual environments—the DSP and Silcton.
Method: 76 participants learned both environments, in separate sessions 1 week apart (learning and test for each environment were in the same session). At test, participants completed several tasks (e.g., pointing or travelling from one object to another). We measured accuracy for Silcton and DSP, and place- or response-based strategy preference for DSP. Strategy was measured in the DSP by determining whether participants followed a familiar path, or took a novel shortcut.
Results: Accuracy on Silcton was highly correlated with success on DSP, showing convergent validity. Strategy preference in the DSP was not correlated with accuracy in either environment. However, correlations between accuracy on the DSP and strategy preference varied by performance in Silcton. Strong Silcton navigators who preferred a place-based strategy had higher accuracy on the DSP, whereas weaker Silcton navigators showed the opposite pattern.
Conclusions: Navigation strategy and accuracy are, in part, dissociable. However, people who excel at one strategy benefit when they use that strategy, instead of another.

Individual differences in cue combination during navigation

Xiaoli Chen[1] and Timothy P. McNamara[2]

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Background and Aims: We examined the manner in which people integrated visual cues and self-motion cues during spatial navigation when the two cues varied in reliability.
Method: Participants walked in immersive virtual reality from a starting location to three successive waypoints and then attempted to return to the firstwaypoint using (a) visual cues alone, (b) self-motion cues alone, (c) consistent visual and self-motion cues, or (d) visual and self-motion cues in conflict.
Results and Conclusions: Performance was statistically optimal, or nearly so, under most conditions. A striking discovery existed in the large individual differences in the extent to which participants were able to use visual cues relative to self-motion cues. These individual differences were positively correlated with the extent to which participants relied on visual cues relative to self-motion cues in combined cue conditions. The etiology and implications of these individual differences will be discussed.

When do people use path integration to build metric maps of space?

James Negen and Marko Nardini

Durham University, UK

Background: There are many possible ways to navigate a large space. One is to build a full metric representation of distances and angles that all fit together correctly—a 'map'. To help, you can track where things were when you last saw them by path integration updating as you move ("it was 3 m behind, then I turned 90° left. Now it's 3 m left"). It's also possible to represent the space more simply as a graph structure ("A is connected to B but not C").
Aims: To investigate when metric navigation strategies are used, to what extent, and by whom. Specifically, to place participants in a virtual reality space that is graph-consistent but metric-inconsistent, and measure the extent to which they use metric strategies such as path integration even when these are detrimental.
Method: Participants navigated a 7-room maze in virtual reality. Each corner of each room was 90°, but they could turn 540° before they faced the same wall. Control tasks will have the same graph structure but normal (or no) metric structure.
Results: Participants quickly performed above chance. After visiting each room at least once, they made errors that were closer than chance expectation to a veridical path integration projection in normal space, $t(11) = -3.182$, $p = .0087$.
Conclusions: These initial data showing use of path integration even when it is clearly not useful suggests that subjects automatically integrate locations into a metric representation. Further data will clarify whether and how they adapt with further experience.

Navigation ability predicts the spatial organization of free recall

Steven A. Marchette, John Ryan and Russel A. Epstein

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Background: Space provides a scaffold for encoding experiences with the world; however, individuals vary greatly in the quality of their spatial representations. This suggests the possibility that individuals might differ in the degree to which the spatial organization of the physical world guides their free recall.
Aims: To test the hypothesis that navigational ability predicts the spatial organization of memory search.
Method: We asked university students to freely recall the names of familiar places (e.g. campus buildings) and related performance to self-report measures of navigational ability. As a control condition, participants freely recalled objects that belonged to a given semantic category (e.g. animals). We scored participants' responses in terms of the relative distance between successively recalled items. For places, distance was based on spatial proximity in the world; for objects, distance was based on semantic proximity within a latent semantic analysis.

Results: Navigation ability predicted the degree to which order of recall reflected real-world proximity among retrieved places, even though recall of their locations was never required. Further, this relationship was selective, as navigation ability did not predict whether order of recall reflected semantic proximity among retrieved objects. Finally, we observed a close relationship between memory organization and retrieval success: individuals with higher semantic or spatial memory organization recalled more items.
Conclusions: These results suggest that individuals with better sense-of-direction rely more heavily on their cognitive maps as guides for memory retrieval, and this natural "method of loci" allows them to recall more of the places they have traveled through.

SYMPOSIUM 7: Situated cognition in the space of social interactions: From the bodily-self to shared spatial representations

Convenors: Matteo Candidi and Ilaria Bufalari

Sapienza University of Rome, Italy

Background: We constantly experience our body dipped in a space where we act and interact with others. Accumulating evidence from the field of social neuroscience suggest that "private" forms of cognition (e.g., bodily self, action and spatial representation) mutually constrain and are constrained by the social dimension (i.e. social space). Among other mechanisms that might be at play during social interactions, it is widely suggested that sensorimotor (grounded) simulation is a key mechanism bridging the gap between others and us. These simulations, thus, make our cognition situated in a bodily and social space.
Aim: The symposium focuses on different attempts to describe the extent to which grounded forms of cognition contribute to representing the social spaces and, at the same time, how the social dimension shapes more basic forms of cognition. Results of recent research will be presented by four young talented international researchers, engaged in studying the ways in which the social dimension influences: (i) the sense of bodily self, (ii) the perception of others' sensorimotor and emotional state, (iii) the ability to assume other's perspective, and (iv) the representation of the space where we interact with them. The contributions will span across this wide range of cognitive processes, presenting data on neurotypical subjects, neurological patients and autistic individuals.
Approach: The first contribution by Bigna Lenggenhager will focus on how neurological factors and higher-level social norms can both significantly contribute to an integrated experience of body and self as a unity, presented through the case of one unusual condition of bodily identity, the body integrity identity disorder (BIID). Bhismadev Chakrabarti will show how reward processes may guide embodied simulation by focusing on the case of autism spectrum conditions (ASC). This contribution will provide new insights for a potential bridge between two theoretical accounts of ASC, one based on low responsivity to social rewards and one based on atypical embodied simulation. The other two contributions will show how joint action scenarios change our ability to assume others' spatial perspective and how interacting with others contributes to building shared spatial representations. In particular, Natalie Sebanz will show how interacting in the context of joint actions affects our ability to assume others' spatial perspective. Giovanni Pezzulo, will describe the multisensory integrative mechanisms that support spatial and social perspective alignment in social contexts to create a Shared Action Space, which support key computations of social interactions and joint actions.

The bodily self in shared and social space: A neurological perspective

Bigna Lenggenhager

University Hospital Zurich, Switzerland

Background: The perception of ones own body seems like the most private sensation and is built on the continuous integration of various bodily signals. Nevertheless, it has already early been suggested to also be a social phenomenon.
Aims: The aim of my talk will be to use recent evidence from both clinical neurology as well as experimental research in healthy participants in order to pinpoint possible interactions between the private multisensory foundations of the bodily self, and the shared, social space.
Method: I will use examples of various neurological and psychiatric conditions and put a special focus on the example of body integrity identity disorder (BIID). I will corroborate these examples with empirical evidence that combine methods from experimental psychology and virtual reality.
Results: I will show how malleable our bodily self is and how it might be rather easily manipulated both by multisensory as well as by social inputs.
Conclusions: Conclusively, I will argue based on both data from neurological patients as well as from experimental data that there is a mutual interaction of multisensory bodily input and social aspects in building the sense of a bodily self.

The role of reward in simulative processes: Insights from and for autism

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Background: Embodied simulation constitutes a direct mapping of affective and bodily states from a subject to the observer. Spontaneous facial mimicry (SFM) provides one way to quantify embodied simulation, and is seen to be atypical in autism spectrum conditions (ASC).
Aims: Here we test if reward value of a face influenced the extent of SFM of its happy expression (using facial EMG), and if this relationship is modulated by autistic traits.
Method: Four neutral faces were associated with varying levels of rewards (high and low), using an evaluative conditioning task. In the test phase, participants with and without a diagnosis of ASC viewed happy and angry expressions of these conditioned identities.
Results: Participants scoring high on autistic traits (measured using autism spectrum quotient, AQ) did not show a significant difference in SFM between happy expressions of high and low reward-

conditioned faces. Conversely, participants low in autistic traits showed a significant difference in the extent of SFM between the different reward-conditioned faces.
Conclusions: We conclude that (a) reward value modulates spontaneous mimicry of happy faces, as measured using facial EMG, and (b) the extent of this modulation varies inversely as a function of autistic traits. Our study suggests that the autistic deficit may lie in an atypical modulation of simulative processes by the reward value of the stimulus. This is consistent with the social reward deficit hypothesis, which suggests that people with autism do not attend to and empathize with social stimuli, because they do not find them rewarding.

Spatial perspective taking in the context of joint action

Natalie Sebanz, Pavel Voinov and Günther Knoblich

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Background: Many of our actions are performed jointly and involve coordination between two or more agents. Research on joint action has studied how individuals form action plans that include others' actions, and how co-actors achieve precise temporal coordination. An important question in joint action research is when and how co-actors adopt each other's spatial perspectives, and how well complementary perspectives can be combined.
Aims: The present study investigated how two co-actors integrate information across different perspectives when viewing the same scene.
Method: Participants performed a novel object location task. They were asked to locate a target within a 2D projection of a 3D container. We generated projections from different camera angles to simulate different perspectives on the same layout. In a series of experiments we systematically manipulated: (a) the angular difference between two individual views; (b) participants' ability to exchange information through verbal communication; (c) the presence of feedback.
Results: Pairs of participants outperformed individuals looking at the scene from a single viewpoint and reached the same level of accuracy as single individuals having sequential access to both viewpoints. Judgments of individuals with more accurate estimations received more weight during interpersonal integration. There was no additional benefit of verbal communication.
Conclusions: Individuals having different viewpoints on a visual scene can use the shared environment to integrate complementary location information.

Shared Action Spaces: (How) does the brain merge the co-actors' spatial representations during social interactions?

Giovanni Pezzulo

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Background: Humans excel in various joint actions—e.g., lifting together an object or performing team sports—but the underlying neuro-computational mechanisms are incompletely known. The "motor cognition" framework highlights the importance of sensorimotor simulations and internal models for social interactions. However, with few noteworthy exceptions, most theories in this framework are essentially "individualistic" and do not sufficiently consider the possibility that the brain uses neuronal representations that incorporate information relative to the co-actor(s), e.g., representations (and alleged models) of "me and you as a team".
Aims: This (theoretical and computational) contribution proposes that, first, co-actors use internal (generative) models of their joint task; and second, that these models include elements that extend beyond individualistic variables (e.g., my part) to incorporate joint elements, thus creating a "Shared Action Space" (SAS) between the co-actors. It discusses how a SAS might support key computations of joint actions, e.g., remapping between frames of reference of the co-actors, perspective taking, performing the sensorimotor transformations required for lifting jointly an object, predicting the sensory effects of such joint action, performing "signalling" actions that fix the SAS.
Method: The contribution includes a theoretical discussion and computational simulations of joint actions.
Results: The expected result of this ongoing workis a novel proposal that extends the current motor cognition view of joint action towards a more "intersubjective" perspective.
Conclusions: The tentative conclusions are that we need a more intersubjective view of joint action—and the novel proposal offered here is a first step in this direction.

SYMPOSIUM 8: Motor perspectives on social interaction

Convenor: Claudia Gianelli

Division of Cognitive Sciences, University of Potsdam, Germany

Background: How basic actions, such as reaching and grasping, take place into space is an obvious topic for kinematics experiments. But how our movements depend on the way this action space is shared with other individuals is, instead, an intriguing but relatively new topic. Moreover, the social dimension affects our actions in several ways, not only when the actual action space or simple presence is shared with another person. In this sense, our actions take place in a "social space" which is not limited to the physical properties of the environment. Crucially, the motor system takes into account this social space when planning and performing actions, as recent experiments have shown.
Aim: The aim of this symposium is to bring together young researchers who share the general interest of a motor perspective to investigate social interactions. At the same time, they approach this complex and multifaceted phenomenon from different points of view, focusing on different but necessarily complementary aspects (e.g. strictly motor or neurophysiological).
Approach: The symposium merges experimental, methodological and theoretical contributions and gives researchers a unique opportunity to meet and discuss the future of a young, yet very promising, field of research.

Sensorimotor information flow in interacting partners

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Background: Humans are innately social creatures, but cognitive neuroscience, traditionally focused on individual brains, is just beginning to investigate social cognition through realistic interpersonal interaction.
Aims: Quantitative investigation of the dynamical sensorimotor communication among interacting individuals in a goal-directed task.
Method: We recorded upper-body motion capture of 23 dyads jointly building a wooden block tower. Subjects built ten towers. We recorded upper-body movements via motion capture. We then applied Granger Causality methods to the arm motion kinematics time-series to extract the pattern of sensorimotor information flow between participants.
Cross-correlation analyses on arm velocity profiles were used to measure the amount of automatic imitation between participants. We also administered questionnaires to analyse the quality of joint interaction experience.
Results: Validation of the joint goal-directed task and of the computational methods to extract sensorimotor communication flow and automatic kinematic imitation in such kind of turn-taking joint non-verbal task. Data suggest that arm velocity profiles converged and the lag for cross-correlation was diminished to optimize interaction and coordination.
Conclusions: Quantifying human-to-human sensorimotor interaction, in a way that can be predicted and controlled, is probably one of the greatest challenges for the future of human–computer interaction. in this case, embracing a systemic and situated view, would be critical to consider dyads as a single dynamical system instead of two interacting entities sharing information. The whole idea of motor convergence goes in that direction as it would allow, for example, the possibility to design technologies to optimize group decision-making by promoting low-level automatic convergence.

Complementary actions: Novel perspectives

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Background: Many daily activities involve performing an action while simultaneously encoding other events. This is particularly interesting during complementary forms of social interactions wherein two (or more) individuals coordinate their joint actions in a balanced manner. But despite interest, relevance, and theoretical development on how people represent their own and other person's actions, there is still a considerable lack of understanding of the cognitive mechanisms and neural networks governing interactive performance.
Aims: The aim of this survey is to outline the neural bases and the psychological processes underlying joint actions with specific reference to complementary actions.
Method: I shall present behavioral, neurophysiologic and neuroimaging data which highlight the importance of studying complementary actions in the context of the action–perception domain.
Results: Available data, obtained with a variety of techniques, indicate a dedicated network of brain areas underlying the planning and execution of complementary actions.
Conclusions: How one's own action is influenced by other's actions during social interactions is just beginning to be understood. The idea that observing an action automatically triggers an inclination to execute it was largely based on the fact that most studies did not explicitly challenge the automaticity and flexibility of the visuomotor transformation process. Complementary actions provide an ideal mean to shed further light on forms of social behavior frequently occurring in daily life situations.

Perceiving social intention in motor actions at the second-person perspective

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Background: Recent findings support that our ability to predict the course of motor actions and intentions behind these actions is deeply related to our action capabilities and to the environmental constraints. Following this conception, it has been postulated that the spatio-temporal parameters of voluntary motor action may help optimize human social interactions. However, it is unknown whether individuals spontaneously perceive informative social cues borne by action.
Aims: This study investigates for the first time if social intention can be detected from motor actions at the second-person perspective.
Method: In this study, an actor and a partner participated in a task consisting in grasping and moving a wooden dowel under time constraint. This task could be accomplished by either the actor or the partner depending on auditory cues. Before this main action, the actor systematically performed a preparatory action, viz., placing the dowel on a starting mark. The information about who would make the main action was provided only through the actor's headphones.
Results: Analysis of motor performances revealed that actors initiated the preparatory and main actions differently depending on whether or not they knew they had to do the main action. Strikingly, partners showed similar effects on the main action despite having received only irrelevant prior information.
Conclusions: Our data support that social intentions could be spontaneously perceived in voluntary motor actions and suggest an implicit cognitive processing of the social scope of other's action during social interaction.

Keeping social interaction social: New kinematic methods and analyses for improving validity

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Background: Research on imitation and social interaction has often made use of single participants being presented with pre-recorded video stimuli. This is in spite of evidence that shows reduced neural activation to video versus real life movement stimuli.
Aims: With this in mind, we aimed to discover the degree to which video stimuli may affect the imitation process using a novel motion tracking paradigm with high spatial and temporal resolution.
Method: We used 14 motion tracking points to record the hand, arm, and head movements of two individuals in an imitation experiment. One individual freely moved within given parameters (moving balls across a series of pegs) and a second participant imitated. This task was performed with either simple (one ball) or complex (three balls) movement difficulty, and either face-to-face or via a live video projection.
Results: A cross-correlation and multivariate analysis revealed that imitation accuracy (as represented by grip position) was reduced in video compared to face-to-face feedback, and for complex compared to simple movements. This was most prevalent in the left–right and forward–back motions, relevant to the imitator sitting face-to-face with the actor or with a live projected video of the same actor.
Conclusions: The results suggest that in tasks which require object-directed imitation, video stimuli may not be an ecologically valid way to present task materials. The implications of these results are discussed with regards to previous findings, and with suggestions for future experimentation.

Eye contact during action observation triggers allocentric action representation

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Background: Understanding the goal of others' actions is an essential component of interactive behavior thought to rely on common action execution and observation neural processes. This capacity presupposes the ability to apprehend and represent the world from the others' perspective or frame of reference.
Aims: The present study aimed to provide evidence for a mechanism allowing observers to encode observed actions from the perspective of another person.
Method: We tested whether the observation of left/right hand-action and eye-gaze cues could modulate lateralized action responses. Forty-eight participants were presented with sequences depicting an actor gazing at (or not) and grasping (or not) a left or right object. Participants had to respond to two numerical signals, indicating either a left or right hand response. The signal appeared either below the eyes of the actor or on his hand, therefore attracting participants' attention to the different cue locations. The observed actions could be spatially congruent or spatially incongruent with the participants' hands responses.
Results: We found evidence that participants adopted an allocentric action representation, with responses for spatial incongruent conditions being quicker than for spatial congruent conditions. This effect was present across all the observation conditions, but only when participants' attention was oriented towards the actor's eyes.
Conclusions: These results suggest that making eye contact with an actor induces an automatic spatial representation of the observed action from the actor's perspective, facilitating allocentric congruent motor responses. The social significance of such a mechanism will be discussed.

SYMPOSIUM 9: How do numbers move mentally? The interplay between numerical cognition and multiple dimensions of space

Convenors: Luisa Lugli[1] and Bodo Winter[2]

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Background: What is the interplay between spatial cognition and numerical cognition? Based on the seminal finding that people respond quicker with their left hand to smaller numbers and with their right hand to larger numbers (Dehaene, Bossini & Giraux, 1993), several studies have investigated horizontal associations between numbers and space. However, by now, more and more studies indicate the existence of multiple spatial mappings (Shaki & Fischer, 2012; Winter, Perlman & Matlock, 2014; see also, Lugli, Baroni, Anelli, Borghi & Nicoletti, 2013), not just horizontal ones. Moreover, more and more studies indicate spatial biases not just for the processing of magnitudes, but also for the processing of ordinal information (counting sequences), as well as for arithmetical operations, such as addition and subtraction.
Aim: In this symposium, we highlight interactions between numerical and spatial cognition, focusing on how numbers can be represented through a large set of different spatial frames of reference. We bring researchers together that have studied horizontal, vertical, radial, sagittal, and size-based associations between numbers and space to highlight the diversity of ways through which numbers can be thought of in terms of space. This work shows that spatial–numerical associations, such as the horizontal mental number line, are not monolithic and unchanging. Instead, multiple spatial–numerical associations appear to co-exist, and become activated to differing extents based on the situated nature of the task. Moreover, spatial–numerical associations do not appear to be uniformly distributed across the population, with some people having preferences for certain mappings. Given this, we want to ask such questions as: How stable are certain spatial frames of reference? In which situations are particular frames of reference dominant? What cognitive and cultural factors affect the choice of a particular spatial mental representation? And can the different spatial frames of reference be combined, or are they mutually exclusive in a particular situation?
Approach: A diverse set of researchers, each a specialist in the domain of numerical cognition, will present their experimental data on multiple spatial mappings: horizontal (Lourenco, Goebel, Shaki, Lugli), vertical (Lachmair, Goebel, Lugli) and size-based (Winter).

We will not only explore associations between space and magnitude, as was done in the original SNARC effect study and is done here by Lachmair, Winter and Lourenco, but also associations between space and arithmetical operations (Shaki, Lugli), as well as associations between space and numerical order (Goebel). Besides emphasizing the diversity of mental space/number connections, the speakers will show how a diverse set of methods can be utilized to broaden the scope of numerical cognition research, including cross-cultural research (Goebel), gesture analysis (Winter), psychological experiments in lab settings (Lachmair, Shaki, Lourenco) or natural contexts (Lugli). Thus, the symposium's unique line up of researchers allows us to collectively broaden the perspective on space/number associations, both methodologically and theoretically.

Up or down? Reading direction influences counting direction: A cross-cultural comparison

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Background: In cultures where reading text progresses from left to right most adults and children count from left to right, the reverse is found in cultures with right to left reading.
Aims: The current set of experiments investigated whether vertical counting is also influenced by the cultural direction of reading.
Method: In two experiments we observed the direction and order in which participants counted objects presented in horizontal, vertical and square displays. We compared counting direction and order of children and adults from a culture with left to right reading (UK) to those from a culture with mixed reading direction (Hong Kong: left to right and top to bottom).
Results: Independent of culture, the horizontal array was mostly counted from left to right. While the majority of English-speaking children counted the vertical display from bottom to top, the majority of the Cantonese-speaking children as both Cantonese- and English-speaking adults counted the vertical display from top to bottom. This pattern was replicated in the counting pattern for squares: all groups except the English-speaking children started counting with the top left coin.
Conclusions: Our results show clearly that counting in the vertical direction is influenced by longstanding as well as more recent experience of reading direction.

When words meet numbers: Spatially grounded associated response codes?

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Background: A recent study shows that high and low numbers ("8", "9" vs. "1", "2") facilitate the processing of congruent nouns with an implicit directional cue upwards or downwards ("bird", "root"). But for verbs ("rise", "fall") this congruency effect is reversed showing hampering for congruent categorized verbs. This indicates that the processes between nouns and verbs run different.
Aims: We aimed to investigate the congruency effect between different word-categories and numbers by reversing the order of presentation.
Method: In Experiment 1, participants read centrally presented up- or down-verbs ("rise", "fall"). During a variable time interval (TI1 = 300 ms, TI2 = 500 ms, TI3 = 800 ms), a high ("8", "9"), low ("1", "2") or catch- ("5") number was presented. Subsequently, participants had to respond to a white square as quickly as possible in cases of "1", "2", "8" and "9" by pressing the spacebar. In Experiment 2, participants performed the same task with up- and down-nouns ("bird", "root") instead of verbs. In congruent trials words are up and numbers high or down and low, respectively. The other trials are incongruent.
Results: Results show an interaction of congruency, word-categories and TI. For nouns, congruent trials are faster in TI1 and TI2 than incongruent trials and vice versa in TI3. Interestingly, for verbs, congruent trials are slower in TI1 than incongruent trials and vice versa in TI2 and TI3.
Conclusions: Results suggest an influence of TI on congruency between numbers and words. This could be due to different temporal dynamics of simulation processes between nouns and verbs.

Moving through the space: How arithmetical calculations are involved

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Background: A growing number of studies demonstrate a connection between spatial and numerical cognition, indicating the relevance of vertical and horizontal spatial dimensions for number processing. Recently, these spatial biases have been reported also for arithmetical calculations. However, the relative strength of the influence of the vertical and horizontal dimension on calculations is still a matter of debate.
Aims: An overview of a series of experimental findings obtained in our lab will be presented. We will discuss past and recent behavioral evidence showing the impact of several types of movement on our ability to perform basic calculations.
Method: We focus on a series of experiments in real-life conditions. Additions or subtractions were calculated along different spatial dimensions while actively performing a whole body movement (i.e., taking the stairs or walking), or while passively experiencing the direction of the motion (i.e., taking the elevator or using a wheelchair).
Results: Results demonstrate an influence of the movement experienced, both along the vertical (Lugli et al., 2013) and the horizontal dimension (Anelli et al., 2014), over the type of arithmetical calculations performed. The role played by the type of movement performed, that is active or passive movements, will be discussed also in light of new experimental findings (Lugli et al., in preparation).
Conclusions: Overall, these findings add new evidence in favour of an embodied nature of number processing. They indicate that the arithmetical operations are connected with the processing of spatial information and are influenced by action-related processes.

Gesture space corresponds to mental number space: Evidence from "tiny" and "low" numbers

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Background: Numerical cognition research has demonstrated size-based and vertical associations between space and number. For example, people have been shown to form a larger grip aperture when grasping for relatively large numbers (Andres, Ostry, Nicol & Paus, 2008) and to respond more quickly with upward directed responses to large numbers (e.g., Schwarz & Keus, 2004).
Aims: The present study examines how size-based and vertical space/number associations are systematically reflected in naturally occurring co-speech gestures.
Method: An American TV News database was searched for the phrases "tiny number," "huge number," "high number" and "low number." A random subset of 1320 videos with these phrases was coded for whether gestures were produced in association with the spoken phrase. When this occurred (N = 314), we coded the gestures for hand configuration, spatial orientation of the palm and major axis of hand movement (up/down/left/right).
Results: When speakers say "tiny number" they produce pinching gestures; with "huge number," the palm is flat and the hands often move away from the body. For "high numbers," the palm tends to be oriented upward. For "low numbers," the palm is oriented downward. Movements are also aligned consistent with speech (up for "high," down for "low"). The horizontal axis shows no differences.
Conclusions: Co-speech gestures in natural discourse, precisely, in TV news reports, appear to systematically reflect spatial mappings discussed in the numerical cognition literature. Vertical and size-based associations between space and number are deeply entrenched in our culture and communicative practice.

Spatial biases in mental arithmetic without spatial responses? Operational momentum revisited

Samuel Shaki

Ariel University, Israel

Background: Recent studies found various violations of mathematical axioms during mental arithmetic, such as the operational momentum (OM) effect, which involves systematic underestimation and overestimation biases for subtraction and addition outcomes that are also accompanied by spatial leftward and rightward errors, respectively (McCrink, Dehaene, & Dehaene-Lambertz, 2007; Pinhas & Fischer, 2008). A violation of commutativity ($a + b = b + a$) and identity ($a = a$) axioms were found in line production task, in which participants produced longer line when $n1 < n2$ compared to $n1 > n2$ and that unit size increased with result size (Shaki, Sery & Fischer, 2014).
Aims: The present study explores the various competing biases contributing to operational momentum (OM) and other violations of mathematical axioms in various arithmetic operations, by removing the directionality component from participants' responses.
Method: In a series of experiments, participants were asked to produce self-calculated outcomes of single-digit arithmetic operations by changing bi-directionally the length of a horizontally extended line, using radially arranged buttons.
Results: (a) we found OM dissociation between zero and non-zero problems: while an OM effect was found in zero problems, a reverse OM effect was found in non-zero problems and (b) we expect to find a violation of commutativity axiom in multiplication, similar to the violation we found in addition (Shaki, Sery & Fischer, 2015).
Conclusions: In light of the results, I propose a new model of the OM, its components (the operands' values, the sign-space association, and the sign-outcome heuristic) and their weights.

Probing the mental number line: A between-task analysis of spatial–numerical associations

Stella F. Lourenco

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Background: The phenomenon of the mental number line (MNL) has received much support from different behavioral paradigms demonstrating spatial–numerical associations (SNAs). In Westerners, the MNL shows consistent left-to-right orientation across paradigms. Similar behavioral effects, however, could reflect task-specific strategies or general cognitive abilities, rather than a shared MNL.
Aims: The aim of the current study was to provide a strong test of the MNL theory by assessing the consistency of individual differences across SNA tasks. These tests included judging the parity or magnitude of numbers by responding with one's left or right hand a numerical Posner task in which left and right sides of space were cued by numbers, a random number generation task while the participant faced either left or right, and a number bisection task in which participants indicated the center of a line composed of numbers. The MNL theory predicts correlations across these SNA tasks.
Method: 125 participants (though data collection remains on-going) completed a battery of SNA and control tasks. SNA tasks represented well-known tasks from the literature. Control tasks included two types; one set paralleled the SNA tasks and another assessed general cognitive abilities. Tasks were shortened from the originals to allow for testing within a single session.
Results: Correlation analyses revealed significant associations across several SNA tasks, even when accounting for similar task structure, general cognitive abilities, or response times.
Conclusions: These findings provide unique support for the MNL hypothesis. They also begin to shed insight on the potential explanations that may account for variation in the strength of the associations among different SNA tasks.

SYMPOSIUM 10: Neurocomputational approaches to spatio-temporal attention

Convenors: Luca Simione[1] and Onofrio Gigliotta[1,2]

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Background: Since the seminal work, awarded with a Nobel prize, of Alan Lloyd Hodgkin and Andrew Huxley in which the propagation of action potentials was described by a set of differential equations, computational approaches in modelling specific parts of the brain have been gaining interest and consensus. Early computational neuroscience primarily focused on the molecular behaviour of a neuron, or of a population of neurons, avoiding to face the molar behaviour of a whole organism. This problem was addressed for the first time by the connectionism. Connectionists not only concentrated on molar behaviour (e.g. pronouncing English text as in NetTalk) without worrying about fine-grain biological constraints, but added 'artificial bodies' to their 'artificial brains' by using neural networks to control embodied agents, for example in disciplines such as Evolutionary Robotics. Recently a new field called 'computational cognitive neuroscience' is trying to link molecular behaviours to molar ones fostering a more accurate modelling style heavily based on biological constraints (Ashby and Helie, 2011).
Aim: Objective of the present symposium is to discuss neurocomputational approaches to spatio-temporal attention by taking into account how the gap between molecular and molar behaviours can be bridged according to this new perspective. The mutual link between neural simulations and experimental works will also be extensively discussed, by highlighting the capacity of the neurocomputational approach to theoretically frame the experimental results and to shed light on new hypotheses to be tested. In this symposium we would like to address spatio-temporal issues in cognition, by encouraging a cross fertilization among applicants of different approaches in order to highlight the power of computational approaches in this important field.
Approach: As reported above, neurocomputational approaches come in different forms, spanning from coarse to fine-grained ones, e.g. from embodied and situated approaches in which an artificial brain is meant to control the behaviour of a specific artificial body, to the simulation of the behaviour of a single neuron or a group of neurons. For this reason, in our symposium we will hold contributions approaching the study of spatio-temporal attention by means of different kind of neural network models. Through computer simulations of these models, we will deepen how the neural mechanisms and the environmental constraints interact in order to obtain a range of fundamental attentional effects, including the selective attention, the hemi-spatial neglect, and the attentional blink.

Temporal integration in the context of computational models of the attentional blink

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Background: When successive stimuli are presented within a brief interval (typically <250 ms), human observers may integrate these into a single comprehensive perceptual object or event. Such rapid stimulus sequences are used often in research on the attentional blink (AB), which reflects the difficulty of attending to the second of two target stimuli if they are shown within about 500 ms. However, whether temporal integration occurs at all in AB studies has been debated, with some authors proposing that attentional prior entry mechanisms suffice to account for task performance with successive targets. Most (neuro-) computational models of the AB consequently do not feature a temporal integration mechanism, precluding interactionsbetween integration and attention.
Aims: We aimed to test the assumption of independence between attention and temporal integration, as (implicitly) made in various recent computational models of the AB.
Method: We examined the relationship between attention and temporal integration, using a modified rapid serial visual presentation paradigm with target stimuli whose visual appearance allowed the perceptual combination of successive targets. We examined extended target sequences in particular and contrasted the integration of task-relevant and task-irrelevant stimuli.
Results: The results showed that temporal integration interacts with attention, and can extend across three successive stimuli (up to 240 ms), but only while these fit the target template; the occurrence of nontargets strongly inhibited integration.
Conclusions: The observed interactions between temporal integration and attention can be predicted by the STST model (Bowman & Wyble, 2007), but not by its successors, nor by the majority of competing models of the AB, which would need to be revised to include a mechanism of temporal integration.

Attention increases the acuity of conscious perception: All-or none percepts, temporal variance and the simultaneous type/serial token model

Howard Bowman

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Background: There has been considerable interest in whether conscious perception is all-or-none, i.e. that one either experiences a complete percept or no percept at all. There is thoughconfusion in the literature. We though emphasise that the empirically supported finding is that conscious perception is more all-or-none during the attentional blink (AB). This, though, does not automatically imply that conscious perception in general is all-or-none.
Aims: Our aim is to explain this and other losses of sensitivity using the simultaneous type/serial token (STST) model.
Method: We use neural modelling and EEG experiments.

Results: We found that the P3 component of the Event Related Potential, which is taken as a marker of conscious perception, is less sensitive to stimulus strength inside the AB. This can be explained with STST, since the activation trace for the second target during the AB loses sensitivity through time. Combining this with the delayed consolidation known to arise during the AB, one obtains a simple explanation for a more all-or-none pattern during the AB. This loss of acuity can also be seen in the temporal domain. In particular, consistent with delayed consolidation, the P3 component occurs later during the ABandwe have shown that there is increased variance in the P3's latency during the AB.
Conclusions: Loss of acuity is then a very general consequent of the AB, which can be seen in a number of ways, e.g. less strength sensitivity (more all-or-none), increased consolidation latency and increased variance in this latency.

Modelling selection and consolidation for storage in visual working memory

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Background: Consolidation is the process of transforming a fleeting perceptual representation into a durable working memory (WM) representation which is stable against new sensory inputs. The understanding of consolidation for storage in WM appears central for theories and models of attentional and conscious processing. It also appears crucial and timely to understand how selective attention operates for WM consolidation.
Aims: Given that the mechanisms for WM consolidation are still remarkably unclear, our neurocomputational modelling study will focus on simulating its plausible cortical mechanisms.
Method: A cortical model with architecture as in Dehaene et al. (2003), and with an explicit representation of neural activation and (oscillatory) phase variables, as in Seth et al. (2004), is used in the study. The model originally emphasizes parallel representation of multiple items (up to four) in a neural global workspace for conscious access, based on flexible synchronization and desynchronization patterns of distributed neural oscillatory activities.
Results: The model accounts for key experimental findings on the temporal and functional properties of consolidation for storage in (visual) WM, including set size and masking effects, and the role of selective attention, and leads to novel experimental predictions.
Conclusions: Our neurocomputational modelling study sheds light on plausible cortical mechanisms for (visual) WM consolidation, with important implications to understand consolidation for storage in WM in interplay with attentional and conscious processes.

Selection-for-action emerges in neural networks trained to learn spatial associations between stimuli and actions

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Background: The objects present in our environment evoke multiple conflicting actions at every moment. Thus, a mechanism that resolves this conflict is needed in order to avoid the production of chaotic uneffective behaviours (Neumann, 1987). A plausible candidate for such role is the selective attention (see Simione & Nolfi, 2014), capable of inhibiting the neural representations of the objects irrelevant in the ongoing context and as a consequence the actions they afford (Cisek, 2007; Tipper, 1992). Most neurocomputational models of selective attention and action selection imply the presence of lateral inhibitory circuits leading to a winner-take-all (e.g. Bundesen, Habekost, & Kyllingsbæk, 2005; Cisek, 2007; Deco & Rolls, 2004).
Aims: Our goals were (i) to describe the learning process of associations between stimuli and actions (i.e. affordances) in a neural network model, and (ii) to study how the model handle conflicts arising from the simultaneous activation of multiple actions.
Method: We trained a multi-layer deep neural network (see Hinton, 2007; Stoianov & Zorzi, 2012) to associate multiple visual-action associations. By means of the generative properties of this kind of model, we were able to study the emergent properties of the unsupervised learning process by directly observing the model regeneration of the input patterns.
Results: Our main result was the spontaneous emergence of an inhibitory mechanism aimed to solve conflicts between multiple afforded actions by directly suppressing the irrelevant visual stimuli eliciting the wrong actions for the current context.
Conclusions: Our results suggest that this inhibitory mechanism emerged as a result of the incorporation of context independent probabilistic regularities occurring between stimuli and afforded actions.

Neuromodelling based on Evolutionary Robotics: On the importance of motor control for spatial attention

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Background: The mainstream approach in modelling neuropsychological phenomena has been focused mainly in (a) reproducing their neural underpinning by neglecting the importance of having a complete sensory-motor system and (b) producing only an individual ideal computational model. Evolutionary Robotics (ER) represents an efficient way to bridge the gap between neural substrate and behaviour, by means of a sensory-motor apparatus, and a powerful tool to model a population of individual that statistically reproduce a targetphenomenon.
Aims: Left neglect refers to the inability to process incoming visual stimuli from the left side. A condition that can be tested through the

cancellation task, a test in which an individual is asked to cancel with a pen stroke a series of target stimuli. Our main aim is to replicate performance of human individual both healthy and injured by implementing bio-inspired attention networks in a neurorobot provided with a sensory-motor apparatus.
Method: In an ER experiment a population of neurorobots is randomly generated and evaluated according to performance on the cancellation task. After the first generations individuals are ranked according to their performance. The best are then replicated and mutated in order to repopulate the next generation. We ran different evolutionary experiments by varying the attention network in order to reproduce neuropsychological data.
Results: Preliminary results suggest that left neglect results from intra and interhemispheric disconnections.
Conclusions: ER allows to easily model the whole behaviour (inside and outside the brain) of a population of artificial individuals. Preliminary results show that can be used fruitfully in neuropsychological modelling.

SYMPOSIUM 11: Computing embodied architectures

Convenors: Athina Papadopoulou, Theodora Vardouli, and Cagri Zaman

[1]Department of Architecture, Massachusetts Institute of Technology, USA; [2]Design and Computation, Department of Architecture, Massachusetts Institute of Technology, USA

Background: The human aspects of space became a subject of systematic study in the 1960s and 1970s, with the establishment of environmental psychology and the phenomenological turn in architecture. Several design and research approaches developed during that periodthat took into account people's action, emotional responses, and sensory aspects in the study and design of space. These approaches led to computational frameworks for an embodied understanding and analysis of space. Bill Hillier's space syntax, Kevin Lynch's cognitive urban elements, Phillip Thiel's envirotectures, are a few examples of such efforts. Despite significant overlaps between embodied approaches inthe field of architecture and embodied approaches in field of spatial cognition, the associations between the two fields remain limited.
Aim: *Computing embodied architectures* aspires to encourage exchanges between spatial cognition methodologies, architectural research and computation, forming the ground for future cross-fertilization. The aim is to examine ways in which architectural inquiries and intuitions can contribute to spatial cognition research and, conversely, ways in which tools and techniques from cognitive science and psychology can inform architectural design decisions. More specifically, the symposium asks: What forms of embodied computational approaches could we bring today in architecture to re-engage the body when thinking of space and making space? How can the architectural perspectives inform the discourse on spatial cognition?
Approach: Taking these questions a launching pad, *computing embodied architectures* brings together contemporary research and projects that incorporate the sensory processes, the body and its movement in designing, making, and thinking about space and the built environment, while inquiring into the potentials of computational ideas and techniques for describing, understanding, or enriching the interactions of bodies in and with space.

Displaced, detached, disembodied: Perpetually connected yet [mostly] out of touch

Edith K. Ackermann

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Background: What's different nowadays, as compared to previous generations, is that most of us belong to more than one community, and no one seems to stick to any one group or place for long. Instead, we live our lives in-between, across realms (physical, virtual, digital). We travel faster farther, yet we increasingly go places without moving our physical bodies, or being mindfully engaged.
Aims: As a psychologist, I discuss how the millenials play, learn, mingle, roam, trade, settle. I seek ways for youngsters to venture off beaten paths while remaining securely attached. In working with architects, I identify ambient qualities that make room for new ways of being-in-place in a media-saturated world.
Approach: Theoretical. Experiential. Using Winnicott, Lynch, and Goodman's concepts of holding, transitional object/zone, wayfinding, place making—and insights from millennial research—I help inform the design of sense-responsive environments for lifelong learning in the digital age.
Results: To compensate for the unsettling consequences of self-inflicted or imposed displacements, people of all ages seek new equilibrium (reclaiming, reshaping bodies and territories; rethinking what to bring along, leave behind, trade along the way, wondering where's home). We also witness a proliferation of GPS-operated "smart" aps that promise to get us back into place—and to our senses—in novel ways.
Conclusions: Who we are—how we feel/think/act—depends on where (and when) we are! Dwelling into the places we traverse, however shortly, is a key to mindfulness, as defined by Ellen Langer. Without it, we set ourselves on automatic pilot. We are being transportedyet we remain un moved. We appear in person, uncommitted.

(e)Scapes (for) bridging visual-making and computing

Onur Yüce Gün

Design and Computation, Department of Architecture, Massachusetts Institute of Technology, USA

Background: Humans have long preceded computers in computation: we naturally compute via intertwined acts of active perception and bodily action. We observe, interact with and learn from places and things while we wander in scapes (Casey). Such explorative learning applies to creative design activities. Visual activities that take place in design processes are genuinely rooted in the engagements of the human body with places, environments and mediums. Neither more processing power, nor a bodiless intelligence can substitute for these interactions.
Aims: My aim is to centralize human's embodied actions and perceptions in characterization of visual activities in design. Intentionality is essential to design; it should be vigilantly preserved in the age of Computing. I introduce the Broadened Drawing-Scape, a prototype that helps bridge embodied acts of visual-making (a term that I coin to describe all visual practices that take place during the design process) and digital computing.

Method: I propose a novel model and a computational setup to bridge analog (embodied) and digital (algorithmic) modes of visual activities in design. I isolate individually hand-drawn strokes and use them as seeds to generate interactive algorithmic patterns.
Results: I use the setup in international workshops and teaching to make novel drawings via applying shape rules (Stiny) that help utilize hand-drawn traces. We draw and analyzen a series of drawings and build spatio-temporal models of drawing processes.
Conclusions: Broadened drawing-scape holds the potential to expand one's phenomenological visual design activities and help merge the explorative power of rule based algorithmic drawings with intuitional foundations of hand-drawing.

A neuropsychological perspective of spatial experience

Panos Mavros

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Background: Emotion is an intrinsic part of any spatial experience and, whether intentionally designed or serendipitous, contributes to the perceived affordances of space. Emotion is a major component of decision-making and behavior (Damasio, 1994; Lowenstein & Lerner, 2003; Pfister and Bohm, 2008), and prior research has demonstrated that low-cost neuroimaging is sensitive to psychological changes in the built environment (Mavros et al., 2012; Aspinall et al., 2014; Roe et al., 2014).
Aims: For this symposium, we will present findings from two experiments on (1) spatial decision makers and (2) the urban experience of visually impaired (VI). The first will set the discussion on the interaction between the urban qualities and pedestrian decision-making process and the latter explores differences in the spatial experiences of VI and sighted, and implications for inclusive urban design.
Method: A modified Emotiv EEG neuroimaging headset, as well as psychophysiological (skin conductance and heart-rate variability), behavioural and self-reported data were registered during 'structured' and 'open' walking protocols that maintained varied environmental exposure.
Results: Preliminary results suggest the method is sensitive to the subjective experience of individuals, e.g. highlighting locations of stress and arousal. Data analysis from VI and sighted groups suggests different perceptions and affordances of the urban environment.
Conclusions: The experiments demonstrate how urban locations elicit different emotional responses; resulting 'emotional cartographies' suggest novel opportunities for design: using visualisation for empathy and perspective-taking with different user-groups, to challenge assumptions, target or assess design interventions. The presentation will reflect on the explanatory and confounding factors, limitations and theoretical implications.

Enchanting spaces of time-past: Investigating the effects of reading metaphors on public engagement with archaeological remains

Dimitra Ntzani

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Background: Archaeological remains are often discussed as 'palimpsests', the dismantled 'manuscripts' that wait to be 'read'. Once 'deciphered' and recorded, 'storytelling' or 'narrative' approaches shape their communication. These expressions are indicative of a prevailing metaphorical model that conceptualizes archaeological remains as inscriptions. The model, a loan from memory literature, shapes both professional and public engagement with past remains.
Aims: Storytelling, the enactment of the reassembled archaeological 'script', is the last stage of the reading process, and a metonymic model that has both enhanced and constrained the design of archaeological galleries and programmes. To escape its spell (Reddy 1979), the paper examines alternative forms of engagement that reading metaphors structure and focuses on the critical readings of archaeological sites by archaeologists.
Method: The research presupposes that metaphorical models are experientially and culturally grounded (Lakoff and Johnson 1980). It employs the means of cognitive ethnography (Hutchins 2003), the micro/macro analysis of original video recordings, to examine the effects of reading metaphors on archaeological workshops managed as public engagement programmes.
Results: Comparative analysis shows that while the storytelling model presupposes a form of containment, establishes flow, and provides coherent responses to a non-enquiring audience. Archaeological readings evolve as systematically disruptive processes that anchor participants to points of interest and encourage them to explore.
Conclusions: By investigating the vices and virtues that reading models bring to the heritage domain, I propose an alternative museography; one that conceptualises public engagement not as containment in the repositories of inherited bjects, but as the puzzling navigation in the vast fields of time-past.

Motion metrics and mental maps

Paloma Gonzalez Rojas

Massachusetts Institute of Technology

Background: The measurement of motion is developed mostly in Computer Science and Transport Engineering; Seer et al., in "Kinetics and Human Kinetics" exposes most of the techniques for it. K. Schechtner et al., in "Understanding Walking Behavior" exposes our unconscious spatio-temporal behavior, analyzed in Urban Analysis. However, correlating motion and spatial features is, to the best of my knowledge, unprecedented. Robert F. Port and Timothy Van Gelder in "Mind as Motion" backgrounds dynamic cognition and spatial mental maps, supporting the linkage with motion.
Aims: This study focuses in empirical research about people's motion in relations with space, by building a metric to measure it, and compute a system of parametric rules correlating spatial features and motion. The study attempts to present a framework for embodied spatial cognition studies along with speculating over constructing mental maps, both developments built through motion parameters.

Method: Collect data from people's motion in space in real-world conditions in several countries, for extended periods of time. Position and skeleton data is collected with Kinect sensor, and 3D actions with video camera. The position data is analyzed as trajectories in 2D, obtaining *Speed*, *Time Spent* and the *Shape of Trajectory*. *Gesture* statistics are obtained from video. Data is processed with computation.
Results: The hypothesis is that peoplés motion adapts towards architecture features, which is validated by the results. A system of rules correlating motion parameters with spacial features volumetric configuration, based on peoplés motion statistics in different architecture settings is the deliverable of the study.
Conclusions: Motion entails embodied spatial cognition, reflecting learning from low level actions for future choices. Different spatial settings and cultures generate different motion behaviors. Spatial mental maps incorporate bits from parametric rules from our bodies, bridging experience with motion.

SYMPOSIUM 12: Individual differences in wayfinding

Convenors: Ineke van der Ham[1], Jan Wiener[2], and Tobias Meilinger[3]

[1]Utrecht University, The Netherlands; [2]Bournemouth University, UK; [3]Max Planck Institute for Biological Cybernetics, Tübingen, Germany

Background: Wayfinding concerns the ability to get from A to B, one of the most fundamental behavioural problems we face on a daily basis. Typically, humans show large variation in wayfinding performance as well as in the strategies employed, even within relatively homogenous samples such as university students.
Aim: This symposium aims to further our understanding of human wayfinding behavior, by investigating the factors that contribute to such individual differences in performance and strategy selection.
Approach: We address individual differences in wayfinding behavior from a number of different viewpoints: First, we will focus on the effect of age to see how wayfinding performance and strategy selection develops in young age and how it is affected by typical and atypical ageing. Secondly, we will look at effects of expertise, specifically how orienteering experts and novices differ in their spatial abilities, spatial styles and environment representations. Finally, we will report on individual differences in the ability to correctly distinguish left from right and in the strategies used during the acquisition of environmental knowledge. Bringing together wayfinding research from these different areas will allow us to highlight some of the factors that contribute to individual differences in wayfinding behaviour.

Individual differences in the development of spatial frames of reference

Marko Nardini and James Negen

Durham University, UK

Background: It is not clear how or why children transition from egocentric (self-centred) to allocentric (world-centred) spatial frames of reference in direct search tasks. Many studies have documented this shift, but have not looked closely at the transitional stages.
Aims: We aimed to understand spatial behaviour during a childhood transition from egocentric to allocentric spatial recall. Are these two kinds of encoding combined or used in competition, and are individual children consistent in which encoding they use?
Method: Using Bayesian model comparison, we carried out a detailed new analysis of transitional spatial search patterns at 4 years in Nardini et al., Cognition (2006). We asked what kind of combination or mixture of egocentric and allocentric representations is shown by the group as a whole, and by individual participants.
Results: The model that best explained the data was one showing a shift from egocentric to allocentric representations at 4 years—choosing either an egocentric or allocentric response, not pointing in the middle. This explains the previous group-level analyses, which found the average error at chance. However, at the level of individuals, responses were mixed, indicating that first learning allocentric coding does not guarantee its reliable use.
Conclusions: Modelling distributions of search responses shows us how allocentric and egocentric reasoning compete at 4 years in direct search. In new studies in development, we are dissociating reference frames and modelling responses and individual differences in a naturalistic search task in immersive virtual reality.

Do you still know how to get there? Effects of cognitive ageing on route memory

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Background and Aims: Research into the effects of cognitive ageing on route navigation usually focuses on differences in learning performance. In contrast, we were interested in age-related differences in route knowledge after successfully learning routes. Moreover, we compared performance of typically ageing older participants who performed high (27–30) or lower (23–26) on the MoCA (the Montreal Cognitive Assessment).
Method: A young and two older (high/low MoCA) participants group were trained until they could correctly recall short routes. We then tested their abilities to recall the sequence in which landmarks were encountered (landmark sequence task), to recall the sequence of turns (verbal directions task), to indicate the direction of turn at each landmark (landmark direction task), and to identify the learned routes among distractor routes from a top-down map perspective (perspective shift task).
Results and Conclusion: The results reveal a number of age-related performance differences in route learning and route knowledge. However, the most interesting findings concern the two older participant groups: While their learning performance as well as their performance on the landmark sequence and verbal direction tasks was similar, the participant group with the lower MoCA scores was selectively impaired in the perspective shift task and the landmark direction task. These findings indicate that subclinical ageing-related changes in cognitive abilities affect different aspects of route knowledge differentially.

Learning through "orienteering": Comparing the visuospatial abilities and environment representations of individuals with and without orienteering experience

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Background: Orienteering sports practitioners develop cognitive skills and strategies that enable them to approach their task efficiently, i.e. using map and compass to navigate from place to place (Millet et al., 2010). Little is known about whether practicing orienteering improves an individual's spatial abilities (Cornoldi et al., 2003), spatial preferences, and efficacy in everyday movements.
Aims: This study investigated whether practicing orienteering furthers the development of good spatial skills, spatial preferences and efficacy in everyday movements.
Method: Three groups of participants selected by years of orienteering experience (OE)—18 controls (OE = 0; age: 42.33), 18 beginners (OE = 4.6 age: 24.65); and 18 experts (OE = 21.56; age: 45.89)—completed several visuospatial tasks and questionnaires (De Beni et al., 2014), and a questionnaire on their movements and wayfinding methods. They also studied a map and their recall was tested with map drawing and aligned and counter-aligned pointing tasks.
Results: By comparison with controls and beginners, experts: (i) were more accurate in visuospatial tasks; (ii) had a stronger self-assessed sense of direction and preference for allocentric strategies; (iii) were more accurate in counter-aligned pointing at landmarks on a map (and as accurate as for aligned pointing); and (iv) scored higher for using maps as everyday navigation aids (and lower for using satnavs or asking for directions)-, and lower for getting lost in unfamiliar places.
Conclusions: This study showed that extended practice with orienteering improves spatial competences (abilities and preferences) and everyday movement habits by comparison with little or no practice.

Left right confusion: Effects of strategy

Ineke J. M. van der Ham and Haike E. van Stralen

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Background: Identifying left and right in a spatial environment is an important element in wayfinding. However, in contract to above/below and front/back, left and right are more difficult to distinguish. Moreover, there is substantial variation between individuals in the ability to correctly identify left and right. Observations suggest that there is also large variation in the type of strategy employed to identify left and right. The majority of participants indicate to use parts of their body (typically hands) to perform such a task.
Aims: The aim of this study was to examine whether the extent of left right confusion (LRC) in healthy participants can be attributed to the use of body representations.
Method: In two separate experiments, participants verbally responded 'left' or 'right' to a stick figure presented to them, with one hand highlighted. The figures would appear in different configurations and the participants was seated in different positions (hands crossed or not, hands visible or not)
Results: Results indicate no direct effect of figure configuration or participants' position on LRC. However, figure configuration and participants' position interact significantly. Gender and handedness do not affect level of LRC.
Conclusions: LRC is in part determined by body representation, but at a subtle level, depending on the precise task at hand.

The acquisition of survey knowledge through navigation

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Background: Survey estimates such as pointing, straight line distance estimation, or finding novel shortcuts to distant locations are common tasks. Although involved reference frames and brain areas were examined the underlying processing is widely unknown.
Aims: We examined how experience influences the development of survey knowledge.
Method: Participants learned a simple multi-corridor layout by walking forwards and backwards through a virtual environment. Throughout learning, participants were repeatedly asked to perform in pairwise pointing from each turn between segments to each other turn.
Results and Conclusions: Pointing latency increased with pointing distance and decreased with pointing experience, but not with learning experience. From this observation, we conclude that participants did not access an encoded representation when performing survey tasks, but instead performed an on-the-fly construction of the estimates which was quicker for nearby goals and became faster with repeated construction, but not with learning of the underlying elements. This could involve mental travel to the target location, or the incremental construction of a mental model of non-visible object locations. Furthermore, participants made systematic errors in pointing, for example, mixed up turns or forgot segments. Modelling of underlying representations based on different error sources all suggest that participants did not create one unified representation when internally constructing the experimental environment, but instead constructed aunique representation at least for each orientation the environment was navigated. We do not find indications that this separation changed with experience or other individual differences.

SYMPOSIUM 13: "Fictive motion" and situated cognition: How to resolve the tension?

Convenors: Jordan Zlatev[1] and Benjamin Fagard[2]

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Background: Situated cognition focuses on *presence*, and thus on the centrality of perception and bodily interaction. In part, this overlaps with the perspective of embodied cognition, but there is also a tension. In particular, the popular notion of *mental simulation* (e.g. Barsalou 2009) implies at least a degree of distancing: you need not "simulate" what is present, but rather what is absent. A phenomenon where this tension comes to the fore is the (apparently universal) tendency to use motion verbs (and related constructions) to describe static situations such as (1) *The road goes through the forest* and (2) *The mountain range goes from the Artic to the Black Sea*. Indeed, the most popular term for this is "fictive motion" (e.g. Talmy 2000), and the most common explanation is that it involves the simulation of motion (Matlock 2010). However, from a phenomenological perspective, one may distinguish at least three different structures of experience that motivate the use of motion expressions in the description of static scenes: (i) the active nature of perception, (ii) the correlational nature of intentionality and, (iii) re-enactive imagination (Blomberg and Zlatev 2013). With respect to (i), the perception of entities that *afford* (human) motion, and with respect to (ii) entities that allow for visual scanning are predicted to elicit motion verb descriptions. These are experiences of *non-actual* rather than "fictive" motion. Only in the case of (iii), when the speaker actively imagines a protagonist moving along the entity, or the entity itself moving, is there not just presentation but re-presentation (Gallagher and Zahavi 2008).
Aim: To test the analysis of non-actual motion as a predominantly presentational phenomenon, Blomberg (2014) developed an elicitation tool involving a balanced set of pictures showing static, linearly extended figures like roads and fences, from either a first-person perspective (1 pp) or third-person perspective (3 pp). Speakers of Swedish, French and Thai all produced most non-actual motion (NAM) descriptions in the condition afford + 1 pp, providing evidence for the proposed analysis. However, substantial inter-individual variation demonstrated the need for further research. The goal of the symposium is to stimulate such research, and continue the debate on the (in) adequacy of concepts such as "mental simulation", on the proper analysis of non-actual motion and more generally on the relations between situated and embodied cognition.
Approach: Participants in the symposium consider experimental evidence from additional languages, including Italian, German, Finnish, and Swedish Sign Language. In addition to experimental evidence, some of the presentations consider synchronic and diachronic linguistic corpora, as evidence of general language use and language change (Fagard 2010).

Eliciting different perspectives upon fictive motion: Evidence from Finnish

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Background: In Finnish, the linguistic means dedicated to encoding actual motion are also used to encode fictive motion, but in the latter case the relevant constructions are comparatively simple and basic. Nevertheless, they allow a great deal of variation in how the stimuli are described. This is due in part to the resources of Finnish (in particular, a huge number of motion verbs), and in part to the variegated nature of the stimuli employed. Some of the variation calls into the question the figure versus ground asymmetry, which is generally taken for granted in the cognitive–linguistic literature.
Aims: All these types of variation will be discussed more in detail, concentrating on expressions of boundary crossing (=movement into and/or from an enclosure), typical context for use in (dynamic) route versus (static) scene descriptions, stimulus complexity, event segmentation (=level of granularity), and differences in scene coherence (=unity vs. fragmentation).
Method: Elicitation and corpus analysis. The data consists of descriptions of video clips (Ishibashi, Kopecka &Vuillermet 2006) and a picture set designed by Blomberg (2014). There are 50 participants, with the median age of 25 years.
Results: The hypothesis was that stimuli experienced by Finnish speakers vary depending on whether or not they allow a fictive-motion interpretation and, if so, whether they are conducive to be viewed from the 3rd person perspective or from the 1st person perspective. In connection with relatively simple and coherent stimuli this indeed proved to be the case, but no longer in connection with more complex stimuli.

Does the road go up the mountain? Fictive motion between linguistic conventions and cognitive motivations

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Background: Fictive motion (FM) characterizes the use of dynamic expressions (motion verbs) to describe static scenes (The road goes up the mountain). Two competing explanations have been proposed to account for this phenomenon (crucial in terms of cognitive motivations for language use): enactive perception (Talmy 2000) versus visual scanning (Matlock 2004).
Aims: Test competing explanations; identify language-specific constraints.
Methods: We compare FM strategies in Romance (French/Italian), Germanic (German/English) and Slavic (Serbian/Polish) through (i) an experimental set-up: 4 languages, 40 participants (students aged 20–25); 2 training + 24 target pictures + 12 distractors, 2 × 2 design (scanning vs. enactive perception × 'paths' affording human motion vs. non-affording); (ii) a corpus approach: translation corpus, 100 occurrences/language.

Results: The experiment yielded significant differences for motion-affordance versus no motion-affordance ($\chi^2 = 231$, $p < .001$), for all four languages. Significant differences between languages included mean frequency of FM expressions (from 30 % in Italian to 50 % in German), but not (non-)expression for any given picture type. The corpus study showed low frequency of FM across languages, except for Talmy's sensory and radiation paths (frequent + high translation ratio). Major difference between languages: unlike enactive perception, scanning presented interesting variations, with posture verbs in Serbian and English versus FM elsewhere (e.g. for inanimates: The trunk lay on the ground, vs. French Le tronc rampait ["crawled"] sur le sol).
Conclusion: The importance of enactive perception could explain both the universality of FM and the fact that language-specific conventions appear mainly in very specific contexts—the ones furthest from enaction.

Non-actual motion: Phenomenological analysis and linguistic evidence

Johan Blomberg[1] and Jordan Zlatev[2]

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Background: Sentences where motion verbs are used to describe static situations, e.g. The highway crawls to the city have been used as indications for human cognition as geared toward dynamism and change (Talmy 2000; Langacker 1990). Different concepts are used in the literature, e.g. fictive motion, subjective motion and abstract motion. We show that these accounts are analytically unclear but can be phenomenologically re-interpreted as different possible experiential motivations.
Aims: We present a framework where previous accounts are accommodated without prioritizing either of them, which points to the multifaceted character of the phenomenon. To highlight this, we propose the concept non-actual motion (NAM). We argue this is more compatible with the situated cognition approach than explanations such as "mental simulation" (e.g. Matlock 2004).
Method: Through phenomenological analyses we show that several motivations contribute to the use and conventionalization of NAM-sentences (Blomberg 2014). We investigate the expression of NAM by means of a picture-based elicitation task with speakers of Swedish, French and Thai, regarded as examples of the three language types in motion typology. Pictures represent figures that either afford human motion or do notafford human motion (±afford); crossed with this, the figure extended either across the picture from a third-person perspective (3 pp) or from a first-person perspective (1 pp).
Results: All picture types elicited NAM-sentences with the combination [+afford, 1 pp] producing most NAM-sentences in all three languages. NAM-expressions also conform to language-specific patterns for the expression of actual motion.
Conclusions: NAM shows interaction between pre-linguistic motivations and language-specific conventions.

The expression of non-actual motion in Swedish sign language

Jonas Ekström, Johan Blomberg and Jordan Zlatev

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Background: Non-actual motion (NAM) sentences appear to be motivated by three complementary experiential processes: enactive perception, mental scanning, and imagination (Blomberg and Zlatev 2013). But how does NAM manifest itself when 3-D space and motion are used in the actual expression of motion events, as in signed languages? Would the same motivations apply and would they result in a more fine-grained expression? Swedish sign language (SSL) commonly expresses spatial meanings through so-called depicting verbs (Liddell 2003). These display the relative position of figure and landmark objects, the trajectory of motion or the shape of spatially extended objects.
Aims: We explore the degree to which native SSL speakers use depicting verbs and other expressions of motion in the context of NAM-sentences. We then compare our results with previous studies of spoken languages.
Method: The stimuli developed by Blomberg (2014) were used for obtaining descriptions from six native speakers of NAM. The stimuli contained target pictures (displaying extended figures, e.g. roads) as well as control pictures (displaying less extended figures, e.g. trees). Descriptions were video-recorded and analysed with respect to the map ping between expression and content.
Results: Dynamic depicting verbs (with a moving hand representing a trajectory) were used in nearly all elicitations from the target stimuli, while controls gave rise to more static descriptions. The descriptions were semantically richer than similar descriptions in spoken languages. The results support the role of the three motivations, though the distributions of NAM-expressions for the conditions ± afford and 1st/3rd person perspective differed from spoken languages.

SYMPOSIUM 14: Spatial language and spatial cognition

Convenor: Dedre Gentner

Northwestern University, USA

Background: Spatial language provides speakers with ways to learn and think about space.
Aim: This symposium presents developmental and cross-linguistic work on how spatial language connects with spatial cognition. Taken together, they suggest that spatial language is not simply a reflection of spatial cognition, but instead is an important influence in shaping spatial cognition.
Approach: Gentner et al. use experimental studies in a museum and in the laboratory to show that spatial analogical comparison can help children learn an important spatial principle, and that spatial language can enhance this learning effect. Majid et al. use cross-linguistic comparison of how language varies across different semantic domains; they find that spatial language varies more across languages than does language for other domains such as color or body parts—showing that spatial language is not solely determined by the world. Levine et al. uses longitudinal methods to trace early language and

cognition. They find that early use of spatial language predicts later spatial ability, even on nonlinguistic tasks. They further find that boys receive more complex spatial language than girls. The causes and implications of this difference are explored.

Spatial language and spatial comparison combine to support children's learning

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Background: Prior evidence suggests that analogical comparison supports spatial learning.
Aims: Can analogical comparison help children learn to use diagonal braces in construction, and can spatial language augment analogical comparison.
Method: Study 1 (at the Chicago Children's Museum) had three age groups: 6, 7, and 8 years, and three between-subject conditions: No training, high-alignable pairs, and low-alignable pairs. Children in the HA and LA groups interacted with two juxtaposed model buildings—one with a brace (stable), one without (wobbly). They then engaged in (a) free-form Construction and (b) a targeted Repair task. Study 2 was conducted at Northwestern University. The participants were 6-year-old children. The method was the same as in the Museum study, except that for half the children we noted that the more stable structure had a brace (without pointingto the brace). Our purpose was to discover whether younger learners could benefit from the comparison experience, and whether having spatial language would improve performance.
Results: Among the two oldest groups, the HA and LA groups used more diagonals than the NT group; and, as predicted, the HA group performed best. However, the 6-year-olds did not show a gain from the analogical experience. In Study 2, wefound that 6-year-olds could gain from the comparison experience in a quieter lab setting; and that using the spatial term 'brace' further improved children's performance. We also replicated the finding that children learn better from high-alignment than from low-alignment comparisons.
Conclusions: Analogical comparison and spatial language support rapid spatial learning.

Spatial relations in closely related languages

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Background: According to many linguists, meanings expressed in grammaticised expressions, such as spatial prepositions, are more likely to be similar across languages than terms expressed in open class lexical items (cf. Talmy, 1983). On the other hand, following Gentner (1981), we might predict more variation in the meanings of prepositions than nouns. This is because domains such as containers are expressed as concrete nouns, and therefore predicted to be "given by the world"; whereas relational systems, such as prepositions, are said to be constructed by language.
Aims: We tested which semantic domains showed most variation, thereby pitting the Talmyan and Gentnerian predictions against each other.
Method: We tested the hypotheses by comparing12 Germanic languages. Naming data from at least 20 speakers of each language were collected for spatial relations, containers, colours, and body parts. The naming data were converted into similarity matrices and subjected to multivariate statistics.
Results: Spatial relations expressed in prepositions had the most variation in meaning, far more than containers, colours or body parts. We then asked what underlies the variation found across domains. Is it the result of geographic proximity or language relatedness? The answer depends on the domain examined: similarities in spatial relations correlated with language-relatedness, but similarities in colour naming largely correlated with geographic distance between languages.
Conclusions: The results are more consistent with Gentner's predictions, than Talmy's. Spatial relations show more variation than other semantic domains, and are more strongly shaped by language history.

Variations in parents' spatial language predict children's spatial skill

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Background: Prior evidence suggests that cross-linguistic differences in the lexicalization of spatial relations predict differences in spatial thinking.
Aims: Do variations in the spatial language young English-speaking children hear predict differences in spatial thinking? Are there gender differences in spatial language input?
Method: Study 1: We videotaped naturalistic parent–child interactions for 90 min, every 4 months, in 58 children between child ages 14 and 46 months, coding parent and child language, including spatial words. Children's spatial skill was assessed at 54 months. Study 2: From the same longitudinal study we coded parent and child language during naturalistic puzzle play interactions. Study 3: In a laboratory study, we assessed children's puzzle assembly skill and then videotaped parent–child dyads playing with an easy and difficult puzzle, coding all parent and child language, including spatial words.
Results: Children whose parents used more spatial words performed better on the spatial visualization task at 54 months, controlling for overall language input. Further, parents used more spatial language with boys than girls during naturalistic puzzle play, possibly because boys played with harder puzzles. In the lab study, where we controlled for puzzle difficulty, parents still provided more spatial

language to boys. Further, parents modulated their spatial language use to the child's puzzle skill with boys but not girls.
Conclusions: Differences in spatial language input may contribute to differences in spatial skill. The use of spatial language during spatial play may play a role in reported gender differences in the spatial thinking.

SYMPOSIUM 15: Architectural psychology and inhabited spaces: A multidisciplinary approach to improve quality of life

Convenor: Francesca Pazzaglia

Department of General Psychology, University of Padua, Italy

Background: Architectural psychology examines transactions between individuals andtheir built environments andincludes theory, research, and practice aimed atimproving humanrelations with the environment and making the built environment more humane (Gifford, 2014). Psychological implications of architectureinvolvemany fields (education, health, work, leisure, etc.) and can contribute to the improvement of life. Nevertheless, there is surprisingly little research on it and even less adopts a multidisciplinary approach.
Aim: The symposium aims to fill this gap. Researchers from different backgrounds (architectures, engineers, social and cognitive psychologists) discuss and share their ideas on how architecture and psychology could interact to improve human quality of life.
Approach: The impact of architectural design on human behavior and well-being is examined in the different contexts of urban environments, infrastructures, and residences. The interventions show the importance of considering cognitive and affective variables in the design of space within a multidisciplinary approach, in order to address the many challenges of our time. Several examples are given on how interactions between architectural design and psychology can positively modify the perception of a place and, consequently, its use and meaning.

New challenges for architectural psychology

Francesca Pazzaglia

Department of General Psychology, University of Padua, Italy

Background: Architectural psychology (AP) is a branch of environmental psychology that investigates the psychological processes of the interaction between human beings and their environment, with special attention given to the built physical environment. Spatial representation and orientation behavior, quality of life and urban environments, perceived well-being in healthcare environments, and landscape perception are relevant topics in AP.
Aims: The aim is to provide an updated review of the literature on these themes.
Method and Results: Research published by academic journals in the last 10 years is analysed and summarized.
Conclusions: Theories (with relative strengths and weaknesses), applications and future developments are discussed.

Urban environment and well-being

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Background: Architectural and environmental psychology literature show the importance of urban design in provoking stress feelings or enhancing wellbeing and quality of life. In particular, perceived quality of design and broader environmental features at the urban level seem to play a role in eliciting positive psychological molar responses, such as place attachment and satisfaction.
Aims: The aim of this contribution is to show a critical review of the main results obtained in a set of cross-cultural studies on perceived quality of urban features at the neighbourhood level.
Method: An array of studies had been carried out in different countries. The questionnaires included the extended or the short version of the 11 scales measuring Perceived Residential Environment Quality Indicators (PREQIs) and of the scale measuring Neighbourhood Attachment (NA). In some of the surveys, a scale for measuring Residential Satisfaction (RS) and a set of items tapping Walkability (W) patterns were also used. Multivariate analyses were applied in each study.
Results: Both versions of PREQIs and NA showed a similar factorial structure and a good or acceptable reliability across different geo-cultural contexts. All aspects covered by PREQIs (i.e., architectural, social, functional, and contextual) emerged as associated to molar psychological responses (NA, RS, W).
Conclusions: The use of tools such as PREQIs and NA in the urban planning domain can promote a "user-centered" vision. The improvement of the environmental and design quality of our cities from the urban residents' point of view should indeed fostertheir satisfaction and wellbeing.

Footbridges as elements for urban rehabilitation and renewal

Enzo Siviero

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Background: When a bridge is designed, we start from the basis that it is visible in all its parts. In actual fact, due to the position and speed of the observer, the bridge can be perceived partially and for a limited period of time. The area and time within which the bridge can be perceived are entities that can be quantified and, therefore, measured (Perceptive quantity). Footbridges make it possible to create closer relations between the user and the work, as walking on them implies moving at a slower pace.
Aims: The aim is to understand how the perception of a footbridge can prove to be an effective knowledge base for planning, and an instrument for Urban Rehabilitation.
Method: This paper will explore the ways in which existing footbridges can change the perception and the meaning of a place. It will

also investigate the connection between the design of footbridges and planning tools.
Results: Italian legislation distinguishes between two forms of quality: internal, also referred to as technical-performance and, more general, work function apply; and external, namely connected with the social-economic, environmental and landscape impact of the work. The results involve the study of the effects that a footbridge may have on the urban landscape, taking the relationship between the internal and external quality of the work into consideration.
Conclusions: As regards the insertion of footbridges in the landscape, the implementation of perceptual and multidisciplinary criteria allows us to use quality design tools that are able to rehabilitate the place.

Bridges in the landscape: Qualitative aspects

Michele Culatti

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Background: The poor architectural quality of the infrastructure tends to degrade the landscape, generating "non-places". Moreover, the "perception" is not used in sufficiently great depth as a tool for interpretation and a design criterion for the inclusion of the bridges in the landscape.
Aims: The aim is to use the concept of perception as a criterion for a critical interpretation of bridges and a design criterion for better inclusion in the landscape.
Method: In the study of the relationship between bridges and landscape, perception comes into place both as a cognitive process and an anthropological phenomenon. According to a cognitive theory, perception implies grasping something in its characteristics of form, function and meaning; according to an anthropological theory, perception implies feeling being in a space, defining it in its boundaries, density and directionality and using it in its parts. This approach provides for the extrapolation of the parameters belonging to these perceptive phenomena to use them as critical interpretation criteria of bridges.
Results: Indicate a cultural route by which to structure qualitative–quantitative indicators to determine the relationship between a work and the landscape, based on the exploration of the perceptive dynamics. Increase, during the design stage, control over the effective perception of bridges, seeking to envisage the impact on the landscape but striving to also interpret the possible integrations with the landscape itself.
Conclusions: The application of perceptive criteria, deriving from various different disciplines, enables us to use qualitative design tools that can improve the relationship between the work and the landscape.

Reducing spatial disorientation for older adults with memory difficulties: Towards dementia-friendly architecture

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Background: Older adults and those experiencing dementia often experience marked deficits in their orientation and navigation abilities; this is reported in neuropsychological studies as well as through qualitative interviews. However, the majority of these interviews only involve home-staff and carers. Very few interviews are conducted with the person experiencing memory difficulties themselves. In order to know how to adjust environments to compensate for decreasing orientation abilities, voice must be given to older adults and those experiencing dementia (Jonas-Simpson, 2003).
Aims: This exploratory research aims to understand the navigational experiences older adults with memory difficulties encounter whilst living in a communal living environment. One key aim is to highlight common themes and patterns in participants' experiences of orientation within their living environment.
Method: In-depth semi-structured interviews with retirement-home residents who experience memory complaints and Alzheimer's type dementia were conducted. Questions began broad (e.g. by asking them to describe their experiences of navigating in their living environment), before considering specific navigation difficulties.
Results: Using a thematic analysis, key themes that were reported by the participants were identified. Specifically, environmental cues that both supported and hindered orientation were reported. In addition, the duration of residence and the positioning of residents' independent apartments played a key role in the extent to which disorientation was experienced.
Conclusions: The themes discovered through these interviews are discussed in relation to existing dementia and navigation research as well as dementia friendly design guidelines.

SYMPOSIUM 16: The quiet eye as an objective measure of situated and/or spatial cognition

Convenor: Joan Vickers

University of Calgary, Canada

Background: The quiet eye (QE) is a perceptual-motor characteristic of elite performance found in sport, medical and law enforcement tasks. An earlier and longer QE duration is an expertise characteristic of focus prior to and during a critical movement. Theoretically, the QE represents the time needed to organize the neural networks underlying the control of the movement. QE training programs help trainees adopt an expert's QE leading to better motor performance.
Aim: In this symposium we discuss the quiet eye (QE) within the two themes of the conference: situated and spatial cognition. Joan Vickers will provide a short introduction to the QE, followed by QE studies in surgery, aiming at a far target, illusions, archery and golf.
Approach: Joe Causer et al. presents three QE studies in surgical knot tying in which residents were taught how to adopt the QE characteristics of expert surgeons. Residents who maintained a long duration QE on a specific location in tissue were rated higher in performance and were faster in tying the knots, illustrating the importance of focusing on specific spatial targets to the exclusion of movement of the hands. Andre Klostermann et al. shows the performance-enhancing effects of experimentally manipulated QE durations as a function of both target position predictability and target visibility. When the QE duration was truncated performance declined, thus supporting the assumption that the QE phenomenon supports the processes of sensorimotor integration. Mark Wilson et al. explore the coupling between perception and action by examining the influence of illusions on aiming performance in a ball-rolling task. Participants were less accurate, and had shorter QE durations when targets were perceptually

smaller. Claudia Gonzalez et al. shed light on the underlying mechanisms of the QE using a field based archery task and a computer based archery simulation during low and high "noise" conditions. Distinct QE behaviours were found across expertise levels, with novices exhibiting shorter QE durations compared to experts in the high noise compared to the low noise task conditions. Sam Vine et al. present a study in which eye-blinks are measured and their role relative to QE duration and process of attentional disengagement explored in a golf-putting task. Blinks play an active role in the release of attention from external stimuli, and a shift of attention to internal processing.

Developing spatial cognition through the identification and training of visual attention in surgical skills

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Background: Surgery is a highly complex, dynamic and unpredictable environment, with critical decisions and actions being implemented under high levels of anxiety. Despite this, relatively little is known about how simple surgical tasks, such as knot-tying, are most effectively accomplished, and the best ways to teach these skills. Traditional methods of training surgical skills focus on the technical, instructional-based techniques, neglecting the development of attention and spatial cognition. One method of measuring spatial cognition is through eye movements.
Aims: To understand expert spatial cognition in surgery, we measured eye and hand movement of expert and less-expert surgeons whilst performing a knot-tying procedure.
Method: Our data showed a longer final fixation duration on the target location (quiet eye; QE) for experts, which enables a more effective knot to be tied. This technique enables surgeons to process information relating to tension and placement, and focuses attention on the task. Subsequently, we designed a QE knot tying training programme for surgical residents, with another group of residents following the traditional technical training route.
Results: Our data showed that orientating attention to the knot-tying location for longer enabled more effective knots to be tied, but also a quicker movement time. Residents in the QE training group also managed to maintain performance in a more complex transfer task, and high-anxiety scenario.
Conclusions: These data suggest that training QE may enable more effective learning of spatial cognition in surgical skills. This has implications for medical education, potentially expediting skill development and could also lead to a reduction in surgical errors.

The quiet eye and information processing: Facilitation of stimulus identification and response selection

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Background: A prerequisite for high performance in motor tasks is the acquisition of egocentric sensory information that must be translated into motor actions. A phenomenon that supports this process is the quiet eye (QE) defined as long final fixation before movement initiation. It is assumed that the QE facilitates information processing, particularly regarding movement parameterization.
Aims: The question remains whether this facilitation also holds for the information-processing stage of response selection and—related to perception crucial—stage of stimulus identification.
Method: In two experiments with sport science students, performance-enhancing effects of experimentally manipulated QE durations were tested as a function of target position predictability and target visibility, thereby selectively manipulating response selection and stimulus identification demands, respectively.
Results: The results support the hypothesis of facilitated information processing through long QE durations since in both experiments performance-enhancing effects of long QE durations were found under increased processing demands only. In Experiment 1, QE duration affected performance only if the target position was not predictable and positional information had to be processed over the QE period. In Experiment 2, in a full versus no target visibility comparison with saccades to the upcoming target position induced by flicker cues, the functionality of a long QE duration depended on the visual stimulus identification period as soon as the interval falls below a certain threshold.
Conclusions: The results corroborate earlier findings that QE efficiency depends on demands put on the visuomotor system, thereby furthering the assumption that the phenomenon supports the processes of sensorimotor integration.

"Use your illusion II": Influencing spatial cognition and action

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Background: Wood et al. (2013) proposed a three-stage process of bias in far aiming tasks to explain the effect of illusions on golf putting performance: Illusory context biases perceptual processes, which in turn bias subsequent attentional control related to movement planning (quiet eye; Vickers, 1996), which in turn biases motor performance.
Aims: The current study sought to replicate and extend this model using a new task and by including an additional illusion.
Method: Sports science students (mean age 20.7, SD = 1.7 years) volunteered to take part in the study. Ebbinghaus and Delboeuf illusions were projected onto a putting green (central target = 5 cm) in 4 blocks of 10 trials. Participants wore an ASL mobile eye gaze registration system and rolled golf balls from 10 ft (1.8 m) to targets and were prevented from seeing the outcome of their attempt. Radial error (cm), quiet eye duration (QED; ms), and perceived hole size (PHS; cm) were subjected to 2 × 2 RM ANOVA.
Results: Significant main effects were found for both illusion type and size across all three variables (F's >5.58, p's <.024). While both types of illusion were successful in biasing PHS (5.4 vs. 6.2 cm), QED (848 vs. 903 ms) and RE (34.9 vs. 31.7 cm), this effect was greater in the Delboeuf illusion.
Conclusions: The results add support to Wood et al.'s model but also suggest that distraction effects of the Ebbinghaus illusion might also partially explain previous findings.

Quiet eye duration in expert and novice archers: A task complexity dichotomy

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Background: Quiet eye behaviour is found in many sporting tasks that require accurate aiming and longer quiet eye durations (QED) are characteristic of experts compared to non-experts.
Aims: Our aim was to investigate task complexity effects on QED and examine distinct cognitive programming loads during archery aiming tasks.
Methods: Ten expert and 13 novice archers completed a field-shooting task and eye movements were measured using electrooculography (EOG), which validated skill-based QED effects. Participants then took part in a computer-based archery task and shooting was controlled using a joystick to move the crosshairs. Task complexity was manipulated by implementing two levels (high and low) of random movement (noise) into the crosshair position when aiming at the target. Since expertise QED effects in the fieldwere validated with EOGs, eye movements for the computer task were measured using EOG and ASL Mobile Eye gaze-tracker.
Results: Both experts and novices showed reduced accuracy in the high-noise blocks. EOG results showed longer QED in experts compared to novices in the high-noise condition. The experts' longer QED may suggest superior processing efficiency and/or reduced distractor-effects of the joystick's movement. A linear relationship between accuracy and QED was only observed during high-noise conditions. ASL results revealed that both groups had longer QED in the high-noise task.
Conclusions: The longer QED of the groups did not result in better performance, but may reflect increased processing demands of the more complex task. Results further identified task complexity effects in QED and demonstrate the importance of online controlmechanism during the QE programming period.

Blink and you might miss it: Blinks may reflect an inward shift of attention, during the performance of a skill

Sam Vine, Rosanna Walters-Symons and Mark Wilson

University of Exeter, United Kingdom

Background: The relationship between the quiet eye (QE; Vickers 1996) and performance is well established, with longer QE durations associated with both expertise and accuracy. Blinks are involved in the process of attentional disengagement through the activation of the default-mode network and deactivation of the dorsal attention network (Nakano et al., 2012). Blinks play an active role in the release of attention from external stimuli to internal processes (Nakano et al., 2010).
Aims: Blinks occurring throughout the performance of a skill may indicate shifts in focus of attention, and the neural networks active during the QE. We predict that QE and blink metrics (e.g. timing and number of blinks), during the alignment and execution phase of a skill may be a stronger predictor of performance accuracy than QE alone.
Method: We aim to examine this contention in a golf putting task using a 2 proficiency (expert vs. novice) × 2 outcome (hit vs. miss) design. Participants will putt from 10 ft to a standard size hole; blinks will be recorded using a high frequency camera mounted on the participant's head.
Results: We hypothesise that experts and more successful performance will be characterised by both longer QE durations and fewer and more optimally timed blinks. The performance data captured to date confirm the expert and novice distinction (experts were more accurate than novices).
Conclusions: If findings are as expected the study will add to our understanding of the processes that underpin the QE and help to qualify some of the current findings in the literature.

SYMPOSIUM 17: Multimodal perspectives on spatial cognition

Convenor: Kenneth D. Forbus

Northwestern University, USA

Background: People interact with space via multiple modalities, including vision, language, and sketching.
Aim: The goal of this symposium is to explore how the modalities we use influence spatial cognition. One theme is that qualitative representations may serve an integrative role.
Approach: This symposium brings together multiple disciplines (AI, Psychology, and Linguistics) to explore this topic.

Learning about space, time and activities from a robot perspective

Anthony G. Cohn

University of Leeds, UK

Aim: This talk will show how qualitative representations can be used to represent knowledge about activities and how activity representations can be learned.
Approach: Video data is abstracted to create a qualitative spatio-temporal representation which is forms the basis for learning symbolic qualitative models of activity, whether through supervised or unsupervised methods.
Results: Performance will be illustrated on a number of domains, using a variety of qualitative spatio-temporal representations and learning methods, including novel methods based on relational graphs.
Conclusions: Whilst metric information plays its part, qualitative representations are surprisingly powerful and facilitate learning and allow abstraction from noisy data. They may also facilitate a more cognitive representation of activities.

Computational problem solving in spatial substrates

Christian Freksa

University of Bremen, Germany

Background: The ability to perform spatial tasks is crucial for everyday life and of great importance to cognitive agents such as humans, animals, and autonomous robots. A common approach to accomplish this ability in AI is to represent spatial configurations and tasks in form of knowledge about various aspects of space and time. Suitable algorithms then use the knowledge to compute solutions to spatial problems. However, for complex problems, the computational complexity of these algorithms increases unfavorably compared to everyday human problem solving.
Aims: We identify forms of interaction between computation and spatial affordances in the bodies and environments. The aim is to maintain spatial integrity of topologic, distance, and orientation information as well as additional modalities that become disintegrated in formal approaches.
Method: Natural embodied and situated agents often solve spatial tasks without detailed knowledge about geometric, topological, or mechanical laws; they directly relate actions to effects that are due to spatio-temporal affordances in their bodies and environments. Accordingly, our approach employs the strong spatial cognition paradigm that makes spatio-temporal substrates an integral part of the problem solving engine. This permits simultaneous processing of inherently interdependent relations in space.
Results: We will demonstrate the approach to spatial problemsolving and discuss how it overcomes complexity limits of computational approaches in purely formal systems. We will show how spatial and temporal structures in body and environment can substantially support (and even replace) reasoning effort in computational processes.
Conclusions: We distinguish models of cognitive processes from models for understanding cognitive processing.

Affordances and the functional characterization of space

James Pustejovsky

Brandeis University, Massachusetts, USA

Background: There has been significant attention recently in neuropsychological and neuroscience to the notions of affordances and situated activity. This area is far less studied and well understood in the linguistic semantic modelling and qualitative reasoning communities.
Aims: This talk shows how affordances can be modelled within a formal semantics for qualitative spatial reasoning.
Method: We define a modal characterization for the affordance space associated with an object, as part of the "teleotopology" of a situation. Agents, objects, and their affordances are constrained through an affordance calculus, which identifies: (a) what activity is afforded by an object; (b) the localization (embedding space) for an activity; (c) how this region is oriented and configured relative to the Agent.
Results: We will show generated simulations of numerous models of how space is functionally encoded by various objects.
Conclusions: Models of qualitative spatial reasoning enriched with modal relations (encoding function and use of objects) may provide an interesting computational bridge to work being done in the cognitive neuroscience of situated activity and affordances.

Sketching our way to spatial learning

Kenneth D. Forbus

Northwestern University, USA

Background: Sketching is a powerful modality that people use to work through spatial ideas. It is so powerful that we often recast non-spatial material in spatial terms, so that we can using sketching to work through ideas.
Aims: This talk will provide evidence that qualitative representations are crucial in how we use sketches to reason and learn.
Method: We describe CogSketch, a computational model of sketch understanding and a platform for new kinds of sketch-based educational software. CogSketch computes human–like visual relationships, rather than focusing on recognizing objects, which is what most AI sketching software does. This gives it the ability to model aspects of human visual problem-solving, and enables the same system to be used with a wide range of science topics and a wide range of ages of students.
Results: These ideas will be illustrated with examples from using CogSketch to model human spatial reasoning and to help students learn. This will include how hierarchical levels of representation are used in CogSketch, and some results from classroom experiments.
Conclusions: Qualitative representations provide a bridge between the quantitative world of low-level perception to the symbolic world of conceptual thought. This mediating role can be quite complex: Hierarchical levels of spatial representations can be needed even in understanding relatively simple sketches

SYMPOSIUM 18: Situated cognition in the arts

Convenors: Anne Reboul[1] and Bernard Guelton[2]

[1]CNRS Universitè de Lyon, France; [2]Institute-Acte, CNRS, France

Background: Decoupling seems contradictory with situated cognition, and it is tempting to conclude that decoupled cognitive processes, being largely independent from the environment, are *ipso facto* non-situated. Representational art can be seen as an important test of the notion that decoupled cognitive processes are necessarily non-situated:

- On the one hand, from an audience perspective, artworks may seem non-situated and non-spatial in as much as the audience appears to be a passive receptacle rather than an active participant. What is more, artworks often involve fiction, which can be seen as the epitome of a decoupled and non-situated activity, given that it concerns not only absent, but non-existent objects.
- On the other hand, artworks trigger a variety of sensory processes in the audience, and immersion (the impression of being submerged in an environment) is often supposed to be the result of successful art.

- Additionally, recent artistic practices, through the use of digital interfaces in situation of mobility, allow the "audience" to coordinate between different cities and to collaboratively create fictive spaces through their own routes in their respective cities. This shifts the problem of the relation between art and situated cognition, and opens new cognitive dimensions for the audience.

Aim: The main aim of the symposium is thus to examine the notion that decoupled cognitive processes are necessarily non-situated from the standpoint of artworks. While decoupled processes in general can be claimed to be indirectly dependent on the environment, as they are usually dependent on concepts that have to be grounded in reality, this is not enough to claim that they are situated. The phenomenon of immersion is, however, a much stronger argument for two reasons: (a) the decoupled processes are directly dependent on the artwork itself as a physical element in the environment; (b) they are additionally situated in the alternative environment in which the audience is plunged, and to the construction of which they cognitively contribute.
Approach: The symposium will examine situated cognition in decoupled cognitive processes through investigation of the form of cognition that artworks, both traditional and contemporary, trigger in the audience.

Decoupling, situated cognition and immersion in art

Anne Reboul

CNRS Universitè de Lyon, France

Background: Situated cognition appears to be incompatible with strong decoupling, in which representations are deployed in the physical absence of a target (that which they represent) and are not oriented toward action (the representation is not entertained as a means to any physical action). Art consumption seems to be the epitome of a strongly decoupled process.
Aims: Showing that art consumption is a cognitive process in which strong decoupling is combined with situated cognition.
Method: In keeping with the conference call, which mentions philosophical approaches, a philosophical analysis of what happens in art consumptionwill be proposed.
Results: No experiments are contemplated for the time being.
Conclusions: In art consumption, the artwork is a physical part of the environment and controls what the audience perceives. Yet the target of the artwork (that which it represents) is not physically present and the audience does not act. Thus, art consumption is a cognitive combination of strong decoupling and situated cognition. In addition, art consumption may imply immersion, which means that the audience is simultaneously immersed in two environments (the art environment embedded in the actual environment), with the artwork acting as the link between them

Immersion as an embodied cognition shift: Aesthetic experience and spatial situated cognition

Bruno Trentini

Université Paris 1 - Panthéon-Sorbonne France

Background: Immersion in a virtual space does not imply the negation of the spatial cognition of the real space. Instead, immersion enables a twofold perception of space: the real space and the virtual space into one is immersed. The experience of immersion is also often accompanied by a reconfiguration of one's own body, which is of particular interest to study the limits of situated cognition. Thus, immersion appears to be a borderline case in situated cognition: which is the space that provides the cognition?
Aims: We want to show that aesthetic experience towards immersive art comes from the awareness that one's cognition depends on the context. The balance between affordances in the real space and in the virtual space is also important in order to precise the arena of the spatial situated cognition.
Method: Aesthetic experience regarding spatial cognition will be described using an approach of embodied aesthetics, that is to say an approach which connects phenomenology of perception and physiological prospects.
Results: No experiments are contemplated as of now.
Conclusions: Immersion comes from a shift in perceptive associations, which adapt to a novel context and give the impression of operating in a novel space. Plasticity and flexibility of spatial cognition enable the emergence of aesthetic experience through a behaviour which results from an adaptation, but which is paradoxically inadequate for an actual action.

Intersection of reality and fiction in art perception

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Background: The thesis of embodied cognition claims that perception of the environment entails a complex set of multisensory processes which forms a basis for the agents potential and immediate actions. However, in the case of artworks an agent becomes an observer and action turns into a reaction. This raises questions about the presence of embodied or situated cognition involved in art reception.
Aims: The study aimed to assess the bodily correlates of perceiving fictional spaces (e.g. perspectival spaces) and objects (e.g. still lives) in the absence of a possibility of an actual physical immersion or manipulation of represented forms.
Method: The subjects were presented with paintings by Vermeer and De Hooch whilst their body sway and eye movements were recorded. Moreover, test and questionnaires on mental imagery (MRT, VVIQ, OSIQ) were administered.
Results: Three major results were obtained. Fixations to distant elements in paintings (i.e. backgrounds) (1) and perception of complex perspectival layouts (2) were accompanied by an increase in body sway. Furthermore, positive correlations between scores in mental rotation test and body sway were found (3).
Conclusions: The results of the experiment suggest that in certain cases—despite the fictional character of art—observers embodied reactions resemble reactions to real stimuli. It is proposed that these reactions are mediated by mental imagery (e.g. mental rotation) that is necessary for a construction of alternative to real artistic worlds.

"Hupareel": Experiences and immersions in an hybrid reality game between Paris–Shanghai–Montreal

Bernard Guelton

Institute-Acte, CNRS, France

Background: In location-based mobile games participants interact between themselves in physical, virtual and fictional spaces. The distinctions between embodied, situated, extended, distributed and shared cognition, form a theoretical framework that can beinvestigated through the use of digital interfaces in situations of mobility.
Aims: Nature of immersions (i.e. "absorption" physical, virtual, fictional) and relationships with situated cognition will be examined in LBMG project called "Hupareel" between three distant cities Paris–Shanghai–Montreal.
Method: Confrontation of different kinds of interactions between mobile participants through: (1) Interactive mobile visualizations. (2) Audio protocols instructions and interactions between participants: video recordings and interviews. (3) Interactive maps: GPS Tracks measurements.
Expected Results: We'll examine the characteristics of audio interactions compare to visual interactions between participants. Interactions with audio protocols facilitate embodied and situated cognitions and imply "concentrated immersion", while interactive mobile visualizations via Skype and interactive maps facilitate distributed and shared cognitions and imply "transportation immersion".
Conclusion: It will be argued that every monolithic conception of immersion failed when a hybrid Reality Game is experienced between physical, fictional and virtual spaces. Absorption as transportation and absorption as concentration will be the main opposition developed and engage the question of situated cognition. Additionally, derived from participation theatre and artistic performance, we'll consider the performance characteristic of HRGs with two disappearances: (1) spectator and audience, (2) the work of art as physical object.

SYMPOSIUM 19: Eye movement-related brain activity in visuospatial information processing

Convenors: Andrey R. Nikolaev and Cees van Leeuwen

Laboratory for Perceptual Dynamics, KU Leuven, University of Leuven, Belgium

Background: The surrounding space is visually sampled by means of saccadic eye movements. These are tightly coupled with brain activity that reflects perceptual and cognitive processes evaluating the sampled information. Saccadic eye movements, because ofrecent advances in eye-tracking technology, are now easy to use in combination with measurement of ongoing brain activity. This allows researchers to use eye-movements as markers for segmentation of ongoing brain activity into subsequent episodes. Consequently, the simultaneous recording of brain activity and eye movement has increasingly become popular in various fields of vision research. In particular, it is advantageous for the investigation of processes associated with free visual exploration of the environment.
Aim: The symposium will discuss the dynamical neural mechanisms underlying perception, attention and memory, especially, in naturalistic viewing conditions. In addition, the symposium will contribute to a better understanding of the range of research questions that can be approached by the co-registration of eye-movement and brain activity, the requirements for experimentation, and methodological solutions for recording and data processing. The target audience of the symposium will be visual neuroscientists and psychologists who are interested in the neurophysiological correlates of brain processes accompanying free viewing behaviour and who wish to extend their methodological arsenal in this field.
Approach: All works presented in the symposium will have two common features: co-registration EEG and eye movements, and an experimental paradigm implying unrestricted eye movements during extended viewing behaviour. Using these tools the presenters investigate processing of visuospatial information in a wide range of perceptual and cognitive tasks. The topics will include free visual exploration of scenes, visual search, viewing in 3D space, memory encoding across saccades.

Eye movement-related brain activity in free visual exploration

Sebastian Pannasch

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Background: Human eye movements are essential for visual perception. During fixations, information is extracted from the environment and internally processed. Since highest visual acuity is limited to the small foveal region, fast saccadic movements are required to redirect the foveal region from one fixation point to another. Analyzing fixation durations and saccade amplitudes during everyday activities allows understanding what details of the environment receive attention.
Aims: I will demonstrate that combining the analysis of eye movements and brain activity in the context of scene viewing can reveal important insights about the mechanisms of information processing.
Method: In the present experiments our subjects explored natural scenes. Presenting distractors during the image exploration prolongs the affected fixation. In search for an explanation, simultaneously recorded EEG activity allows for an analysis of eye-fixation related potentials (EFRPs). The examination of particular EFRP-components revealed distinct processing mechanisms with regard to repeated distractor presentation and the length of preceding and following saccades. Furthermore, the fixation based segmentation of brain activity can provide neurophysiological evidences for the involvement of different attentional mechanisms.
Results: The analysis of eye movement related brain activity helps to better understand attentional mechanisms such as the interplay between bottom-up and top-down processing.
Conclusions: The obtained findings seem to be related to distinct streams of visual processing (i.e. the dorsal and ventral pathways). I will furthermore discuss the relevance of the task (i.e. naturalistic behaviour) for the understanding of visuospatial processing.

Perceivers' internal state tags fixation-by-fixation visual information: An EEG-eye movement co-registration study

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Perceivers' internal state affects perception. We hypothesized that fixation-by-fixation visual information is tagged with internal state information. We investigated peri-fixation brain activity for internal state-specific tagging. Laterally from a central fixation point, participants were presented a visual image of an object for identification, to which they moved their eyes as soon as possible. In the same location, next, a text appeared that could either be an easy or hard question about the object, to be answered by pressing one of two alternative buttons, or it could be an instruction to simply press one of these two buttons. Text conditions were either blocked or randomly mixed, in order to induce one of two different internal states, in which either the task was certain in advance or it was not. Eye movements and electroencephalogram (EEG) were recorded simultaneously during task performance. Using eye-event-time-locked averaging and independent component analysis, saccade- and fixation-related EEG components were identified. Cross-frequency phase synchrony of the EEG signal was observed between the alpha/beta1 frequency ranges of fixation-related activity and between the beta2/gamma1 ranges of saccade-related activity, 50 ms prior to fixation onset in the mixed-phrase condition only. We interpreted this result as evidence for tagging of fixation-by-fixation EEG activity with internal information about task uncertainty.

Predictions of visual content across eye movements and their modulation by inferred information

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Background: The brain is believed to operate through probabilistic inference, testing and refining predictions about the world.
Aims: Here, we tested the existence of sensory predictive signals originated on overlearned contingencies between gent's actions and the consequent changes in sensory input. We focused on vision, where eye-movements are continuously changing the visual input, producing local changes in acuity and global visual-field shifts that could in principle be predicted.
Method: 15 subjects participated in a combined EEG and eye-tracking study. We compared error signals to saccade-contingent changes of direct and indirect inputs by contrasting the EEG activity after saccades to a stimulus presented inside or outside the blind-spot.
Results: We observe two main results: (1) both early ($\sim$100 ms) and intermediate ($\sim$200 ms) lateralized EEG responses to saccade-contingent stimulus changes that suggest the occurrence of error signals to low and middle-level predictions within the visual modality; (2) a late effect which was compatible in timing and topography with a P3 response, suggestive of violations of global constancy predictions. Remarkably, this late, change-related response was diminished for blind-spot trials. These results indicate that both sensory and associative predictive signals exist for transformations of visual input secondary to subjects' eye-movements.
Conclusions: We show that predictions of visual content occur across multiple levels of visual processing. These predictions are based on internal models that differentiate between signals that originate from the outside world and those that are exclusively inferred.

Encoding of visuospatial information in free viewing

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Background: Visual neuroscience is shifting from the traditional stimulus–response paradigm to the analysis of continuous, ongoing visual processes. This shift in focus requires new types of markers for segmenting ongoing brain activity into task-relevant episodes. A natural candidate for this may be saccadic eye movements, as enabled by the simultaneous recording and combined analysis of EEG and eye movements.
Aims: We describe the range of research questions that can be approached by the co-registration of EEG and eye movements, discuss its methodological problems and their solutions. Next, we present an example of such an analysis for a change-detection paradigm.
Method: We applied saccade-related segmentation in a paradigm in which participants freely explored a visual scene prior to a change detection task. We analysed eye-movement related potentials time-locked to the saccade onset in the presaccadic interval.
Results: We illustrate the main features of the saccade-related EEG and discuss two approaches to EEG segmentation: relatively to the saccade and fixationon sets. We consider how to avoid contamination from overlapping effects of sequential eye movements. Finally we present the results of the change detection study. These results indicate that overt attention is needed for successful encoding and that dissociation between the direction of eye movements and attention leads to change blindness.
Conclusions: Co-registration of EEG and eye movements is a valuable tool for visuospatial research, particularly for studying free viewing behaviour.

SYMPOSIUM 20: Situated spatial cognition and social processing: Body, emotions and interactions in space

Convenor: Tina Iachini

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Background: Spatial cognition is intrinsically situated: it deals with "places" or contexts where events occur. In particular, near body peripersonal space is fundamental for interacting both with objects and a special category of "objects" with emotional and motivational meaning: human beings (Lloyd, 2009). Spatial behaviour is intrinsic to social phenomena since the delimitation of an appropriate spatial boundary around the body is crucial for efficiently acting and communicating with others, for expressing the quality of social interaction and the desired level of intimacy. In all these cases, perceptual and motor processes must cooperate in recognizing the emotional value of the social context for reacting appropriately. Some recent literature has shown that social information may modulate the representation of peripersonal space and has suggested a close relationship between basic visuomotor-spatial processing and complex social processing (Cléry et al., 2014; di Pellegrino & Làdavas, 2014; Iachini et al., 2014; Teneggi et al., 2013). However, the mechanisms and characteristics of this relationship are still to be explored and comprehensive theoretical models have yet to be proposed.
Aim: Present the most recent data about the relationship between spatial and social processing, and discuss theoretical models that put the notion of body acting and feeling in space at the roots of our social experience. In particular, we will try to clarify the link between low-level sensorimotor processing and high-level socio-cognitive processes in how we represent our bodies in space, with particular regard to peripersonal space.
Approach: By assuming the centrality of body as a source of action potentiality with a special role in the peripersonal area, we will start by asking what makes the representation of body special in acting with others in space (Saulton et al.). Then, the multisensory contribution to the plastic representation of body in space will be discussed (Tajadura-Jimenez). Recent data will offer new knowledge about the mechanisms underlying the social influence of spatial processing for action (Coello & Quesque) and how the expert body (martial arts) may mediate situational awareness and the interpersonal spatial processing (Lloyd). Moreover, new findings about the link between emotional and interpersonal factors in spatial processing (Balconi) and the role of perspective-taking and personal space regulation in autism (Frassinetti et al.) will offer interesting insights in the "hot" cognition of sensorimotor space. Finally, an example of top-down influence via moral belief manipulation on interpersonal distances will show that complex socio-cognitive and basic visuomotor processing are closely interwoven in spatial cognition (Iachini et al.).

The interaction of social and spatial cognitive processes in naturalistic social interactions

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Background: Coordinating actions in human social interactions relies on visual information about the interaction partner as well as knowledge about one's own body. However, these processes have rarely been examined in realistic human interactions.
Aims: Our research aims at deepening our understanding about social spatial interactions in human interaction by examining an important cognitive representation of the human body underlying perception and action, namely the body model. In addition, we also present work on how visual social information influences action execution in naturalistic interactions.
Method: We use psychophysical methods to compare shape and size distortions between the body and objects in localization judgement tasks. We also examine the influence of a partner's body appearance on movement trajectories in naturalistic human interactions using an interactive virtual reality setup. Participants executed a high-five with an avatar that either looked like a robot or a human.
Results: We found evidence that distortions previously selectively attributed to the body, e.g. hand, are also observed with objects. In addition, actions were influenced by task irrelevant factors such as the visual appearance of the interaction partner.
Conclusions: Non-verbal social interactions are influenced by non-body specific spatial representations and non-action related social information about the interaction partner.

The hearing body: Influences of audition on body and space representations

Ana Tajadura-Jimenez

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Background: Our body demarcates the physical boundaries between our own embodied existence and the external world. It is through audition and other senses that we receive information that leads to unified and coherent representations of our own body and the space immediately surrounding it. These representations are central to act upon the environment but also to self-identity and self-esteem.
Aims: While the role of audition in forming body-representations has received less attention than that of other modalities, I will present evidence from our recent studies showing that the sounds that accompany almost every of our bodily movements are used to form these representations.
Method: With a series of psychophysical and psychophysiological experiments in adult participants we are investigating the effect of real-time manipulation of action sounds in the represented dimensions of one's body and the space surrounding it. We are also exploring the consequences of these changes in motor behavior and emotional state.
Results: Our results have revealed that action sounds can alter body-representation, with consequences for motor behavior and emotion. In particular, the altering of sounds related to one's body induces changes in the mentally represented length of one's own arm as well as in the represented height and width of one's own body, and

changes the way people interact with the space surrounding them (e.g., it changes reaching movements and gait).
Conclusions: The sounds that accompany almost every bodily movement are highly rich in information about the body. Our results provide evidence of an auditory-dependent plasticity of body-representation.

The motor encoding of peripersonal space and its role in social interactions

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Background: Peripersonal (PS) and extrapersonal (ES) spaces are differentially represented within the visual brain (Previc, 1998). PS contains the objects that we can immediately reach and manipulate, and specifies our private area in a social context (Cardellicchio et al., 2011; Iachini et al., 2014). Yet, it is not known whether objects in PS automatically activate the motor system, and how PS influences social interactions.
Aims: A set of researches has been conduced in order to investigate (1) the role of affordances and intentionality in the motor coding of objects in PS, (2) the relation between PS and interpersonal space in social interactions.
Method: We used an original combination of virtual reality and EEG recording technics. Through time–frequency decomposition of EEG signals, we analysedμ rhythm desynchronization over the centro-parietal region while judging the reachable/unreachable characteristic or prototypical/distorted appearance (Gaussian blur filter) of visual objects presented in either PS or ES. We then evaluated the relationship between PS representation and the control of social distances, by measuring the feeling of comfort with approaching human-like point-light displays, before and after having used of a 70 cm wooden rakeknown to modify PS.
Results: EEG μ rhythm desynchronization was observed 315 ms after objects presentation but only in reachability judgments for prototypical object located in PS. Furthermore comfortable interpersonal distances were predictable from the (modulated) size of PS.
Conclusions: These data support the embodied and situated nature of PS and reveals that PS has a crucial role in the regulation of social interactions.

Situational awareness and interpersonal spatial processing in martial artists

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Background: Studies have shown that a person's perception of space around the body changes as a function of their environmental awareness. It is important to understand the link between environmental awareness and interpersonal space as the number of attacks on people listening to music through headphones is on the increase (prompting some running clubs to even offer self-defence courses).
Aims: To investigate the link between environmental awareness and interpersonal space and whether this differs in people trained in self-defence.
Method: 24 martial artists and 24 controls will take part. Using a modified version of the stop-distance paradigm the participant approaches the experimenter from one of four directions: walking forwards, backwards and with their left/right side facing. The participant stops at the distance from the experimenter at which they feel most comfortable (D1) and then approaches again until they do not wish to get any closer (D2) and the distance recorded. This is repeated with the participant listening to music through headphones. The participant is then approached by the experimenter and tells them to stop at D1 and D2.
Expected results: We expect differences in D1 and D2 between martial artists and controls. Preliminary results show participants get significantly closer when approaching the experimenter than they allow the experimenter to get for both measures. This research will provide empirical support for the dangers of listening to music through headphones and how training in self-defence increases situational awareness.

The "emotional" and "interpersonal" body in spatial cognition

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Background: In order to interact effectively, we need to represent our action as produced by human beings. According to direct access theories, the first steps of visual information processing offer us an informed direct grasp of the situation, especially when social and emotional (interpersonal) components are implicated. Biological system detection may be the gateway of such smart processes and then may influence initial stages of perception fostering adaptive social behaviour.
Aims: To investigate early neural correlates of human gesture detection in ecological situations with more high or low social impact, we compared scenes showing a human versus artificial agent interacting with a human agent.
Method: 20 volunteers participated to the study. They were asked to observe dynamic visual stimuli showing realistic interactions. EEG was recorded and then ERP (event-related potentials) for selected ROI were computed. Each stimulus depicts an arm executing a gesture addressed to a human agent. Visual features of the arm were manipulated: in half of trials it was real; in other trials it was deprived of some details and transformed in a statue-like arm.
Results: Morphological analysis revealed an early negative deflection peaking at about 155 ms. Peak amplitude data have been statistically analysed by repeated measures ANOVAs. It was found that the peak was ampler in the left anterior fronto-temporal region, in particular when the gesturing arm was human.
Conclusions: The early negative deflection, N150, which we found to be different between the human and artificial conditions, is presumably associated to human agency detection in high interpersonal context.

The effect of perspective-taking and personal space regulation in autism

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Background: Personal space is defined as the protective area around the body in which intrusion by others causes discomfort (Hall et al., 1966). Recently, studies in our laboratory using a stop-distance paradigm (Gessaroli et al., 2013) revealed that children with autism spectrum disorder (ASD) prefer larger personal space compared to children with typical development (TD), and that interpersonal distance reduces after interaction with an unfamiliar adult in TD but not in ASD children.
Aims: Here, our primary aim was to verify whether the modulation of personal space depends on the quality of social interaction (a positive vs. a neutral interaction), both in TD and ASD children. Moreover, we investigated whether personal space differs when participants directly regulate the distance between themselves and others versus when they judge personal distance between others.
Method: To this aim, a stop-distance paradigm was performed in two conditions. In the first-person perspective participants was asked to directly regulate their personal distance, while in the third-person perspective participants were asked to judge the appropriate interpersonal distance between another child and the confederate. Both conditions were performed before and after a positive or neutral interaction with an unfamiliar adult confederate.
Results: Results showed that TD children felt comfortable at a closer distance after than before a positive interaction, whereas no difference was found beforeand after a neutral interaction. This was not true for ASD children.
Conclusions: These findings reveal that the quality of social interaction and the perspective of the experience differently influenced personal space in TD and ASDchildren.

I do not have a good impression: Moral information and spatial behavior in virtual interactions

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Background: The usage of near body distance is a key component of social interactions (e.g. Lloyd, 2009). A previous study (Iachini et al., 2014) has shown that reachable distance (peripersonal space for acting with objects) and comfort distance (interpersonal space for interacting with people) share common mechanisms and reflect the social valence of stimuli. Social psychology has shown that the moral evaluation of others is crucial in social interactions because affects the formation of impression and, consequently, the intention to approach or avoid a person (e.g. Brambilla et al., 2013). However, it is not known whether moral evaluation may modulate the size of body space.
Aims: Assess whether the size of peripersonal and interpersonal spaces is affected by moral information about people.
Method: 36 participants interacted with male and female virtual humans described in terms of morality by positive, negative and neutral (as a control condition) sentences. The modulation of body space was measured (in cm) by reachability-distance and comfort-distance judgments while participants stood still (passive) or walked towards virtual humans (active).
Results: In both spaces (but stronger in comfort-distance) distance was reduced when the moral connotation of virtual humans was negative whereas expanded when it was positive. Moreover, both spaces were modulated by the passive–active condition and the social valence of stimuli (e.g. distance was reduced females and increased with males, expecially in the passive condition).
Conclusions: Consistent with an embodied cognition approach, the findings suggest that high-level socio-cognitive processes have a top-down influenceon the way we represent the space surrounding our body.

SYMPOSIUM 21: Should we stay or should we go? Evidence from lab and field studies of convergent strategies in spatial decision-making by nonhuman primates

Convenors: Francine L. Dolins[1] and Paul A. Garber[2]

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Background: Across and within primate species, the comparison of laboratory and field studies affords an assessment of how changes in the social environment, the physical construction of space, and ecological factors, such as landmarks and patterns of resource distribution, play a role in forming navigation strategies and in goal-directed foraging behavior. For some primate species, resources are clustered within a group's home range of <1 hectare (ha) while in other species' resources are widely scattered within home ranges of over 20 km^2. Moreover, given that virtually all primates live in social groups, individuals may monitor the behavior and travel routes of others as part of their spatial and decision-making strategy.
Approach: Observational field studies suggest that primates re-use paths and turning locations (nodes or choice-points) associated with a single landmark or an array of landmarks within a complex, three-dimensional environment to localize foraging, resting and sleeping sites, and to avoid areas associated with high predation risk. In contrast, experimental field studies and those conducted under controlled conditions in the lab present individuals with choices among a set of landmarks and geometric features that can be used to guide spatial behavior to foraging sites or goals.
Aim: Combined these studies provide an understanding of what spatial information may populate an animal's internal representation of that environment or space. By comparing evidence from the lab and field and across species, the presentations in this symposium will explore the convergence of cognitive strategies from each spatial context, offering insight into the rules that guide spatial strategies and situated cognition in nonhuman primates.

Experimental field study of social and spatial foraging strategies in wild tamarins (Saguinus weddelli, Callitrichinae, Primates)

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Background: All species of tamarins are characterized by a system of cooperative offspring caregiving in which adults are tolerant of each other and share food and co-feed with infants and juveniles. This requires a system of highly coordinated spatial and social decision-making.
Aims: To identify the strength and context of dyadic partner preferences, socio-spatial relationships, and patterns of subgrouping on individual feeding successunder conditions of changing food availability.
Method: We conducted a series of field experiments to examine the effects of food productivity and resource density on social foraging strategies in a group of 9 individually marked tamarins in Brazil. The tamarins were presented with 8 visuallyidentical feeding platforms located 5 m apart in a circular arrangement. In two experimental conditions 2 of the 8 platforms contained a concealed food reward and in the remaining two conditions all eight platforms contained a concealed food reward.
Results: We found that as the number of baited feeding platforms decreased, the number of tamarin co-feeders increased. When only two platforms contained food, 3–8 tamarins shared the platform during 54–66 % of visits. Using social network analyses (SOCPROG) we found no consistent pattern of dyadic partner preferences. Rather, tamarins formed 1–3 cliques during all experimental conditions, with juveniles, the breeding female, and low ranking adult males the primary participants.
Conclusions: By regulating their social and spatial relationships, the feeding success of juveniles and low ranking group members was similar to that of dominant individuals.

Spatial and temporal nodes in the paths of bearded capuchin monkeys (*Sapajus libidinosus*) and the effects of landscape

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Background: Previous analyses of capuchin spatial decisions indicated that their movements do not conform to a minimum resistance model of movement. Instead, capuchins moved nonlinearly in zones of high habit at suitability. When travel was experimentally manipulated, movements were more linear and lower in habitat suitability. These results may suggest opportunistic natural movements and goal-directed movement in the experiment.
Aims: We aim to evaluate paths of wild capuchin monkeys ($n = 8$) for evidence of opportunistic movement.
Method: We identified temporal (>8.01 min) and spatial nodes (using the Change Point Test, $q = 5$) and compared these nodes with move points regarding elevation, vegetation, bare soil, shadow, and proximity to human development, roads, and ridges. We also used viewshed analysis to determine the visibility of nodes. We will discuss habitat suitability of areas beyond travel nodes in the direction of prior travel.
Results: Change points occurred significantly closer to roads ($m \pm SD = 36.01 \pm 35.07$) than move points ($m \pm SD = 53.99 \pm 43.66$) ($p = 0.02$). No other significant differences existed in the landscape of nodes and move points. Nodes were often invisible from prior nodes.
Conclusions: Capuchin monkeys often change movement direction close to roads. Change and stop points are often invisible from prior nodes, suggesting that use of nodes is opportunistic or based on route memory, rather than on visual perception from previous nodes. If capuchins choose their paths opportunistically, we expect our results to show that zones just beyond change points are lower in habitat suitability than zones beyond non-change points.

The role of competition on individual routing decisions: Lessons from foraging experiments on wild vervet monkeys

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Background: Social animals are faced with the challenge of acquiring sufficient resources while in the midst of competition with conspecifics.
Aims: The goal of this study was to determine how routing decisions changed when individuals were foraging solitarily compared to when competitors were present.
Method: I conducted two foraging experiments with vervet monkeys (Chlorocebus pygerythrus) at Lake Nabugabo, Uganda with individuals alone and as part of a group.
Results: In the first experiment, vervets had to solve an open Traveling Salesman Problem with six, equally-rewarding platforms, arranged to allow assessment of distance optimization or use of three simple heuristics. Single foragers usually took the path consistent with the most efficient heuristic (convex hull). However, when others were present, vervets shifted their strategies to the heuristics that were most efficient in a competitive situation, dependent on their dominance rank (additive gravity for dominants and the nearest-neighbor rule for subordinates). In the second experiment, I examined whether vervets prioritized highly-rewarding food sites. Five platforms were set in a large pentagon (5 m apart) with one or two sites providing six-times more food than others. Solitary individuals did not travel to highly-rewarding platforms first (they used the nearest-neighbor rule), unless competitors were present (a gravity or "take-the-best" heuristic).
Conclusions: Results from both studies support that vervets are able to quickly interchange context-dependent heuristics to make fast, optimal navigation decisions and that foraging decisions differ with the presence of competitors. Natural selection appears to have favored different spatial movement heuristics for solitary and social foraging vervet monkeys.

Monitoring of spatio-temporal patterns of resource availability by humans in a virtual reality foraging task

Carlo De Lillo and Melissa Kirby

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Background: Field studies suggest that fruiting synchrony informs search for food in chimpanzees foraging in forest environments.
Aims: We aimed to identify the cognitive abilities deployed by humans in an immersive virtual reality task designed to capture essential aspects of chimpanzees' foraging under experimental conditions, difficult to implement effectively with chimpanzees. We assessed reference memory for tree species that need to be avoided as they never yield fruit, working memory for trees visited in any foraging bout, and the ability to monitor fruiting patterns across trials to predict the likely location of fruit.
Method: Participants navigated through arrays of coloured poles representing tree species and checked them for the presence of food items. Participants experienced either predictable or unpredictable patterns of food availability. Experiment one (N = 20, age range = 19–39) featured a single pattern, whilst Experiment two (N = 24, age range = 18–34) featured two patterns.
Results: Participants learned to avoid trees that never yielded fruit and gradually improved their working memory for checked trees. Importantly, in predictable conditions, participants monitored multiple patterns of fruit availability and confined their searches at the outset of a foraging bout to trees that were most likely to yield fruit.
Conclusions: These results provide a taxonomy of the skills required to forage efficiently for ephemeral resources in the forest canopy that can inform the assessment of the cognitive bases of foraging in non-human primates. They support theories suggesting that foraging for ephemeral resources in the forest canopy triggered the expansion of brain capacity in primates, including humans.

Chimpanzee goal-directed foraging and navigation in a virtual environment: Spatial knowledge, distance, or sight of goal as prioritizing factor?

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Background: Foraging primates localize resources across ecologically complex landscapes and routes, exploiting feeding sites that balance navigational efficiency and effort with nutrient intake, seasonal availability, competition, and group size.
Aims: Using a virtual maze environment, we tested four captive chimpanzees' navigational strategies, effort expended (distance traveled/time), and the effect of direct visibility of the goal or an obstructed view during travel.
Method: Subjects were given four route options: 'shortest', 'short', 'medium length' or 'longer path' to localize the goal. On a random basis, the 'shortest' path was blocked while the goal remained visible. The other three routes were always available on all trials. The 'short' path required navigators to twice turn away from the goal prior to localization, the 'medium length' required one turn away, whereas the 'longer path' led directly to the goal, which was always visible along this route (cf. the "marshmallow test" in a spatial context). Landmarks were available on each route but not necessary to successfully localize the goal site.
Results: Results show that when available, the 'shortest' path was selected most often, while the 'longer path' (with the goal always visible), was selected for the majority of successful trials.
Conclusions: These findings suggest that maintaining visibility of the goal was a high priority over that of distance traveled. In the wild, navigators may work to maintain visibility of a goal/landmark or a sub-goal/landmark in a series of travel bouts within a longer route, as when traveling in large-scale space, where visibility between landmarks is obscured by forest or other environmental features.

Visual cues, predictive of food location, do not override the acquisition of spatial information in humans in a virtual reality foraging task

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Background: Field studies have suggested that non-human primates acquire mental representations of fruiting trees and build a mental map of their environment when foraging. However, associative learning suggests salient visual cues may overshadow learning of spatial information.
Aims: We aimed to experimentally assess with humans in a virtual reality task, which is difficult to implement effectively with non-human primates, whether spatial knowledge is acquired during foraging tasks where visual cues could overshadow spatial ones.
Method: Participants (N = 10, age range = 18–20) foraged for hidden food items among locations that were identifiable by colour simulating the visual appearance of fruiting trees. Fruit became available according to a temporal pattern simulating the ephemeral ripening of fruit in the forest canopy. In a transfer phase, we removed the informative value of colour to assess the implicit acquisition of their relativespatial location.
Results: After the removal of the distinctive visual cues, participants showed the ability to search correctly in a variety of measures. Searches to correct locations at the outset of trials were above chance level, and searches to locations that never yielded fruit were below chance level. The ability to anticipate the location of food on the basis of a temporal pattern was also preserved.
Conclusions: Humans acquire spatial knowledge of aforaging environment in presence of potentially competing visual cues. These experimental results are discussed in relation to field observations of chimpanzees suggesting the acquisition of maps of fruiting trees despite the potential for visual cues to overshadow it.

SYMPOSIUM 22: Numbers in the eye of the beholder: What eye movements reveal about numerical cognition

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Background: The eyes, often called the window to our minds, reveal the focus of spatial attention and are therefore a perfect research subject for the study of situated spatial and embodied cognition. Studying eye movements in relation to number processing seems particularly promising: First, number magnitudes are represented in a generalized magnitude system that is also involved in the control of eye movements, and second, numbers are represented along a spatial "mental number line", and are therefore strongly linked to spatial attention. Recent research has used eye movement analyses to advance the understanding of fundamental numerical cognition in a variety of tasks: Number categorization tasks revealed that eye movements follow the same spatial-numerical associations that have been found for manual responses (small-left, large-right in Western cultures). Moreover, eye movement studies have identified different strategies involved during the number line estimation task, a classical task for assessing a person's number representation. Finally, eye movements shed light on the cognitive processes involved in more complex number processing, such as processing fractions and integers, and solving arithmetic problems.
Aim: The aim of this symposium is to provide an overview of new empirical findings and developments on the fascinating link between eye movements and number processing.
Approach: Internationally leading researchers present their newest findings on eye movements during number processing to update the audience. J. van't Noordende will highlight the added value of eye movements when assessing the sense of numbers in children with and without dyscalculia by means of the numberline task. K. Moeller will show how eye movements reveal different cognitive strategies in the bounded and unbounded number line estimation task. D. Burr will present a new approach in interpreting the logarithmic compression that is characteristic for the numberline task. M. Hartmann will show that eye movements on a blank screen reveal spatial–numerical associations during mental arithmetic. Finally, following the idea of generalized magnitudes, A. Myachykov will present an eye-movement study on the interplay between number magnitudes and object affordances.

Using eye tracking to measure number line estimation strategies in children with mathematical difficulties

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Background: Number line estimation is one of the skills underlying mathematical performance. Previous research has shown that eye tracking is a valuable tool to investigate number line estimation strategies. Moreover, recent case studies have shown that eye tracking can be used to differentiate between children with dyscalculia and children without such a disorder.
Aims: The current study extends previous findings on number line estimation strategies using eye tracking to a larger group of children with mathematical learning disabilities (MLD).
Method: A group of 9–11 year old children with MLD (N = 14) was compared to a control group of children without math difficulties (N = 14) on a 0–100 and a 0–1000 number-to-position task. A Tobii T60 eye tracker was used to measure the children's eye movements during task performance.
Results: The behavioral data showed that the children with MLD had higher error scores on both number lines than the children in the control group. The eye tracking data showed that the children with MLD made more use of the midpoint of the line as a reference point and adapted their strategies less to the number they had to estimate.
Conclusions: The eye movements show that children with math disabilities attend to different features of the number line than children without math difficulties. Children with math difficulties are probably less capable to adapt their strategy to the number that has to be estimated and make less efficient use of reference points for estimation.

Strategies in unbounded number line estimation?—Evidence from eye-tracking

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Background: The unbounded number line estimation task (with only the start point and a unit but no endpoint given) has been claimed to provide a purer measure of numerical estimation than the standard bounded version of the task (with given start and endpoint). For the latter, recent studies found influences of solution strategies on performance, for instance, proportional judgments—as documented amongst others by eye-tracking data.
Aims and Method: In the current study, we evaluated these different solution strategies by directly comparing participants' estimation performance as well as their corresponding eye-fixation behavior in bounded and unbounded number line estimation in the range of 0–50.
Results: In line with previous studies, we found evidence suggesting bounded number line estimation to be solved by proportion-based strategies: participants' eye-fixation behavior indicated the prominent use of reference points with increased numbers of fixations at and around these (i.e., start-, mid- and endpoint). This was different for unbounded number line estimation. Here, the fixation pattern did not indicate the use of reference points but showed a continuous decline of the number of fixations along the number line with increasing number size. Additionally, we observed that in unbounded number line estimation participants' first fixation on the number line was a valid predictor of the location of the target number.
Conclusion: In sum, these data corroborate the idea that unbounded number line estimation is influenced less by propositional strategies not directly related to spatial–numerical estimations as compared to its bounded counterpart.

Serial dependencies cause logarithmic-like compression of the numberline

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Background: Mapping of number onto space is fundamental to measurement and mathematics. However, numberline mapping of young children, unschooled adults and adults under attentional load or making speeded responses shows strong compressive non-linearities, thought to reflect intrinsic logarithmic mechanisms, later "linearized" by education.
Aims: We advance and test an alternative explanation to log-transform, that the non-linearity results from adaptive mechanisms incorporating the statistics of recent stimuli. This theory predicts strong serial dependencies, whereas a static logarithmic non-linearity predicts trial-wise independence.
Method: We presented subjects with dot patterns ranging from 1 to 100 dots and asked subjects to indicate their magnitude on a clearly delineated numberline. In "dual-task" sessions, subjects had to first resolve a difficult orientation-colour conjunction task, then respond on the numberline.
Results: We found strong and highly significant correlations between numberline mapping of the current trial and the magnitude of the previous trial, in both adults (particularly in dual-task) and school children. The dependencies were particularlystrong at the beginning of pointing trajectories. The current response was influenced by up to 20 % by the previous trial value, sufficient to account quantitatively for the compressive shape of the numberline. A Kalman-filter model shows that the dynamic serial dependency leads to a reduction of reproduction error, and hence improvement in overall accuracy.
Conclusions: The results show that strong serial dependencies exist in numberline tasks, sufficient to account for the shape of the number line, without resorting to static non-linearities like logarithmic transform. This dynamic strategy results in a reduction of reproduction error, and hence in an improvement in accuracy.

Spatial biases during mental arithmetic: Evidence from eye tracking

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Background: While the influence of spatial–numerical associations in number categorization tasks has been well established, their role in mental arithmetic is less clear. It has been hypothesized that mental addition leads to rightward and upward shifts of spatial attention (along the "mental number line"), whereas subtraction leads to leftward and downward shifts [Fischer and Shaki (2014). Spatial associations in numerical cognition—From single digits to arithmetic. The Quarterly Journal of Experimental Psychology, 67, 1461–1483].
Aims: We addressed this hypothesis by analyzing spontaneous eye movements during two different mental arithmetic tasks.
Method: In Experiment 1, participants counted aloud either upward or downward during 45 s while looking at a blank screen. In Experiment 2, participants solved verbally presented arithmetic problems (e.g., 2 + 7, 8–3) aloud while looking at a blank screen.
Results: Experiment 1 revealed that fixation position during upward counting continuously shifted rightward and upward over time. Similarly, Experiment 2 revealed that gaze position shifted more upward when participants solved addition compared to subtraction problems, and the horizontal gaze position was partly determined by the magnitude of the operands. Interestingly, the difference between addition and subtraction trials in Experiment 2 was only driven by the operator ("plus" vs. "minus") but was not influenced by the computational process.
Conclusions: Spontaneous eye movements during mental arithmetic reveal spatial biases: Continuous counting (Experiment 1) leads to the hypothesized mental movement along the number line during computation, while solving arithmetic problems trial-by trial (Experiment 2) was characterized by a semantic association between operation and space.

The interplay between remembered affordances and the perceived numbers: An eye-tracking study

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Background: Previous research revealed similarities between objects' representations stored in working memory and those formed online during concept apprehension (e.g., Moorselaar, et al., 2014) suggesting that memorial and perceptual representations are similarly grounded in sensorimotor simulation. Other studies show similar sensorimotor simulations in representations of number (van Dijck & Fias, 2011; van Dijk, et al., 2014a; Lendinez, et al., 2011), time (Bi, et al., 2014; Fischer-Baum & Benjamin, 2014), and volumetric grasp affordances (van Dijk, et al., 2014b). These reports provide support to the ATOM theory of magnitude (Walsh, 2003) suggesting an interplay between magnitude-related knowledge both in online and offline representations.
Aims: We investigated the interplay between magnitude-related SNARC effect and objects' microaffordances stored in memory.
Method: We used the paradigm described in van Dijck et al. (2014b): Participants memorized objects with power- and precision-grip microaffordances before hearing an auditory number (> 5/< 5) in one of two voices. Participants were instructed to identify the voice and make a saccade: left to voice A/right to voice B in Experiment 1; up to voice A/down to voice B in experiment 2.
Results: Initial results confirm that memorized microaffordances interacted with the magnitude of the perceived numbers in directing visual attention: Upward and rightward saccades were initiated faster after hearing larger numbers preceded by the presentation of a power-grip object while the reverse was true for the downward and leftward saccades.

SYMPOSIUM 23: Embodied space in architecture and neuroscience: Measures and mechanisms

Convenors: Andrea Serino and Isabella Pasqualini

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Background: Architectonic space engages several aspects of embodiment. For instance, the sensory experience of an interior volume has been attributed to the effects of the void module on the immersed observer. Whereas, the experience of an observer standing in front of the architectonic whole has been subsumed as the summary effect of the building's structural elements. These aspects of architectonic space have been associated to distinct concepts of embodiment in architecture, based on spatial cognition (e.g. through perspective changes) on the one hand, or, the embodied perception of meaning or symbolic content (e.g. through empathy) on the other. Therefore, from a theoretical point of view, the sensory experience of architectonic space may be related to distinct perceptual mechanisms: visual (or visuo-vestibular) and somatosensory (or sensorimotor). In Neuroscience, embodiment refers to the processing of an external stimulus as referenced to one's own body perception, and is based on multisensory integration and sensorimotor mechanisms. Embodiment responses to architectonic stimuli evoke in the observer distinct multisensory sensations (i.e. touch, proximity, containment, drift etc.), which are also connected to emotional perception of space and feelings, such as familiarity, safety and identification. Several authors have recently highlighted the need of scientific methods to study architectonic space. It seems critical that at the level of perceptual processes such measures collect behavioral mechanisms, neural correlates and emotional states at the same time, since architectonic space evokes an experience that encompasses the full body and may not be completely captured by one singular phenomenon. Today, the characteristics of these perceptual mechanisms, which integrate architectonic content, remain speculative in question to data. The development of scientific methods to assess specific aspects of architectonic space is however fundamental to the study and improvement of architectonic and urban space, yet also to the future advancement of novel technologies in the fields of architectural design and urban planning.
Aim: The aim of our symposium is to discuss different concepts of embodied space in architecture and neuroscience, and to present scientific approaches bridging architecture and neuroscience to allow new ways of conceiving and measuring the embodied experience of architectonic space.
Approach: To this purpose we convene experts and scholars from the fields of architecture theory, design, cognitive neuroscience, neuropsychology and computer science. Each contributor will introduce a specific aspect related to the topic of embodied perception of architectonic space and its measurement. We will discuss both theoretical themes relate to the topic and more practical issues related to how interdisciplinary methods can be applied to the study of embodied perception of architectonic space.

The space around our workplace. The notion of embodiment within the everyday office environment

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Background: The average employee spends much part of her or his daily life in the office, which, together with the house, is the most ubiquitous, detailed and lavishly designed human environment. According to this account it is ideal for measuring the physiological responses to architectural settings.
Aims: The research aims to define the notion of embodied space within the typical office environment discussing some recently discovered multimodal properties of our motor system relevant to an embodied account of the architectural space around us.
Method: The research is theoretical and incorporates evidence-based research on embodied simulation and embodied space in the fields of cognitive neuroscience, spatial cognition, architecture and the arts. Graphics and diagrams are included.
Results: The same motor circuits that control the motor behavior of individuals' bodies also map the space around them, and the objects at hand in that very same space with their shape, size, orientation and distance from the perceiver, thus defining and shaping in motor terms their representational content.
Conclusions: It can be stated that the space around us is defined by the motor potentialities and confinements of our body, meaning also that perception always requires action. The better understanding of the notion of embodied space might find vast application in the architectural field of office space planning, where improvements are sought everywhere. Some limits to the research are discussed.

Peripheral extension and central projection: Two forms of embodiment through the dorsal and ventral streams of vision

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Background: Neuroscience has shown hat our central and peripheral visual fields greatly project to the ventral and dorsal visual streams respectively, each of which process distinct information about the world. Central vision is used in the ventral stream for recognizing what an object is. Peripheral vision is used by the dorsal stream for perceiving our relationship with our surrounding environment. These neurophysiological aspects of vision likely affect our embodied relationship with our environment (i.e., the bodily changes in response to our architectural environment that affects our understanding of self both consciously and subconsciously).
Aims: To clarify the roles of central and peripheral vision in architectural experience as bifurcated through the ventral and dorsal streams.

Method: A review of existing visual perception, eye tracking, and embodied cognition experiments together with philosophical arguments and examples from the experience of architecture are provided to examine two separate types of embodiment.
Results: We propose a visual processing distinction that produces separate embodied perceptions of the self that are: (1) projected outward (e.g., projecting the self to a flying kite) using central vision (and the ventral stream) and (2) extended continuously (e.g., extending the self into one's car when parking it) using peripheral vision (and the dorsal stream).
Conclusions: Architecture provides the same account for these two types of embodiment as projected (e.g., feeling the weight of the roof on an ionic capital) and extended (e.g., feeling well balanced while moving through a colonnade) in our visual perception of architecture.

Neurophysiological correlates of embodiment and motivational factors during the perception of virtual architectural environments

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Background: The recent efforts aimed at providing neuroscientific explanations of how people perceive and experience architectural environments have largely justified the initial belief in the value of neuroscience for architecture. However, a systematic development of a coherent theoretical and experimental framework is missing.
Aims: To investigate the neurophysiological reactions related to the appreciation of ambiances, we recorded the electroencephalographic (EEG) signals in an immersive virtual reality during the appreciation of interior designs. Such data have been analysed according to the working hypothesis that appreciated environments involve embodied simulation mechanisms and circuits mediating approaching stimuli.
Method: EEG recordings of 12 healthy subjects have been performed during the perception of three-dimensional interiors (empty, modern and cutting edge furniture) that have been simulated in a CAVE system and judged according to familiarity, novelty, comfort, pleasantness, arousal and presence (9-points Likert scales).
Results: Principal component analysis of behavioral scores resulted in three components: pleasantness/novelty-related ($\sim$50 %), familiarity-related ($\sim$24 %) and comfort-related ($\sim$15 %). Statistical spectral maps (t test, $p < 0.05$, FDR corrected) reveal that pleasant, novel and comfortable interiors produce a de-synchronization of the mu rhythm over left sensorimotor areas. Interiors judged more pleasant and less familiar generates an activation of left frontal areas (theta and alpha bands). An increase of comfort returns an enhancement of the theta frontal midline activity.
Conclusions: Cerebral activations underlying appreciation of architecture could involve different mechanisms regulating corporeal, emotional and cognitive reactions. From the premise that architects design affordances, it might be suggested that people's experience of architectural environments is intrinsically structured by the possibilities for action.

Bodies and objects: Biofeedback response from architectonic experience

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Background: Body ownership (self-identification with one's body) and self-location (feeling to exist at a specific location) are basic components of bodily self-consciousness and embodiment depending on the integration of multisensory bodily signals from interoception and exteroception. Studies from cognitive neuroscience showed that it is possible to alter one's own body experience by modulating interoceptive signals in Virtual Reality.
Aims: Here we provide evidence suggesting that interoceptive biofeedback signals, by modulating the link between interoceptive and exteroceptive bodily signals, alter the bodily experience and also affect the perception of architectonic interiors.
Method: In a mini-Cave participants were exposed to three-dimensional, either Body or Object shapes (Shape condition) that were embedded into the surfaces of two virtual interiors. The shapes glowed either synchronously or asynchronously (Synchrony condition) with the participants' heartbeat. Questionnaires assessed the bodily experience and participants' emotional states. Participants' heart rates were recorded using Electrocardiography. We performed statistical analysis on the Questionnaire data (Anova) and heart rates (Heart Rate Variability).
Results: We found a significant interaction between heart rate Synchrony and Shape associated with Heart Rate Variability. For the Body shapes flashing in synchrony with the heart rates, participants reported higher degrees of self-identification with the virtual interior. Illusory sensations of touch from the walls, changes in the perception of the walls location, as well as feelings of containment were evoked by the Object shapes. Bodies or Objects modulated emotions differently, so that the former induced higher discomfort and fear sensations, while the latter evoked more comfort and happiness feelings.
Conclusions: The present findings show that by manipulating the relationship between interoceptive signals and exteroceptive cues from the environment, it is possible to change the relationship between one's own bodily sensation and the interior space, and such effect varies depending on the shapes the interior walls.

SYMPOSIUM 24: Number-space association: Insights from developmental, clinical and neuropsychological perspectives

Convenors: Isabel Arend[1] and Sarit Ashkenazi[2]

[1]Department of Psychology and Slotowski Center for Neuroscience, Ben-Gurion University of the Negev, Israel; [2]School of Education, Hebrew University of Jerusalem, Israel

Background: In the past several years a number of behavioral protocols have shown an association between numbers and space, in which small numbers are represented on the left side of space and large numbers on the right side of space (Hubbard, Piazza, Pinel & Dehaene, 2005 for a review). The association between numbers and space has been taken as strong evidence for the idea that different magnitudes share a common representational system (Walsh, 2003). Number-space association plays an important role during acquisition of arithmetical understanding. For example, the use of mental models of arithmetic starts in infancy; for instance, it has been demonstrated that 8-month old infants create an automatic connection between space and number representations (de Hevia, 2010). Number-space association has been shown to influence different levels of number processing in adults. For example, the study of individuals with number-form synaesthesia has provided great insights into the way numbers and space are processed (Seron, Pesenti, oel, Deloche, & Cornet, 1992). Even though different lines of research converge in showing the associations between number-space, recent neuropsychological findings have shown also dissociations in number and space processing (Cappelletti, Freeman & Cipolotti, 2009). That is, cortical lesions can affects number processing while sparing the processing of different magnitudes including space.
Aim: The aim of the present symposium is to examine possible associations and dissociations in number-space processing. We believe that this discussion will bring new insights for understanding how the human cognitive system represents different magnitudes and the role of number-space representation in the development of numerical competence.
Approach: In order to examine associations and dissociations in number-space, our symposium will discuss the impact of number-space association from different perspectives: from studies looking at typical and a-typical development; from behavioral and brain imaging protocols in young adults and in number-form synaesthetes; and finally from brain lesion studies.

The relation between early math skills, memory and non-symbolic number-space mapping

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Background: Research has shown that people associate numbers with space. This number-space mapping plays an important role in the development of mathematical skills. Most studies focused on the development of symbolic number-space mapping, by using symbolic number line estimation tasks. Less is known about non-symbolic number-space mapping.
Aims: In this study, the role of various factors in non-symbolic number-space mapping was investigated in Dutch 3.5-year-old children.
Method: Fifty-two children (36 girls, 16 boys) with a mean age of 3.59 years (SD = 0.08) participated in this study. Non-symbolic number-space mapping was measured using a non-symbolic number line estimation task. Early math skills were measured using a dot quantity comparison task and a counting task. Word recall and dot matrix were used to measure verbal and visuo-spatial memory.
Results: It was found that dot quantity comparison and word recall were positively related to non-symbolic number line estimation. Besides this, children's counting direction but not their counting skills (highest amount correctly counted blocks) was related to non-symbolic number line estimation. Children who counted from left to right had lower errors on the number line task than children who counted from right to left. The children will be tested again when they are almost 5 years old (spring 2015). The results of both data collection points will be presented during the symposium and implications for the development of number-space mapping will be discussed.

Domain-specific and domain-general effects on arithmetic: Evidences from typical and atypical development

Sarit Ashkenazi

The Hebrew University of Jerusalem, Israel

Background: The solution of math problems and basic numerical processing tasks involve many domain general (cognitive) and domain specific (preverbal magnitude representation) skills including verbal and spatial working memory, executive function, and magnitude understanding. The present work will point to the critical role of primitive spatial representation of quantities (a mental model of quantities or representation of quantities on the mental number line) in numerical cognition, supported by the mechanism of visuospatial working memory. In addition to the contributions of other domain general and domain specific factors.
Aims: In order to examine the role of domain general and domain specific processes in arithmetic, typically developed students were compared to attention-deficit hyperactivity disorder or math disability (MD) students.
Method: In different studies, participants were required to solve complex addition problems (e.g., 37 + 28) and to indicate the strategy that they use, or during fMRI scan, to solve simple addition problems (e.g., 7 + 8 = 15 correct or incorrect).
Results: Both domain specific factors and domain general factors play a significant role in the strategy selection process and accuracy of complex addition problems. Moreover, testing simple addition, we discovered that MD is characterized by a common locus of arithmetic and visuospatial working memory deficits at both the cognitive and functional neuroanatomical levels.
Conclusions: Hence, the present finding suggests that superior executive function or superior sustained attention abilities can serve as a compensatory mechanism to low approximate number system acuity (math domain specific factor). Importantly, we discovered that visuospatial working memory is an important source of domain-general vulnerability in the development of arithmetic cognition.

Situating numbers on an experienced space

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Background: Recent evidence suggests that the spatial representation of numerical concepts is grounded in sensorimotor experience. Yet, the extent to which numbers are embodied concepts is still to be clarify. Indeed, the flexibility of number-space associations suggests that people make use of different experienced directional signs to build up, online, the most compatible representation.
Aims: In two different studies we investigated whether the flexibility of number-space coding derives from the context-based selection of directional routines.
Method: A first series of experiments required bilingual participants, reading either from left-to-right or right-to-left, to map ordinal information (e.g., Arabic numbers, Hebrew/English number words and days of the week) to all fingers of their right dominant hand. A second study investigated whether spatial coding of ordinal information is grounded on working memory, by measuring spontaneous eye movements in a probe-recognition task and in a recall task.
Results: Results revealed that, while numerical information was preferentially mapped according to participants' finger counting habits (Study 1), for non-numerical ordinal sequences, reading and finger counting directions both contributed to determine a preferential spatial mapping (Study 1). Moreover, in Study 2, results showed that the ordinal sequence was encoded from left-to-right, since eye position deviated the more to the right, the later the serial position of the digit in the sequence.
Conclusions: These findings indicate that working memory is the workspace where numerical and ordinal representations are combined, by adapting previous experience to situational demands at hand.

Number-space association in synaesthesia: An FMRI investigation

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Background: The laterality effect reflects the automatic classification of numbers in terms of left versus right in relation to the midpoint 5. The size congruity effect (SiCE) shows that, when reporting the larger stimulus while ignoring its numerical value, participants are faster in congruent trials, (e.g., numerical value and physical size of the numbers match; 13), than in incongruent trials (e.g., numerical value and physical size of the numbers mismatch; 13). The SiCE increases when the numbers for bilateral, (e.g., 2–8) as opposed to unilateral pairs (e.g., 2–4). The laterality effect has been taken to reflect that, in bilateral pairs, each number of the pair is classified as left/small and right/large, whereas in unilateral pairs both stimuli are classified as either small/small or large/large, supporting the close link between numbers and space.
Aims: Here we look at the neural correlates associated to numbers and space by examining the brain response in a number-space synaestheste (M. M.) and 16 non-synaesthete controls.
Method: Participants reported the physically larger number in a size congruity task. M. M. represents numbers in the following manner: 8 6 4 2 0 1 3 5 7 9, so that large and small quantities are split against the midpoint zero. Congruity and laterality were manipulated orthogonally.
Results: Results showed that only for M. M. the SiCE in unilateral pairs elicited significant activation in right supramarginal gyrus.
Conclusions: These results strongly support the automatic activation of space by long-term numerical representation, and the role of the right supramarginal gyrus in space-numerical coding.

SYMPOSIUM 25: Language, action, and space

Convenors: Anna M. Borghi[1,2] *and Luca Tummolini*[2]

[1]*University of Bologne, Rome;* [2]*ISTC-CNR, Rome, Italy*

Background: The relation between language and space has been one of the first test beds for the embodied and grounded approaches to language because it has provided clear evidence of the role of the body and of perceptual processes in grounding language comprehension. Besides the body and perception, the linguistic encoding of space could as well be grounded on action both in individual and joint action contexts.
Aim: The symposium explores the relation between space, language and action in different contexts. In order to do so it brings together researchers working on the relationship between language, action and space in its multifaceted dimensions. Among others, the symposium aims to address the following issues: how are spatial prepositions and demonstratives conceptualized? What is their relationship with action and with the bodily space? How do different languages, including sign languages, differently capture the spatial dimension? How do perspective and context influence language learning and language comprehension?
Approach: It is highly multidisciplinary since the speakers address the topic starting from different disciplines, from linguistics to psychology and cognitive neuroscience to computer science and robotics, and using different methodologies, from linguistics analyses to experiments to computer simulations.

Linguistic relativity or semantic universals of space? A fresh look at spatial frames of reference

Holger Diessel

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Background: Languages differ in the way they describe space, but there is one aspect of spatial language and cognition that has long been considered universal: the tendency to conceptualize and encode space from of an egocentric, body-oriented perspective. However, this hypothesis has been challenged by Levinson and colleagues who found some unexpected cross-linguistic differences in the use of spatial frames of reference. While speakers of European languages

tend to rely on an egocentric frame of reference, speakers of certain other languages often draw on geographical landmarks or cardinal directions to describe the same spatial scene. This has led Levinson and colleagues to challenge some longstanding assumptions about spatial cognition and language. Specifically, they claim that the body-oriented coordinate system is not generally the most important frame of reference and that semantic parameters of space are not universal (e.g. Levinson 2003).
Aims: In this paper I will take issue with these claims arguing that while linguistic field work has revealed some important cross-linguistic differences in the encoding of space, these findings are not sufficient to question the dominance of the egocentric frame because the most important class of spatial expressions, i.e. demonstratives such as this/that and here/there, are egocentric by definition, but these expressions have been disregarded in the debate about spatial frames.
Method: The analysis is based on a large typological database including information on spatial expressions from more than 300 languages. The data have been gathered from a wide range of sources, e.g. grammatical descriptions, field notes, and the consultation of native speakers.
Results: The analysis shows that demonstratives are generally interpreted within an egocentric frame of reference and that they exhibit a number of properties that characterize them as a particular word class. Demonstratives are universal and non-derived and generally among the earliest words children learn. What is more, demonstratives are much more frequent than all other spatial expressions that do not invoke an egocentric frame.
Conclusions: Taken together, these data suggest that demonstratives are of central significance for spatial language and cognition, supporting the traditional view that there is a general tendency to conceptualize space from an egocentric, body-oriented perspective.

Spatial demonstratives and perceptual space

Kenny R. Coventry

School of Psychology, University of East Anglia, UK

Aims: To examine the relationship between spatial demonstratives (e.g. this and that) and (non-linguistic) representation of space (measured by memory for object location). These words are among the oldest words in all languages, occur in all languages, and are among the earliest words acquired by children—yet empirical work on these terms is in its infancy.
Method: The results of a large series of experiments (8–11, time dependent) will be presented using a novel 'memory game' methodology (Coventry et al. 2008, Cognition; Coventry, Griffiths & Hamilton, 2014, Cognitive Psychology) designed to unpack the relationship between naturalistic spatial demonstrative choice and memory for object location. The experiments manipulated where an object is placed (distance from participant), various properties of the placed objects (familiarity, visibility, ownership), and the dependent variables were demonstrative choice (% use of this) and the difference between memory for location and actual location.
Results: Demonstrative choice (in English) is affected by (a) peripersonal/extrapersonal space, (b) object familiarity, (c) object visibility, (d) object ownership. Memory for object location is affected by (a) peripersonal/extrapersonal space, (b) object familiarity, (c) object visibility, (d) object ownership. Furthermore, there is a correlation (within participants) between demonstrative choice and memory for object location.
Conclusions: There is a direct mapping between language using to refer to objects in space and the (non-linguistic) representation of where objects are in space. Memory for object location is a concatenation of where an object was, and expectations regarding where an object is expected to be. Language employs these representations when mapping onto the spatial world.

Perspective and bodily space in language comprehension

Anna M. Borghi

University of Bologna and ISTC-CNR, Rome, Italy

Background: According to embodied and grounded views participants form a perceptual and motor simulation during language comprehension. One possible limitation of the current studies, however, is the implicit assumption that participants adopt the perspective of the agent performing an action in a rather stable way (Beveridge & Pickering, 2013). Recent research in this field is however starting to emphasize the role played by the context for simulation, highlighting the variability of the adopted perspective.
Aims: During the presentation I will overview recent behavioral and kinematics evidence on language comprehension obtained in our lab.
Method: We will focus on behavioral evidence (RTs and kinematics).
Results: Results of these studies indicate that the adopted perspective flexibly shifts depending on the potential for action an agent has in a context. Specifically, this potential for action can be modulated by linguistic factors, as pronouns and demonstratives: e.g., hearing someone producing "I" leads to faster reaching of objects in a common space (Gianelli et al., 2013; Tummolini et al., in prep.); by the distance of objects from our own body: with near objects close we adopt the agent's perspective while processing action verbs (Costantini et al., 2011); by the situation: we typically conceive objects from the outside, from the front, up close, and visually, but can occasionally ovveride these default perspectives when needed (Borghi & Barsalou, in prep.).
Conclusion: Overall, this evidence testifies that assuming a given perspective is the basis of grounding and situating language, and confirms that perspective is highly variable and flexible.

Actions and spatially informative cues in spoken language comprehension: Evidence from eye tracking

Pia Knoeferle

Bielefeld University, Germany

Background: Much research has examined how either action depictions or spatial cues affect language comprehension, and both of these cues seemto rapidly affect a listener's visual attention.
Aims: To inform models of situated language comprehension it is essential to examine effects of different non-linguistic cues both individually and in combination. To this end, we compared the effects of action depictions with that of spatially informative cues during situated language comprehension.
Method: We recorded participants' eye movements to objects in a scene during the comprehension of related spoken utterances. We crossed two factors, the presence of depicted actions (present vs. absent) and of speaker gaze (present vs. absent), both cueing a target character. Position of the action, when present, did not cue the

location of the target character, but the direction of the gaze cue did. Post-trial, participants performed a verification task and post-experiment they completed a memory test.
Results: Two cues were not better than one and the spatially informative gaze cue influenced visual attention to the target character earlier than the action depictions. However, benefits of the action depiction (but not of the spatially informative gaze cue) emerged during a post-experiment memory test.
Conclusions: These results suggest that distinct visual cues are not necessarily on a par in informing language comprehension and short-term memory encoding but that we must consider their specific relation to language and their function in language comprehension.

Spatial agreement in Italian sign language

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Background: Linguistic research has led to the discovery and description of a very large number of national sign languages, including Italian Sign Language or LIS (Russo & Volterra, 2007), highlighting that grammar and syntax are expressed through modulation of movement, facial expression and in particular the use of space (Emmorey, 2003). The study of sign languages represents a fruitful and promising research line forinvestigating issues crucial for embodied and grounded cognition perspectives.
Aims: We aim to show the role played by space in LIS at lexical and grammatical levels analysing data collected with a sentence repetition task recently developed to assess language skills of children and adults exposed to Italian sign language (LIS).
Method: Ten sentences differing in length and degrees of linguistic complexity were presented. Twenty signing children, 10 deaf and 10 hearing, (age range 8–11 years) and ten deaf signing adults were individually encouraged to repeat each sentence. All repetitions have been videorecorded and analysed.
Results: Space has been used to express different syntactic and grammatical linguistic functions: such as agreement between elements and transfer in space of classifiers constructions. Strong similarities appear in the use of space by adults and children. Asophisticated use of space is acquired quite rapidly, also by hearing children, exposed to LIS at school age.
Conclusions: Signs are, like words, arbitrary, but, being performed with the body, they are more "visible". The simultaneous articulation in spaceof two, or more, units of sense, represents an important cue to understand conceptual representation.

Embodied language learning in humanoid robots

Angelo Cangelosi

Plymouth University, UK

Background: Growing theoretical and experimental research on action and language interaction and on number learning and space representation clearly demonstrates the role of embodiment in cognition and language processing. In robotics, these studies have important implications for the design of linguistic capabilities in cognitive agents and robots for human–robot communication, and have led to the new interdisciplinary approach of Developmental Robotics (Cangelosi & Schlesinger 2015).
Aims: During the talk we will present examples of developmental robotics models and results from iCub experiments on the embodiment biases in early word acquisition studies and number and space interaction effects.
Method: The talk will give a brief overview of the cognitive architectures and experimental setups and methods used in the robotics studies on language and number learning.
Results: Results of several experiments on language and number learning will be presented, both through data charts and videos of robot experiments.
Conclusions: The presentation will discuss the implications of these studies for the "symbol grounding problem" (Cangelosi, 2012) and how embodied robots can help addressing the issue of embodied cognition and the grounding of symbol manipulation use on sensorimotor intelligence.

SYMPOSIUM 26: The body in space

Convenor: Martin Riemer

Aging and Cognition Research Group, DZNE Magdeburg, Germany

Background: Representations of the human body and of the space surrounding it are inherently linked, because the body is the target of environmental effects and the origin of intentional actions upon this environment. Our bodies are experienced as spatial extensions of our phenomenal selves, and the conception of perceived space without the conception of a perceiving self being located within that space is absurd. I cannot perceive space, unless *I* exist in space. The representation of space necessarily relates to a first person perspective, from which it is perceived and which lies within the bodily borders. The space immediately surrounding this body is more relevant for direct actions, and so it is represented differently (e.g., in greater detail) than the more distant space. As a consequence, changing the location and the posture of the own body has immediate effects on the spatial representation of the environment.
Aim: In this symposium, recent research on the link between body and space representations will be presented. Further, it shall provide an insight into specific methods which are frequently used within the field.
Approach: The contributions include studies on the spatial perception of single body parts (e.g., during the rubber hand illusion and after prism adaptation), as well as studies on perceived location and motion of the whole body through space (e.g., in full body illusions, path integration and spatial navigation).

Human navigation in real and virtual environments: The role of locomotion

Ineke J. M. van der Ham

Experimental Psychology, Utrecht University, The Netherlands

Background: In the last few decades, the use of virtual reality in spatial cognition research has greatly increased and the technical

qualities of this method have also vastly improved. Recent developments allow for the integration of real and virtual environments during spatial tasks. This integrated approach allows for a stronger physical involvement in the virtual environment
Aims: The aim of the current experiments was to examine spatial performance in different virtual and real environments, to determine the potential effect of physical involvement.
Method: In experiment 1, route knowledge after learning in a virtual, real, or mixed (virtual and real) environment was measured. Participants were actively walking in both the real and mixed environment. In experiment 2, sports performance (direct shots at a soccer goal) was assessed by means of interactive virtual environments.
Results: In experiment 1, data show that route learning in a mixed environment leads to cognitive performance comparable to learning in a real environment, while maintaining the advantages of using virtual input. Experiment 2 showed that participants' experience of a physical activity was significantly affected by viewing virtual replays of that activity; positively modified replays resulted in higher sense of competence, negatively modified replays had the opposite effect. However, performance was not affected by these replays.
Conclusions: Locomotion plays an important role in the success of using real and virtual environments. Mixed environments may be a valuable tool to assess navigation with virtual presentations, while maintaining real locomotion. These findings could be applied to professional soccer training.

First person perspective: A methodological constraint for path integration studies?

Martin Riemer and Thomas Wolbers

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Background: Studies on path integration are constrained by the fact that spatial distances are always perceived from the vantage point of the body. A spatial distance cannot be perceived per se, but only from the first person perspective. This constraint potentially affects production tasks, in which participants are asked to cover a previously learned standard distance, and discrimination tasks, in which participants have to compare the lengths of two travelled paths. However, responses in reproduction tasks are given while the participant is moving along the path to be estimated, whereas judgments in discrimination tasks are required only after both distances have been completed.
Aims: It was tested whether distance reproduction and distance discrimination are differentially affected by an egocentric coding of space.
Method: Using an immersive virtual environment set-up, subjects performed distance discrimination and reproduction tasks. Interference with egocentric spatial coding was induced by repetitive TMS over the right posterior parietal cortex (PPC).
Results: We report differential effects on the two psychophysical tasks. In distance discrimination, TMS selectively decreased response variability, while the mean accuracy of judgments was unaffected. In distance reproduction, TMS had a selective effect on judgment accuracy, while response variability was not affected.
Conclusions: Errors in distance reproduction do not coincide with judgment accuracy, but rather with altered judgment precision. These results allude to an inherent difference between discrimination and reproduction tasks, which can be traced back to a differential impact of the first person perspective on spatial distance perception.

Body and space: Theoretical concepts and controversies

Jörg Trojan

University of Koblenz-Landau, Landau, Germany

Background: Recent years have seen a revived interest in how body and space are represented perceptually and how they affect human cognition and behaviour. Various conceptualisations of body and space have been proposed, alternately stressing neurophysiological, cognitive, or social aspects, but unified approaches are scarce.
Aims: This talk will give an overview of different views on body and space.
Method: I will review several theories and empirical studies and discuss similarities and differences.
Results: At least three relevant dimensions can be identified in which concepts of body and space may differ: (1) Perspective: While we conceptually differentiate between body and space perception, they imply each other and the underlying mechanisms overlap. (2) Level: Representations of body and space may emerge at different processing levels, from spinal mechanisms guiding reflex movements to those we construct in our imagination. (3) Affect: Bodily and spatial stimuli differ considerably in respect to their affective content. Affect does not only "colour" representations, but guides attention and can distort spatial perception.
Conclusions: Despite many empirical findings, our current views on body and space representations remain ambiguous. One problem may lie in the implicit diversity of "bodies" and "spaces" examined in different studies. Specifications of these concepts may help understand existing results better and are important for guiding future research.

Prismatic lenses and pain

Diana Torta[1] and Jörg Trojan[2]

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Background: Prism adaptation (PA) is a non-invasive procedure which combines visual displacement with a visuo-motor pointing task to promote a reorganization of sensorimotor coordination that may expand to spatial cognition. Prismatic displacement (PD) of the visual field can be induced when prisms are worn but no sensorimotor task is required. PD induces cross-modal conflicts between proprioception and vision.
Aims: Here we explored the effect of PA and PD on the perceived intensity of nociceptive and non-nociceptive somatosensory stimuli. In this way we were able test the effects of spatial remapping and cross-modal conflicts on somatosensory processing.
Method: In three experiments in 41 healthy volunteers we induced PA (experiments 1 and 2) or PD (experiment 3) while participants had to rate the intensity of nociceptive and non-nociceptive somatosensory stimuli applied to the hands.
Results: Our results indicate that: (1) PA leads to a detention of habituation for nociceptive and non-nociceptive somatosensory stimuli; (2) PA leads to a detention of habituation for nociceptive stimuli at both hands; (3) the visuo-proprioceptive conflict induced by PD does not reduce the perceived intensity of the stimuli.

Conclusions: Taken together, these data indicate that a realignment of visual and motor coordinates can directly affect the perceived intensity of somatosensory stimuli, in contrast to cross-modal conflicts that have no effect on somatosensory processing.

Spatial perception of artificial hands and phantom limbs

Xaver Fuchs

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Background: Proprioceptive awareness, i.e., the percept of the spatial configuration of the body, can be conceptualized as a multimodal internal model. In parts, this model is malleable and can be updated by sensory input. Proprioception is elemental, but other senses, for example vision, also have a strong influence. Another component of the model is more hard-wired and maybe even innate. Phantom limbs are an often-quoted example supporting this view. However, the interaction of sensory information and (predisposed) boundaries of perception are still unclear.
Aims: We intended to examine how vision and proprioception are integrated in proprioceptive position judgments in healthy volunteers (study 1) and relate these findings to localizations of phantom limbs in amputees (study 2).
Method: In study 1, we used the rubber hand illusion paradigm (RHI) to induce embodiment of an artificial hand and had volunteers localize both their real hand and the artificial hand. In study 2, we had upper limb amputees localize anatomical positions of their phantom hand. In both studies we used a psychophysical approach, i.e., pointing gestures with the hand.
Results: In study 1, we observed a convergence of perceived positions of the real and the artificial hand towards each other. This finding is in line with perceptual "fusion" accounts of multisensory integration. Study 2 showed that some amputees were able to point to their phantom while others had difficulties with this novel task. The investigation of spatial perceptual attributes of phantom limbs remains a challenge for psychophysical testing.

Self-location and its relation to body ownership in full body illusions

Antonella Maselli

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Background: Self-location refers to the experience of occupying a given position in the environment. Recent research has addressed self-location as one of the key components of self-consciousness, together with the experience of owning the physical body (ownership). An important tool for exploring these components and their multisensory basis is provided by body illusions. Although self-location and ownership are strictly linked to each other (through the body that collects/conveys information from the body and the environment to the brain), recent studies suggest that they may have different neural substrates. Furthermore, the way they reciprocally interact is still under debate. In particular, it is not clear to which extent, during full body illusions, changes in self-location entail changes in ownership.
Aims: To show that self-location and ownership can be dissociated under specific multisensory conflicts. To discuss the differences among the two, in terms of multisensory components and neural substrates.
Method: Immersive virtual reality was used to induce full-body illusions while providing different visual perspectives over an avatar. Self-location and ownership towards the virtual body were assessed with both subjective and objective response variables.
Results: The visual perspective is shown to have a critical and differential impact on self-location and ownership. Seeing the body in the far extra-personal space selectively affects self-location, while concurrent changes in ownership and self-location can be elicited when the physical and virtual bodies overlap in space only partially, even in presence of first-person-perspective violations. Implications for plausible brain mechanisms involved in these altered perceptions will be discussed.

SYMPOSIUM 27: Synchronous movement, cooperation and the performing arts

Convenors: Daniel C. Richardson[1] and Guido Orgs[2]

[1]Department of Experimental Psychology, University College London, UK; [2]Division of Psychology, Department of Life Sciences, Brunel University, UK

Background: When two people meet, they become more like each other. They imitate each other's accent, speech rate and syntax; they look at the same things and use the same words; they adopt similar postures, gesture alike and gently sway together. This behavioural coordination studied in social psychology seems to produce feelings of liking and affiliation between pairs of people. However, little is known of whether these mechanisms of dyadic interaction also describe group interactions, whether moving, singing and chanting together also means that people feel closer to each other and are more likely to cooperate. While it has been observed that across all cultures people dance, little is known about what function dance and the performing arts fulfill in society. The possibility we explore here is that the aesthetic appeal of dance is rooted in the psychological mechanisms of everyday social interactions. Conversely, we propose that the aesthetic principles from dance and choreography can be exploited to study group cooperation.
Aim: We will explore two dimensions of behavioural coordination that have been largely unexplored: its scale and scope. We will look at research extending the scale of coordinated action from pairs of people to groups and crowds, and investigate the scope of its effects, going beyond traditional appears of group affiliation to a discussion of creativity, aesthetics and culture.
Approach: The symposium will start with an overview of behavioural coordination research (Daniel C. Richardson). The next two talks investigate what happens when *more than two* people synchronize their movements in space and time (Emma Cohen & Bronwyn Tarr, Jorina von Zimmermann). In the final part of the symposium, we will look into how group coordination relates to the *creation* (Kate Stevens) and *aesthetic appreciation* (Staci Vicary/Guido Orgs) of performing dance. We will close with an open discussion, summarising future challenges for the field (Guido Orgs).

Behavioural coordination

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Background: Studies on path integration are constrained by the fact that spatial distances are always perceived from the vantage point of the body. A spatial distance cannot be perceived per se, but only from the first person perspective. This constraint potentially affects reproduction tasks, in which participants are asked to cover a previously learned standard distance, and discrimination tasks, in which participants have to compare the lengths of two travelled paths. However, responses in reproduction tasks are given while the participant is moving along the path to be estimated, whereas judgments in discrimination tasks are required only after both distances have been completed.
Aims: It was tested whether distance reproduction and distance discrimination are differentially affected by an egocentric coding of space.
Method: Using an immersive virtual environment set-up, subjects performed distance discrimination and reproduction tasks. Interference with egocentric spatial coding was induced by repetitive TMS over the right posterior parietal cortex (PPC).
Results: We report differential effects on the two psychophysical tasks. In distance discrimination, TMS selectively decreased response variability, while the mean accuracy of judgments was unaffected. In distance reproduction, TMS had a selective effect on judgment accuracy, while response variability was not affected.
Conclusions: Errors in distance reproduction do not coincide with judgment accuracy, but rather with altered judgment precision. These results allude to an inherent difference between discrimination and reproduction tasks, which can be traced back to a differential impact of the first person perspective on spatial distance perception.

Collective speech and coordinated action

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Background: Anybody who has ever taken part in a demonstration, participated in collective praying, sang together with a huge crowd at a concert, or chanted in unison with thousands of other football fans, knows the powerful sensation which collective speech can induce. When we speak, sing, chant, or pray with each other simultaneously, our voices unite to become one.
Aims: Anthropologists have speculated that collective speech enhances group bonding and facilitates group action: those that chant together hunt well together.
Method: We conducted studies in which large groups of participants either chanted words together for a few minutes, or read them out loud individually and out of sync for the same amount of time. Later they played a group coordination game, took a memory test for those words and rated their perceptions of the group.
Results: Our results showed that participants who chanted together in synchrony did better at the subsequent group coordination task, felt more attached to each other, and even remembered more of the words they had previously recited.
Conclusions: The effects of activities carried out together can be observed across modalities. Synchronised speech can have the same positive effects on group affiliation, which have already been shown in relation to synchronised body movement, and also improve group action coordination and individual's memory. Anthropologists have interpreted collective and synchronous movement and speech as fostering group cohesion for centuries. The empirical evidence, which we present, suggests that they were right.

Synchrony, exercise and social bonding

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Background: Social scientists have long hypothesized that group movement in exercise, dance, and drill enhances social cohesion and solidarity. Our research explores causal mechanisms linking group movement and social bonding.
Aims: We present the results of two experimental studies that investigate two interconnected claims: exertive and synchronous movement forges social bonding between participants that is mediated by neurophysiological reward; cues of social support, reciprocally, enhance physical performance in exercise via heightened pain and fatigue thresholds.
Method: Study 1 manipulated synchrony and exercise intensity in a 2-by-2 between-subjects design, and measured social bonding outcomes via standard social bonding questionnaires. In a within-subjects design, Study 2 manipulated cues to social bonding in a warm-up phase, and measured subsequent performance in a challenging anaerobic test.
Results: In Study 1, synchrony and exercise intensity produced independent effects on social bonding—participants in the synchronous and higher intensity conditions reported greater social closeness than participants in the non-synchronous, lower intensity conditions. In Study 2, compared to controls, the condition priming bonding was associated with significantly higher physical performance.
Conclusions: The studies offer support for a relationship between social bonding and coordinated, exertive group movement. Further work is required to elucidate the conditions under which synchrony leads to bonding, and particularly the importance of perceived 'togetherness' and intention in coordination activity. The neuropsychological mechanisms by which social support reduces fatigue and enhances physical performance merit further exploration also.

Distributed cognition and creativity: Effects of collaboration and familiarity on improvising contemporary dance

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Background: In contemporary dance, cognitive events are not necessarily restricted "to the skin or skull of an individual" (Hutchins,

2001) but distributed across dancers during collaborative improvisation. There is some experimental evidence of greater output when people perform problem-solving tasks alone. However, when a task is challenging and paired participants are familiar with each other, pairwise and emergent outcomes are more plentiful than solo outcomes.

Aims: We investigate these factors in the context of dance with the broad hypothesis that innovation is enhanced when dancers improvise together compared with when they improvise alone.

Method: Dancers in a professional company improvised for 2 min alone and then with another dancer. Dancer familiarity (familiar, unfamiliar) and task (expressive, non-expressive) were crossed (within-subjects). The improvisations were video-recorded over 2 h in the dancers' usual improvisation space. After each improvisation, the dancers: stated the number of movement ideas expressed and rated task ease, satisfaction, interest, novelty, originality and clarity.

Results: In the expressive task, the dancers self-reported the expression of a greater number of movement ideas expressed in familiar and unfamiliar pairs (median = 3) than alone (median = 2). Ratings of task ease, satisfaction, interest, clarity, etc. were slightly higher in the unfamiliar pair condition. In the non-expressive task, familiar and unfamiliar pairs again yielded a greater number of self-reported movement ideas (median = 5) than in the solo setting (median = 3.50); ratings of the task were also higher in pairs ($M = 3.02$, SD = 0.82) than in the solo ($M = 2.67$, SD = 0.96) condition.

Conclusions: Distributed creativity, relational cognition, and social facilitation will be used to explain the results.

Aesthetic perception of movement synchrony in dance

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Background: Synchronised movement is an essential and perhaps universal aspect of performing dance. Previous studies have demonstrated that moving in synchrony with others leads to enhanced interpersonal cooperation, trust and liking. Here, we proposed that observing others moving in synchrony might also influence aesthetic appreciation of a dance performance

Aims: The experiment reported aimed to determine whether the presence of movement synchrony among performers influences aesthetic perception of dance within an audience.

Method: We conducted an experiment in which participants observed a dance piece involving movement that was either performed synchronously or asynchronously. During execution (performers) and observation (audience members) of this performance we measured movement synchrony and psychophysiological measures of arousal, including heart rate and skin conductance, using wrist sensors. Explicit ratings of aesthetic appreciation and perceived group characteristics were also collected during and after the performance.

Results: It was hypothesised that the physiological responses of observers would vary as a function of the amount of movement synchrony present amongst the perfomers. Aesthetic ratings, too, were expected to change with respect to the presence versus absence of movement synchrony. Results demonstrating the time sensitive coherence in physiological response between observers and performers at the group and pairwise level will be discussed. The influence of movement synchrony on continuous ratings of explicit aesthetic appreciation will also be demonstrated.

5. Abstracts of Talks

Abstracts are listed alphabetically according to the first author's last name.

Switching reference-frame preferences during verbally assisted haptic-graph comprehension

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Background: Statistical line graphs are widely used in multimodal/educational settings. They present data eliciting the detection of second order entities (e.g. extrema or trends). For visually-impaired people, haptic-audio interfaces, that provide haptic exploration of graphs accompanied by sounds or speech, are suggested for substituting visual graphs.
Aims: Verbally assisted haptic graph exploration can be seen as a task-oriented collaborative activity between two partners, a haptic explorer and an observing assistant, which are disposed to individual preferences for using reference frames. We have hypothesized, that haptic explorers' spatial reference frames are mostly induced by hand movements (action-perspective), whereas the sighted assistants' reference frames are evoked by the provided global view of the graph, integrating the line's direction, conventionally left-to-right, into a "spatiotemporal-perspective".
Method: 13 participant pairs collaborated in exploring seven haptic graphs. All dialogs were video-recorded. While explorers explored the graph haptically, assistants had visual access to both the graph and explorer's exploration process and provided assistance when requested.
Results: The results indicated clear cases of 'misinterpreting descriptions' during 'right-to-left explorations' due to explorers' preference to action-perspective. However, when they realize possible conflicts in graph reading, they switch to spatiotemporal-perspective, which is more relevant for graph conceptualization. The results also indicated that preferred perspective could be switched w.r.t communicational goal; navigational versus descriptional.
Conclusions: Verbal assistance systems should align itself to explorer's current perspective for the sake of successful communication; however the explorer's perspective is not always the most efficient perspective; therefore the assistance should be produced by considering this gap.

Using visual information for spatial advice giving in a primate-inspired autonomous robot

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Background: This paper presents the culmination of a 3-year project on primate-inspired vehicle navigation first reported at ICSC-2012, presenting the project's final results.
Aims: The goal is to find means to complement existing robot navigation methods drawing upon models of mental rotation to reconcile differing frames of references. This allows perspective-taking when given spatial advice by translating it into visual cues prior to beginning a journey. Objectives include creating models by which primates cognitively manipulate spatial information; develop associated perceptual techniques using depth imagery; and integrating these ideas on robots.
Method: Region segmentation or object recognition of current location and projected goal images are derived from Kinect sensor (RGBD). A bootstrap phase initializes object/key segments that correspond to the desired target in both images, after which a feedforward visualization at the aligned orientation (inspired by visual-analog mental rotation models) is performed iteratively on incoming sensor data, guiding the robot to its destination. Spatial advice is presented during the bootstrap phase regarding destination/waypoints in terms of objects and/or scene features.
Results: Results are presented on a Pioneer robot using depth imagery and illustrated with video. Iterative refinement of a navigational trajectory using this method provides a complement to existing navigational methods through the reconciliation of differing frames of reference generated from the current vantage-point, the anticipated goal, and spatial advice from the user regarding objects encountered along the way.
Conclusions: Successful robot navigation based on a process inspired by mental rotations in primates has been achieved and shown through experimental results.

Sensorimotor interference in reasoning from imagined perspectives

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Background: Many tasks of everyday life entail adopting imagined perspectives in spatial environments (e.g., when providing route directions to others). Past research has shown that in many situations people find it difficult to suppress information about their actual perspective in order to reason from imagined perspectives due to sensorimotor interference exerted by the orientation of their body.
Aims: The aim of the project was to evaluate the presence of sensorimotor interference in a variety of learning/testing combinations ranging from reasoning about environments depicted on a computer screen to immersive environments experienced in Virtual Reality and testing while embedded or disembedded from the memorized environment.
Method: Across a series of experiments participants were asked to study spatial environments and memorize the layout of objects contained. Their memory was then tested through perspective taking trials that required pointing to the location of an object from an imagined perspective.
Results: Results indicated that when participants were tested while embedded in the spatial environments they had memorized they had more difficulty responding from an imagined perspective than when tested at a remote location. This was supported by the presence of larger alignment effect (i.e., greater difference between responding from an imagined and an actual perspective) and the inability to benefit from the advance information of perspective information.
Conclusions: Overall, our findings indicate the important role of sensorimotor information for reasoning about immediate spatial

relations and support the predictions of Avraamides & Kelly (2008) on the organizational structure of immediate and distal memories.

Prototype effects on the retrieval of spatial location

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Background: Humans are thought to subdivide space by boundaries. Within these boundaries, memories of the spatial location of visual stimuli are thought to be weighted by their distance to an assumed centre. This produces biases in spatial memory towards this so-called prototype. Previous studies have tested prototype effects using circular shapes, showing systematic response biases towards the centroids of each quadrant. These biases seem to reflect a subdivision of the shape along the horizontal and vertical meridians. However, this seemly universal division of space might not be relevant when the intrinsic geometry of the shape facilitates other subdivisions.
Aims: To test this, we compared categorical effects across different geometrical shapes.
Methods: Participants had to remember the location of a dot in a square, rectangle, circle and rhombus. Then, reproduce with the mouse cursor the location of the dot in the same figure, presented in a different location.
Results: We found similar patterns of biases for the square, rectangle and circle. That is, subjects misplaced dots towards the centroids of each quadrant, as if they were imposing horizontal and vertical boundaries dividing the shapes into quadrants. Analyses of cosine similarity between localization errors and predicted errors towards prototypes confirmed this pattern. We did not find any systematic bias when the remembered dots were presented inside a 90° rotated square (rhombus).
Conclusions: This clearly speaks against a universal division of visual space along the horizontal and vertical meridians in retinal space. Instead, humans appear to divide visual space as a function of the shape of surrounding boundaries.

Planning with the eyes: End state comfort effects in gaze behaviour

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Background: Current motor planning is influenced by the anticipation of more convenient final postures. This effect, termed the End State Comfort effect, has been shown in various circumstances. For example, when grasping an inverted object, an awkward hand posture (i.e. a thumb-down grasp) is usually applied.
Aims: A wealth of studies has demonstrated that our gaze selects the next target to grasp and fixates it until the hand has reached it. We asked the question, whether our eyes reflect further anticipatory considerations for guiding manual interactions. Can the End State Comfort also be seen in eye fixations?
Method: Participants were confronted with one of three familiar objects, either standing upright or upside down, in each trial. They were asked to either drink out of the presented object or to hand it over to the experimenter. Eye movements were recorded via eye-tracking glasses, hand movements via an electromagnetic motion tracker.
Results: Fixations significantly concentrated and lingered in Areas of Interest corresponding to the placement of the index finger, which varied systematically depending on the object orientation. Task effects were also partly present, suggesting that further orders of planning are detectable in gaze behaviour.
Conclusions: Our results show that the End State Comfort and further orders of planning are detected as early as gaze control, prior to grasping. This might have far-reaching implications for deducing action intentions by monitoring the eyes. Moreover, the results indicate that manual and eye fixation planning regions in the brain are even more interactive than previously assumed.

Tracking down the path of memory: Eye scanpaths facilitate retrieval of visuospatial information

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Background: Eye movements and fixations occur spontaneously during recall from long-term visual memory and recent research provides support for the hypothesis that executing these fixations plays a functional role in the retrieval of stored information. However, evidence about whether the spacetime sequence (i.e., scanpath) of these eye fixations is also relevant for the accuracy of memory remains sketchy and ambiguous.
Aims: The main aim of the study was to investigate the role of eye movements' sequences in long-term visuospatial memory.
Method: Eye fixations were recorded while looking at a checkerboard-like pattern during a 8 s encoding. Two days later, in a recognition session, animations were shown where each square that formed the pattern was presented one by one, either according to the same, idiosyncratic, temporal sequence in which they were originally viewed by each participant or in a shuffled sequence although the squares were always in their correct positions. Afterwards, participants judged whether they had seen the same pattern before or not (50 % probability).
Results: Showing the elements according to the original scanpath's sequence yielded a significantly better recognition memory than in the shuffled condition. When participants maintained gaze on the center of the display so that gaze was restricted from enacting the sequence, the advantage of memory accuracy disappeared.
Conclusions: Scanpaths (i.e., the order of fixations and not simply their positions) are functional to visual memory and that physical re-enacting of the original, embodied, perception can facilitate retrieval from long-term visual memory.

The influence of travel behavior on cognition of urban environment

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Background: A widely accepted claim in research on spatial cognition says that the acquisition of spatial knowledge occurs through an

active human–environment interaction. Mobility patterns to and through the activity sites belong to the most significant types of everyday spatial behavior in large scale settings and, thus, have impacts on the acquisition and processing of spatial knowledge.
Aims: This paper examines the effect of travel behavior on the acquisition of spatial knowledge in urban environment.
Method: Two groups of participants living in Riga were surveyed: youth aged 12–17 (n = 213) and adults (n = 176). To acquire data reflecting cognitive representations of urban environment we applied a spatial preposition task and two distance estimation tasks.
Results: The analysis of data shows that the mode of transportation and the level of mobility significantly determine the extent of spatial knowledge. Those participants from both groups that are more active travelers (e.g., frequently walk or bicycle) are more accurate in distance estimation and spatial preposition tasks. At the same time there are no significant differences among those who use passive modes of transportation: the accuracy in spatial representations of urban environment was similar among car drivers, public transport users and car passengers. Therefore, our findings do not support the assumption that car driving is a type of active exploration of the environment.
Conclusions: Our study provides clear evidence that the increase in active interaction with the urban environment generates a richer and more accurate representation of it. Diverse urban transportation experiences have impact on different cognitive structures of urban environment and further shape the processes of spatial decision making and navigation.

Onomatopoeias and ideophones: A new study about the interface between space, image schemas and phoneme clusters

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Background: Onomatopoeias (< old Greek ὀνοματοποιία; ὄνομα 'name', ποιέω 'I make') are mimetic elements representing sounds, and lexicalizations of sounds (to smack). A large set of problems, studies and analyses (based on repositories: Gubern & Gasca 2008: 1000 lemmas; corpora: Zlatev 2007; algorithms: Asaga, Mukarramah, & Watanabe 2008) has been related to onomatopoeias since Cratilo's analysis of the analogical dimension of verbal language. Nonetheless, it is still difficult to adopt a (semantic, functional, or grammatical) descriptive and explicative model of onomatopoeia, because the rules that constrain processes of selection and construction remain idiosyncratic and variable (Dogana 2002, Catricalà 2011).
Aims: Our classification model is based on spatial cognition criteria. The hypothesis (Catricalà 2011) is that onomatopoeias are related to Image Schemas (Johnson 1987), i.e., to the visual mapping of a movement. We also refer to Force Dynamic (Talmy 1983; Jackendoff 1990) as a basic model of conceptual maps (Langacker 1999).
Method: We verified the hypothesis analyzing the onomatopoeias of the Gubern & Gasca dictionary (2008). Moreover, we present an experiment centered on pseudo-onomatopoeias interpretation, i.e., the association between specific categories of pseudo-onomatopoeias and specific spatial/movement patterns. Categories are related to the presence of specific phonemes and phoneme clusters, while visual patterns correspond to different Image Schemas.
Results: Most part of data confirms a correlation between Image Schemas as CONTAINER/CONTAINMENT (crunch, plop) or SOURCE-PATH-GOAL (tattarrattat 'shots') and an occlusive consonant, while liquid and trill consonants correlate with PATH (vroom).
Conclusions: The model needs to be tested on further corpora; it accounts for the polysemy and synonymy that characterize onomatopoeias across languages and cultures.

Recollecting words while processing space: An interference paradigm

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Background: Remembering is the ability to consciously relive a past event. It relies on spatial processes allowing reconstructing a specific viewpoint on the past event. The exact spatial processes involved in remembering remain however unclear. Indeed, models linking episodic memory and space assign different roles and weights to egocentric and allocentric processes.
Aims: The present experiment compares allocentric and egocentric spatial processes interference effects on remembering performance.
Method: Participants performed simultaneously an allocentric or an egocentric spatial task and a memory task (either an episodic or a semantic task). Spatial tasks were adapted from Simons and Wang's (1998) study. Participants studied first an object layout followed by either a rotation of both the participant and the layout (viewpoint maintenance: egocentric condition) or a rotation of the layout alone (mental rotation: allocentric condition), and then they had to indicate which object had moved. Participants performed the memory task during the rotation: they judged the semantic similarity between two heard words (semantic task) or they recollected the study list of a heard word (episodic task).
Results: Results indicated that participants responded faster and more accurately to the egocentric than the allocentric task. Reaction times in the episodic task were however longer when participants performed the egocentric than the allocentric task. Conversely, participants were slower in the semantic task when they performed the allocentric task.
Conclusions: These results indicate that, although the egocentric process is the easiest to perform, it specifically disturbs remembering. Therefore, the egocentric process is more likely to be involved predominantly in episodic memory.

Spatial frames of reference in traditional Negev Arabic: Language-to-cognition correlation

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Background: Frames of Reference (FoRs)—Intrinsic, Relative, Absolute—are cognitive and linguistic strategies used to project coordinate systems onto spatial arrays, to conceptualize angular relations between Figure (F) and Ground (G) objects: Levinson (2003) assumes that linguistic prevalence of one FoR, the normal state in every language, is reflected in cognitive activities. In Yucatecan, a referentially promiscuous system (RPS)—using all three FoRs without 'default perspective'—the language-to-cognition consistency is not verified (Bohnemeyer 2011).

Aims: To investigate the language-to-cognition match in speakers of Traditional Negev Arabic (TNA), a RPS.
Method: I created slots of spatial arrays of 3-D toys or objects, on different scales. Informants were tested linguistically and cognitively on these arrays, according to the 'rotation paradigm' (Levinson et al. 1992).
Results: TNA speakers select the appropriate FoR in context on the basis of properties of G or of G+ some axial constraints. Distinctive features of G are largely based on a domain-specific and cultural-specific ontology, hardly predictable outside the TNA community and exclusive to the spatial domain. Turning to cognitive tasks, however, I found that speakers use exclusively the Absolute FoR.
Conclusions: In RPSs linguistic constraints on cognition seem much weaker than in languages with a predominant FoR. This confirms Landau's linguistic versus cognitive 'task specificity' (2010). The nature and constraining strength of the language-to-cognition correlation can vary across cultures and languages. Speakers of RPSs are very likely to be predominantly Absolute thinkers.

The effect of instruction on the spatial and temporal aspects of route knowledge

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Background: Recent neuro-imaging and neuropsychological studies have provided evidence for separate processing mechanisms ofthe spatial and spatiotemporal aspects of routes. We tested the hypothesis that different instructions lead to selective facilitation of the acquisition of either spatial or spatiotemporal knowledge of a virtual route
Aims: We aimed to assess the effect of instruction on the spatial and spatiotemporal aspects of a virtual route. Generally, this experiment will further our knowledge of the role of space and time in navigation.
Method: During the learning phase, participants viewed a route through a virtual maze in which 24 objects were presented. Prior to learning, participants were given one of three instructions: neutral ("try to remember as much as possible from the route"), spatial ("try to remember where you encounter objects along the route"), or spatiotemporal ("try to remember when you encounter objects along the route"). The testing phase comprised three tasks: object recognition, route continuation (spatial task: assessing coupling of objects and directions), and route order (spatiotemporal task: assessing object order).
Expected Results: The neutral condition will provide a baseline of performance in the three tasks. Relative to the neutral condition, we expect the spatial instruction to selectively facilitate route continuation performance, which is a spatial task in nature. In contrast, we expect enhanced route order performance (a spatiotemporal task) following the spatiotemporal instruction. Lastly, we expect object recognition to be unaffected by the type of instruction, as this task taps into basal object recognition processes.

Spatial frames of reference in gesture: Evidence from bilingual Mexico

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Background: Previous observations suggest that, when describing spatial relations, people may reliably use a particular frame of reference (FoR) in their gestures and, further, that the preferred FoR differs across speech communities.
Aims: (1) Do speakers reliably use a particular FoR in their gestures? (2) If so, what factors determine whether a speaker will use an egocentric or allocentric FoR in gesture?
Method: We developed a novel task designed to elicit co-speech gesture about small-scale motion events. Our participants were bilinguals from the city of Juchitán, Mexico; they varied in their command of both Juchitán Zapotec— whose speakers have previously been found to prefer the allocentric FoR—and Spanish—whose speakers are presumed to prefer the egocentric FoR. Participants watched as an array of blocks underwent a motion event, such as a cylinder rolling under an arch. Participants then moved to the other side of an opaque barrier, rotating 90° in the process, and were prompted to explain what they had seen.
Results: Participants reliably used a particular FoR in their gestures (e.g. depicting the rolling as unfolding toward their Right or, alternatively, toward the south), despite the fact that they rarely used explicit FoR language (e.g. "right" or "south"). FoR preferences in gesture were predicted both by participants' mastery of egocentric vocabulary and by situational factors.
Conclusions: Speakers reliably use a particular FoR in gesture, even when this information is not foregrounded in speech, and the choice of FoR in gesture is shaped by disparate factors.

Measuring land in agriculture and calculating area in Euclidean geometry: An encounter of liminal spaces

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Background: Grasping the Euclidean notion of area of regular shapes is not trivial for farm people who have always measured land by means of a single and ancient algorithm considered by scholars as an approximation. The effort requires moving from the embodied and episodic (path integration-based) world of agriculture to the abstract and map-based space of Euclidean Geometry. It could be described as a liminal one. It is transformative, irreversible, integrative, bounded, and troublesome.
Aims: In this paper I argue that the opposite is also true. To make sense of farm people's practice, a Euclidean scholar would face a kind of liminal space in which the concept of embodiment is brought back to the scene in a creative way.
Method: Data from a previous study conducted in 1990 with illiterate Brazilian farm-workers is integrated with an analysis of ancient knowledge about algorithms of area estimation from Egyptian, Babylonian, Ancient Rome, Hindu, and Chinese mathematics.

Results: The constraint rule that the area of any tract marked out by the ends of a stick moved perpendicular to its present direction, and/or rotated (such as a plough or tractor) can be correctly estimated by the ancient algorithm, can serve as a conceptual articulation of liminal spaces for both scholars and farm people. It integrates embodiment and abstraction in a meaningful way. Geometry recapitulates its origins as measurement of land.
Conclusions: The study raises questions about how map-based and path integration-based representations of space could be articulated to serve a pedagogical function.

Do we forget where the sounds come from?

Franco Delogu and Philip McMurray

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Background: Unlike vision, the cortical representation of sounds is organized according to frequency and not according to stimuli position. This lack of a specific cortical representation of the auditory space opens questions about whether and how auditory spatial working memory is able to maintain sound position for further recall.
Aims: In this study, with the goal to verify if the memory of sound position declines as the maintenance time increases, we tested the influence of the length of the stimulus–response delay on a sound localization task.
Method: In a circular soundproofed room, 25 blindfolded participants heard single burst of white noise originating from 16 different speakers with an azimuthal separation of 22.5° from each other. Their task was to point to sound sources by using a digital pointer when prompted by a LED light flash. The flash was delivered with three different conditions of delay: at 0, 3, and 10 s after the sound was played.
Results: Increasing delays between stimulus and response do not impair sound localization. In addition, we found a bias in the localization responses which were systematically shifted by several degrees toward the 90° and 270°, the two cardinal points of the coronal plane, which correspond to the positions of the ears.
Conclusions: Within a time frame of 10 s after stimulus presentation, humans are capable of a robust representation of sound position. Such representation is biased with a systematic shift towards the positions of the ears.

How language impacts memory of motion events in English and French

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Background: Current debates concern the cognitive implications of linguistic diversity. In this context, Talmy (2000) distinguishes two language types: verb-framed languages lexicalise Path in the verb, leaving Manner implicit or peripheral (e.g. French traverser 'cross'); satellite-framed languages provide compact structures that systematically combine both components (e.g. English run across).
Aims: This study tests whether such typological differences affect speakers' memory performance, thereby aiming to address the question of language-specific and universal constraints on spatial cognition.
Method: Two groups of English and French speakers (total N = 90) participated in a memory task in either of two conditions: (i) in a non-verbal condition, they saw ten short video clips showing motion (Phase 1) whilst repeating syllables (interference task) to prevent internal verbalisation, then two variants of each, one correct and one incorrect (wrong Manner or Path), and had to decide as fast as possible which one they had seen before (Phase 2); (ii) a verbal condition aimed to test the impact of production on memory in Phase 2, by asking subjects to verbalise the clips during Phase 1.
Results: Both English and French speakers made fewer errors in the verbal condition. In the non-verbal condition, English speakers made more errors with Path than with Manner and more so than French speakers. No language effect was found in the verbal condition, where both groups produced more Path-errors.
Conclusions: Findings indicate that verbalisation aids memory performance, irrespective of language. However, crosslinguistic differences impact aspects of cognition even in situations that are entirely non-verbal.

Spatial abstraction for autonomous robot navigation

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Background: Optimal navigation for a simulated robot relies on a detailed map and explicit path planning. This is problematic for real-world robots, whose sensors and actuators are subject to noise and error, and whose environment may be dynamic. This paper reports on robots that rely on local spatial perception, learning, and commonsense rationales instead.
Aims: Our thesis is that spatial abstractions learned from local sensing can support effective, autonomous robot navigation.
Method: The simulated robot experiences real-world actuator error while it navigates autonomously. The robot's decision-making cognitive architecture relies on reactive and heuristic procedures based on simple rationales and spatial abstractions of where it has been. As the robot travels, it learns (and shares) affordances that facilitate movement, including perceived unobstructed areas and trail markers. Together they represent the environment but do not constitute a map. Robots navigate to five sets of targets in each of three environments.
Results: This approach quickly produces efficient travel without planning or a map. Metrics include travel time, decision time, and distance. Experiments examine the impact of each kind of affordance. Comparison with a traditional A* planner shows that performance becomes only slightly suboptimal for one robot. Preliminary data with multiple robots suggest that, because our approach does need to replan when actuators err or robots threaten to collide, it will outperform the traditional approach.

Conclusions: People have been shown not to navigate from detailed mental maps. Robots can also learn to navigate well without them, when they learn from local percepts.

An operational method to integrate cognitive and actual distances in a GIS street network

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Background: Geographers and planners have developed methods to grasp perceived environments. However, these methods are hard to be applied to diverse settings. Moreover, it is extremely difficult to incorporate the measurements taken on a perceived level into a GIS, thus impeding a full use of valuable information on decision making.
Aims: The aim is twofold: to apprehend cognitive distances in an exhaustive way and to join perceived distance values of street segments in a GIS database.
Method: The methods applied constitute a combination of surveys, Multidimensional Scaling and Bidimensional Regression. By means of surveys we have obtained distance estimations among a number of places in a city, in the form of a matrix. MDS has been applied to this matrix in order to obtain a spatial configuration of the places included in the survey. Thirdly, Bidimensional Regression has been adopted in order to fit the spatial configuration of the places (points) to the actual configuration of the same points and, by means of spatial interpolation, we have extended the results of the MDS to the whole street network. Finally, a relational union has allowed the integration of both distances.
Results: Results show a GIS street network database including both actual and perceived distances, which in turn makes possible the performance of distance-based analysis incorporating the perceived dimension.
Conclusions: The methodology adopted has proven to be a sound way to make perceived distances as operational as actual ones in a GIS environment. Limitations are related to data collection costs. Future research will be addressed to alleviate this issue.

Evidence for spontaneous visuospatial perspective-taking during social interactions

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Background: Perspective-Taking is a key component of social interactions. However, there is an on-going controversy about whether, when and how instances of spontaneous visuospatial perspective-taking occur.
Aims: We investigated the underlying factors as well as boundary conditions that could lead to the spontaneous adoption of another person's visuospatial perspective (VSP) during social interactions.
Method: We used a novel paradigm, in which both a participant and a confederate performed a simple stimulus–response (SR) paradigm in a 90° angle next to each other. Crucially, only the spatial orientation of the confederate yielded an overlap between the SR dimensions.
Results: In a series of six experiments we found that participants reliably adopted the VSP of the confederate, as long as he was perceived as an intentionally acting agent with whom they shared the same visual access to the stimuli. Our results suggest that humans are able to spontaneously adopt a differing VSP of another agent and that there is a tight link between performing actions together and spontaneous VSP-taking. Moreover, participants took into account whether their co-actor had visual access to the stimuli, which effectively led to a boundary condition for spontaneous VSP-taking to occur.
Conclusions: Our results show that humans spontaneously adopt a differing VSP during social interactions. Moreover, we differentiate the specific circumstances that can lead to, or constrain, the spontaneous adoption of another agent's VSP. The results suggest that spontaneous VSP-taking can effectively facilitate and speed up spatial alignment processes accruing from dynamic interactions in multi-agent environments.

The influence of body posture and action observation priming on reachability judgment and distance estimation

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Background: Space perception is a multimodal construct, with recent evidence suggesting that action and body representations contribute to spatial cognition. Spatial cognition involving visual judgments of whether an object is within reachable distance, appears to benefit from action simulation processes (Coello & Delevoye-Turrell, 2007). Also, somatosensory representations of an observer appear to be recruited when evaluating the reaching range of others (Lamm, Fischer & Decety, 2007).
Aims: This study investigated how action observation in different postural contexts moderated both judgment of reaching capacity and distance estimation tasks. The goal was to demonstrate that action observation could provide a scaling metric influencing the representation of the environment.
Method: Participants had to judge the reaching capacity of an actor presented from a third person viewpoint and estimate the distances separating the actor from objects. We investigated how two different heights of the actor (i.e., high or low) and how observing this actor performing reaching action could moderate participant's responses.
Results: Results showed a significant influence of actor posture in both tasks, but in opposite directions. When the actor reaching capacity was perceived as bigger, the distances separating the actor from the object were perceived as shorter, while when the actor reaching capacity was perceived as smaller, distances were perceived as longer. Also, after observing the actor's reaching actions, participant's responses in both tasks were more accurate.
Conclusions: We discuss the results regarding how perceived reaching capacity can moderate distance estimation and how action simulation processes seems to be malleable and go beyond the observer's own body proportions.

Neural correlates of mental rotations for different reference frame proclivities

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Background: The present study investigated whether performance and brain dynamics in a mental rotation task (Shepard-Metzler figures) is influenced by the individual spatial reference frame proclivity (RFP).
Aims: To investigate whether or not the RFP, i.e. using an allocentric or an egocentric reference frame during navigation is associated with performance differences in other spatial tasks. Using EEG we investigated the time course and approximate origin of brain dynamics associated with mental rotation in participants with a clear reference frame proclivity.
Method: Participants, categorized a priori with respect to their reference frame proclivity, performed a mental rotation task with quasi 3-D objects rotated either 0°, 50°, 100°, or 150°. Reaction times and percent correct answers were analysed. In addition, high density EEG was recorded and analysed using independent component analyses (ICA) with subsequent clustering of ICs.
Results: Effects of rotation angle on reaction times and percent correct answers were replicated. The RFP revealed an impact on accuracy with allocentric participants demonstrating better performance in mental rotation. EEG data revealed a wide-spread network involved in mental rotation with proclivity-dependent differences in parietal and motor regions.
Conclusions: The proclivity to use a specific reference frame during spatial navigation might be a more general expression of spatial abilities than previously thought. Analyses of brain dynamics during mental rotation demonstrate strategy-specific differences in spatial networks during different spatial tasks.

Virtual places as real places: About the distinction between fiction and interactive virtual reality

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Background: Places are usually perceived real-world experiences. Fiction is situated too, as it happens somewhere, but fictional places are not considered real places. The new phenomenon of virtual places, e.g. in simulations or video games, creates a third category of place. The differentiated exploration of this kind of place-conception is of importance, as for example there is the common perception, that virtual places are equal to fictional places. Furthermore, the over simplified concept that virtual reality uses techniques of deception to make us believe that itis a real environment is highly influencing the debate about virtual phenomena like social media and video games.
Aims: Exploring the relation between reality, virtual reality and fiction with respect to place.
Method: Analysis, categorization and comparison of various types of fictional and virtual places, based on a systematic review of philosophical works about such places and of the representation of places in art (literature, painting, etc.) and computer technology (internet sites, video games, etc.).
Results: Computer technology grants mediated access to concretizations of virtual reality. Like real places, virtual places emerge from people living init and vitalizing it. They become part of our world, although not of our physical world.
Conclusions: Computer-based interactive virtual places are not merely fictional or deceptive, but an extension of the continuum of real places, although not fully persistent. As real places, users and players enliven them. Fictional places however remain passive and cannot be actively explored.

Probability cueing in virtual environmental search

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Background: Studies of visual search behaviour have demonstrated implicit learning of spatial contingencies in the array. In contrast, real world search appears to be less sensitive to probability cues. There are several reasons why spatial learning may not operate consistently across tasks, including the spatial reference frame within which locations are cued, and the effort required to perform the search task itself.
Aims: We investigated whether probability cueing could be observed in a virtual environment. We designed a search task that required an egocentric reference frame to explore, akin to real world search, however physical effort to navigate was not required. We also manipulated the immersive qualities of the environment.
Method: Participants were required to search for a hidden target within a virtual arena which was displayed either on a computer monitor or a 180° curved screen within an environmental simulator. They were not informed that the target was more likely to be located on one side of space than the other. After testing, participants were probed for awareness of the manipulation.
Results: In both the simulator and the monitor environments, significant cueing effects were demonstrated, leading to more efficient search behaviour when targets were located in the cued hemispace. Participants did not express a conscious awareness of the probability cue.
Conclusions: Probability cueing can be reliably observed in a virtual environment, although participants were less aware than previously reported in real world equivalents. This suggests a role for physical effort in the conscious awareness of spatial learning.

Remembering where: Effects of perspective change and object rotation on spatial memory

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Background: Mental rotation and visual perspective taking are both challenging mental operations that show marked individual differences. However, they have mainly been studied in situations where encoding occurs from a single viewpoint, and the task then requires manipulation of the remembered information.
Aims: When encoding occurs from multiple viewpoints, as is common in everyday experience, does purposeful action between viewpoints—i.e., object rotation or perspective taking—enhance memory for static spatial location?

Method: In Experiment 1, participants learned a schematic tabletop environment in one of three ways: by rotating it (object rotation, OR), walking around it (perspective taking, PT), or being shown four canonical views (static views, SV). In Experiment 2, the OR and SV conditions were repeated, with a third condition added to examine the effect of seeing visual flow without purposeful action (visual transitions, VT).
Results: Neither Experiment 1 nor Experiment 2 showed an effect of condition on non-spatial performance, showing that the conditions were equally engaging and supported verbal learning. By contrast, the OR and PT conditions both significantly enhanced spatial performance relative to SV in Experiment 1. In Experiment 2, when participants were shown the back view first, not only did OR significantly enhance spatial memory over SV, but also compared to the group that saw the interpolated motion (VT). Thus, active involvement is important in creating the spatial encoding advantage.
Conclusions: Purposeful observer action at encoding enhances memory for static spatial location.

Long lasting reduction of postural asymmetry by prism adaptation after right brain lesion without neglect

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Background: Right brain damage (RBD) involves postural asymmetry and spatial frames disorders. In acute RBD patients, postural asymmetry is immediately reduced after one single session of prism adaptation (PA), without assessment of effects on spatial frames.
Aim: To assess long-term effects of PA on posture and spatial frames in chronic RBD patients, without neglect.
Method: Six chronic RBD patients without neglect (mean delay: 45 months) were included. Each patient sustained 10 PA sessions of 20 min during 2 weeks. Outcome measures were: (i) posturographic analysis (mediolateral position of center of pressure (Xcop), (ii) subjective straight ahead (SSA) and perception of longitudinal body axis (LBA). Each parameter was assessed by three pre-tests and three post-tests (+2 h, Day + 3 and Day + 7).
Results: In pre-tests, patients showed a shift of the Xcop and SSA. In post-tests, results displayed (i) a significant reduction of mediolateral postural asymmetry at D + 7; (ii) a significant left deviation of SSA at D + 3 and enduring at D + 7; and (iii) no significant modification of LBA. The mean curves of Xcop and SSA between pre- and post-tests were similar.
Conclusions: PA involves persistent reduction of postural asymmetry in RBD patients without neglect. These findings were obtained at a chronic stage. This new effect cannot be explained by reduction of spatial attentional shift. Improvement may be explained by a better calibration of extra personal space frames used for posture, without effect on personal space frame. Findings argue in favour of a bottom-up effect of PA on mechanisms underlying spatial cognition.

On the relevance of Gibson's affordance concept for geographical information science (GISc)

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Background: Ecological psychology focuses on the flow of information between an animal and its physical surroundings. J. J. Gibson, one of its most famous advocates, presented the concept of affordances to describe the reciprocity of functional relations between humans and their environment. Until today, his work has provided a theoretical basis for various studies in Geographical Information Science (GISc).
Aims: This paper aims to explain the high standing of the affordance-concept among GI scientists. Based on existing approaches and own work, it will be argued that it serves well to bridge the gap between the objective, mathematical spatial model traditionally used in Geographical Information Systems (GIS), and human's subjective mental models of space.
Method: In a short review, the major application areas within GISc will be presented, including geo-ontology engineering, information integration, modeling places and agent-based models (ABM). Based on an approach to simulate pedestrian behavior, new potentials for using and extending affordances will be discussed.
Results: Gibson's work presents a valuable basis especially for geospatial semantics. Coupling a spatial object with its action potential represents a novel, action-centered view of the world. Moreover, with the notion of agent-environment mutuality, it can serve to model subjectivity in GIS.
Conclusions: The relevance of Gibson's work to GISc is due to its combination of conceptual simplicity and strength. Extending the concept beyond binary yes/no values to degrees of suitability can further improve its applicability. Practical problems, however, are posed by the required level of modelling detail and different possible formalization approaches.

Formation of spatial thinking skills through different training methods

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Background: There has been a consistent support in spatial literature showing spatial skills are malleable and acquirable. People improve their spatial skill performance by experiencing spatial training from practicing a specific task to playing a video game to learning from drawing. The effects of spatial training can be durable and even transferable if the training involves cognitive process-based tasks. The current study explored different spatial training methods and investigated the sequences of process-based mental simulation that was facilitated by various structures of external spatial representation, such as 3D technology, spatial cues, and/or technical languages.
Aims: The study goal was to better understand how the external spatial representation components fostered planning experiences and

affected spatial ability acquisition (formation of spatial mental models) for further developing spatial training environments fundamental to STEM specifically for architectural and engineering education.
Method: Three experiments with a total of 115 Columbia University's students were conducted using a between-subjects design to examine the effects of spatial training methods on spatial ability performance. The conditions for training environments included 3D-virtual and 3D-direct-manipulation interactions with abstract (nonsense-geometric) and concrete (everyday-object) contents, as well as a control group.
Results: Across three studies, learners in the treatment conditions improved in their spatial skills significantly more than learners in the control conditions. For the first and second study, learners in the 3D-virtual environments improved in their spatial skills much more than learners in 3D-direct-manipulation physical ones. The third study, 3D-direct-manipulation conditions, confirmed promising results about the sequences during spatial thinking formation processes.

Reversing the affordance effect: Negative stimulus–response compatibility observed with images of graspable objects

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Background: Responses are faster when the task-irrelevant orientation of a graspable object's handle corresponds to the location of the response hand. Over the past decade, research has focused on dissociating between two competing accounts of this effect: one rooted in motoric object affordances (Tucker & Ellis, 1998), and the other resting on attentional mechanisms (i.e., Simon effect; Anderson et al., 2002).
Aims/Method: Following this avenue of inquiry, we conducted three experiments, in which grayscale photographs of frying pans and saucepans were centered on a computer display. Subjects had to respond bimanually depending on each object's vertical orientation (upright/upside-down). In addition to horizontal orientation (leftward/rightward handles), Experiments 1 and 2 also manipulated the direction of exogenous attentional shifts (left/right) using laterally-placed, colored markers within the objects.
Results: Both experiments yielded regular Simon effects based on the location of the colored markers. However, in stark contrast to previous research, negative stimulus–response compatibility effects were obtained with regard to the orientation of the graspable handles. This reversed affordance effect was also observed using the original, unedited grayscale photographs (Experiment 3), which suggests that its occurrence cannot be attributed to the use of colored markers.
Conclusions: These unexpected findings appear to support the idea that Simon effects result from automatic and exogenous attentional orienting mechanisms, whereas affordances arise from controlled and endogenous attentional processes (Riggio et al., 2008). Such a top-down attentional account of affordance can accommodate the observed reversal of the effect in the context of task characteristics and stimulus set composition.

The effects of correlated colour temperature on wayfinding performance and emotional reactions: A study in a virtual airport environment

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Background: Wayfinding is a spatial problem solving activity comprising the following interrelated processes; decision making, decision executing and, information processing. Emotions have an influence on attention, decision making, and memory (all factors required for wayfinding). In stressful environments, where white artificial lighting is extensively used, any improvement in users' wayfinding performance is beneficial. Colour temperature is an aspect of lighting, the "colour" of especially white light, expresses warmth or coolness.
Aim: Explaining wayfinding performances of travelers with emotional reactions to CCT of lighting in a virtual airport environment.
Method: The experiment was conducted in two phases between different participant groups in settings; 3000 K (yellowish-white), and 12,000 K (bluish-white). Sixty participants experienced the desktop VE and tested by the researcher one by one. They were asked to direct the researcher from the starting to the destination point. Every six meters, the images were changed by the researcher according to the verbal direction of the participant until finding the destination. Meanwhile, the directions, time spent, errors, route choices and hesitations of each participant were noted. The participants listened to the background noise of an airport to feel sense of presence. A single LED LCD screen of 10.1″ was used in the study. The screen was calibrated as follows: gamma: 1.0, brightness: 0, contrast: 50. The screen resolution was 1024 × 600 and the colour quality was 32 bit. Then, Ekman's universal representativeness of basic emotions, (anger, disgust, neutral, surprise, happiness, fear, sadness) were shown to the participant and asked to choose a single face. In the second phase, the participants rated their level of presence in VE by "Igroup Presence Questionnaire (IPQ)".
Results: The initial results indicate that wayfinding performance of travelers is better under 12,000 K which may be a result of associating the space with a more positive emotion compared to 3000 K.
Conclusions: The findings provide clues about factors affecting performance both for interior architects and environmental psychologists.

Effects of emotional states on temporal order thresholds

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Background: Previous studies investigating how emotion affects temporal information processing mainly focus on the low-frequency time window. However, whether emotion influences temporal processing at the high-frequency time window is largely unknown, especially when visual spatial stimuli are involved.
Aims: The present study aims to investigate whether negative and positive emotional states influence our ability to discriminate the temporal order of visual spatial stimuli, and whether gender plays a

role in it. Due to the hemispheric lateralization of emotion, a hemispheric asymmetry between left and right visual field is expected.
Method: Using a block design, subjects are primed separately with neutral, negative and positive emotional pictures before performing temporal order judgment tasks, where the time interval between the two spatially separated visual stimuli is adjusted according to the staircase method. Temporal order thresholds are calculated separately for the left and right visual field.
Results: Males have similarly reduced order thresholds under negative and positive emotions, while females have higher thresholds under positive emotion as compared to negative emotion. Besides, emotion influences females in much larger magnitude than males, possibly due to gender differences in terms of emotional stability and the ability of empathy. However, we did not detect any apparent trend of differential influence between the left and right visual field by emotion.
Conclusions: Emotion can indeed influence our ability to perceive the temporal order of visual spatial stimuli, and there exists gender difference. However, emotion lateralization does not seem to affect spatial temporal processing in a straight forward way.

Positive it is this way? The role of mood on global versus local landmark use within virtual environments

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Background: "Feelings as information" theory (Schwarz, 1990) proposes that feelings influence the way in which individuals process their environments. This appears to be supported by a growing body of research that has found mood or arousal to affect the use of global and local landmarks (Gardony, Brunye, Mahoney & Taylor, 2011). This is further supported by potential links between mood and attention (Wadlinger & Isaacowitz, 2006) and attention and learning (Mackintosh, 1975).
Aims: The present study aimed to further investigate whether experimental manipulation of participant mood states during learning would have an impact on the choice of landmarks utilised by participants (global vs. local) within a virtual environment (VE) during wayfinding.
Method: An independent groups 2×2 design was used. Mood (positive/negative) was manipulated through the use of autobiographical recall before participants explored a VE with both landmark types present (learning phase), and VE type (local landmarks present/global landmarks present) was manipulated during the wayfinding phase. The dependent variable was measured as the time taken to reach a target within the VE.
Results: Currently (data collection continues) the autobiographical recall method was found to be effective in inducing the desired mood states. No significant differences were found between mood conditions on performance in the wayfinding task, nor have any interactions between mood and VE type been revealed.
Conclusions: The implications of these results for "feelings as information" theory (Schwarz, 1990) are discussed as well as the potential contribution to the arousal versus valence debate in landmark use previously raised by Gardony et al. (2011).

Socio-spatial intelligence: Social media and spatial cognition for territorial behavioral analysis

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Background: Investigative analysts gather data from different sources, especially from Social Media, in order to shed light on cognitive factors that may explain criminal-behavior.
Aims: A former research shows how Tweets can be used to estimate private points of interest. Authors' aim is to demonstrate how social-maps and web-applications can be used in investigative analysis.
Method: 100 Twitter-accounts with approximately 200 Tweets each were submitted to common geographical techniques (measures such as Convex Hull, Mean Center, Median Center, Standard Deviation Ellipse) in order to test the hypothesis that user areas of activity are predictable. Predictions were tested through a set of specific information: clear reference to areas of activity and clear reference about user's residence.
Results: Simple algorithms and procedures could be used to predict where Social Media Users live giving positive results in about 1/3 cases and giving indications about their home location. In up to 80 % of cases, houses were found within a buffer zone of 1500 m with Mean Center as centrum (70 % using Median Center as centrum) with a minimum effectiveness threshold of 12–13 tweets.
Conclusions: The processing of geographical data in conjunction with the Social Media analysis may facilitate the construction of models describing specific behavior of people. The use of GIS tools and Social Media analysis represent an effective approach in order to acquire spatial and territorial information and to better understand social dynamics for the prevention of criminal behavior.

Using 3D immersive virtual environments to monitor human navigation in a human analog of the Morris water navigation task: The VE-HuNT system

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Background: Virtual reality environments, as well as augmented reality instruments, are increasingly being proposed as a relatively inexpensive and non-invasive approach to monitoring spatial cognitive changes longitudinally in older adults. In order to use measurements of navigational ability as an adjunct to other biomarkers as a possible predictive approach to normal aging versus the development of mild cognitive impairment and dementia, reliable and quantitative methodology needs to be developed and tested in a relevant group of subjects over a significant time period.
Aims: The general goals of this project are to develop and test a system for assaying spatial cognition in older individuals and to correlate the observations with assessment of other biomarkers of aging and cognition.
Method: The project employs 3D human scale immersive Computer Augmented Virtual Environment (CAVE) technologies developed at UCSD's Qualcomm Institute and software designed to test spatial

navigation and memory in older human subjects. The tasks are analogous to well-known paradigms used to assay spatial memory in animals, including the Morris Water Maze and the multi-armed radial maze. Parameters measured include path length and time to target, as well as path topology.
Results: The novel instrumentation will be located in the clinic of one of the co-authors (MR), where subjects in current studies and undergoing broad cognitive testing and other phenotypic characterization will also be tested for spatial memory and navigation at fixed time intervals. The data obtained will be analysed to assess correlations and consistency with other biomarker results obtained in parallel.

The place of joy, surprise and sadness in vertical space

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Background: Emotion words/concepts map onto vertical space such that positive ones are placed in upper locations and negative ones in lower locations. Although this pattern is clear for positive and negative emotions e.g. joy' and 'sadness' respectively, the location in vertical space of ambivalent emotions e.g. 'surprise' has not been investigated.
Aims: The first objective was to characterise the emotions joy, surprise and sadness via ratings of their concreteness, imageability, context availability and valence. Secondly we investigated the allocation of these three emotion words in vertical space (objective two).
Method: Participants from six linguistic/cultural groups participated. Participants completed either a) a paper-based rating task used to characterise the emotion words or b) a paper-based location task to implicitly assess where these words are positioned onto vertical space.
Results: Based on previous research, it is hypothesised that these emotions will be rated low in concreteness and have medium levels of imageability and context availability. Regarding the metaphorical relationship between emotion and space, it is predicted that, overall, 'joy' will be positioned in upper space, 'sadness' in lower space, while 'surprise' should be vertically located somewhere between 'sadness' and 'joy'.
Conclusions: The results provide the first demonstration that emotions of ambivalent valence e.g. 'surprise' are metaphorically mapped onto vertical space midway between the locations for negative words e.g. 'sadness' and positive words e.g. 'joy'. It is hypothesised that emotion words with similar characteristics to those studied here may be located in vertical space in a similar fashion; i.e. positive-up, negative-down and ambivalent-'between-positive-and-negative'.

Adapting map organization to task requirements: How epistemic action facilitates map use

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Background: Task performance with static maps decreases with amount of task irrelevant information included (Hegarty, Canham & Fabrikant, 2010). In thematic maps, similar effects may arise from spatial organization of information, depending on its correspondence to task requirements. Interactive maps offer a solution by allowing users performing epistemic actions (Kirsh & Maglio, 1994) to control type and structure of information displayed.
Aims: We hypothesized that providing users with interactive means for restructuring the spatial organization of thematic maps would (a) be spontaneously used for adapting map structure to task requirements and (b) increase task effectiveness.
Method: Users ($n = 90$) were presented 24 pairs of maps of voting results in a fictitious country, either organized by first versus second vote or by recent versus previous election period. In two types of tasks, participants had to either compare the voting results of a particular party across type of vote or election period, respectively. Half of the participants had to solve the tasks with static pairs of maps, while the other half could interactively modify map organization by switching from vote type to election period or vice versa.
Results: The majority of participants in the interactive condition spontaneously changed map organization by epistemic action in case of a misfit between map organization and task requirements. Accordingly, they outperformed participants of the non-interactive condition in terms of number of correct solutions.
Conclusions: The present study shows that by providing opportunities for epistemic actions, thematic maps may afford flexible, task-appropriate spatial reorganization of information, which in turn fosters task performance.

Age-related differences in pointing accuracy in new and familiar environments

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Background: The ability to mentally construct and use spatial representations is essential to independent living, even in old age. Studies using various inputs, such as maps (Klencklen et al., 2012), have shown an age-related decline in the ability to learn new environments, but little is known about how aging influences the spatial representation of well-known places, such as a person's home town (Meneghetti et al., 2013).
Aims: The aim of this study was to investigate age-related differences in spatial mental representations of familiar and unfamiliar places.
Method: Nineteen young adults (aged 18–23) and 19 older adults (aged 60–74), all living in the same Italian town, completed a set of visuospatial measures (self-reports and spatial tests), and were then asked: (i) to point in the direction of familiar landmarks in their town; and (ii) to learn a map of an unknown environment and then point in the direction of landmarks it contained.

Results: Older adults performed less well than young adults in the visuospatial tasks. They were also less accurate in pointing at landmarks in a new environment, but performed as well as young adults when pointing to familiar places. Pointing performance correlated with spatial task accuracy in familiar and unfamiliar environments, and with spatial working memory only in a new environment.
Conclusions: Differences between young and older adults' pointing performance were only seen for new environments, while older adults used mental representations of well-known places successfully, despite their spatial cognitive decline.

Preliminary findings on the effect of scale transformations on spatial memory in immersive and desktop virtual environments

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Background: Desktop virtual environments (VEs) deliver advantages over traditional spatial cognition testing. The availability of immersive VEs opens up new possibilities for investigating spatial learning and mental representations of space.
Aims: We explore learning and recall in VEs using head-mounted displays (HMDs) and desktop VEs. A scaled virtual room and its physical counterpart were used to investigate individual object memorisation and placement.
Method: Following a between-subjects experimental design, participants were asked to navigate a 1.0, 1.2, and 0.8 scaled virtual space either in the HMD or desktop system condition. Participants experienced scaled VEs in different orders, ensuring that all combinations were tested equally. In each VE three virtual objects were placed on the floor. Participants were then asked to place physical versions of the three objects in the physical environment where they remembered them to be. We tracked participant movement, measured object placement, and administered a questionnaire related to aspects of the experience.
Results: A Mann–Whitney *U* test showed that participants learning in HMD placed objects with greater accuracy, felt more confident, and had a higher sense of presence than participants learning in the desktop condition. A Wilcoxon signed-ranked test showed that placement responses preserved fixed ratios of distances between opposing walls after contractions of the environment, whereas responses clustered around locations predicted by fixed distance and fixed ratio models after expansions. Movement data indicates that spatial learning strategies in both systems are different. Based on results, we hypothesise that HMDs might be more valid for understanding spatial strategies used in the real world.

More on the ability to use slope for navigation: Evidence from children

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Background: Humans, like other animals, can use terrain slope as a source of directional information for navigation. However, recent studies (Nardi, Newcombe, & Shipley, 2011, 2013) have shown remarkable individual differences in this ability, and a general difficulty for women.
Aims: We examined for the first time whether children can use slope to navigate. We were particularly interested in assessing whether the sex difference would appear before puberty and the consistent use of heeled footwear. Furthermore, we explored the role of spontaneous and prompted slope perception on performance.
Method: We tested 110, 8- to 10-year-old children in a goal location task similar to that used with adults. In a square, featureless enclosure, children were asked to locate a hidden target when the floor was flat (control condition), sloped (slope condition), or sloped with a "ball drop demonstration," intended to make the slope more salient (ball drop condition). Children could successfully find the target only if using the slope cue.
Results: When the enclosure was sloped, all children performed above chance. Boys outperformed girls, and were also more likely to spontaneously notice the slope. However, once spontaneous slope perception was taken into account, performance did not significantly differ by sex.
Conclusions: The male advantage emerges before the onset of puberty, and the female difficulty is not related to consistent heel use. The main factor driving the sex difference seems to be spontaneous slope perception. We suggest that girls may be less likely to notice the slope because of experiential factors.

Numerical spatial cognition and time: The association may be a product of response bias

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Background: Schwarz and Eiselt (JEP: HP&P, 2009) found that numerically smaller digits were perceived to occur earlier than larger digits and concluded that this difference reflected faster processing of smaller numbers. This difference, however, could also be the result of a response bias whereby the smaller number is confounded with the response of 'first'.
Aims: This study investigated the effect of response bias on the link between time and numerical magnitude by manipulating the congruency between the stimulus and the response.
Method: In Expt. 1, participants ($n = 14$) made temporal order judgements between digits presented to the left or right. Experiments 2 and 3 ($n = 14$, $n = 26$) eliminated response biases using judgements of simultaneity, which have no logical stimulus-mapping with numerical magnitude.
Results: Expt. 1 showed that the point of subjective simultaneity was shifted so that the '9' had to occur before the '2' in order for them to be perceived as simultaneous. While the faster processing of the '2' is consistent with the results reported by Schwarz and Eiselt, it could also reflect a response mapping effect. When this response mapping was removed in Expts. 2 and 3, participants showed no sign of faster processing of the '2'.
Conclusions: The results demonstrate that response biases play an important role in studies purporting to show links between the processing of different magnitude scales and experiments must be designed to eliminate these biases.

Images of situated cognition: Involvement and location

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Background: In phenomenological–topological perspective the key spatial form of situated cognition is a human subject's involvement in phenomenal fields (IPF). The spatial characteristics of this involvement are topological, so in this respect different from the spatial characteristics of the lived space, which still have a dimensional nature. A serious issue arises then, how to connect the usual perception of the lived space with the IPF. Impressionist paintings can be understood as visualisations of the IPF, therefore they may offer an artistic expression of this connection, particularly when they depict the impression of a lived space (landscapes, architecture).
Aims: I aim to explain the connection among lived space and human involvement in phenomenal fields.
Method: I analyse visual reception of several Monet's, Pissaro's, and Cézanne's paintings to describe phenomenologically recipient's attitudes towards depictions of phenomenal fields and lived spaces.
Results: (1) The analysed paintings intertwine images of visual fields based on defocused contours with classical perspectival representations of lived space, so a recipient must combine acts of perception (focusing/defocusing) with acts of spatial projection. (2) The acts of focusing/defocusing provide involvement, whereas the acts of projection take part in constituting lived space as opened for locations. The connection between the lived space and the IPF thus can be derived from the intertwining of both types of acts.
Conclusions: Impressionist paintings reveal a connection between the two spatial aspects of situated cognition: involvement as a spatial attribute of perception and location as a spatial attribute of projection.

The architect's perspective on the tour and map perspective

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Background: Literature in linguistics suggests that when people are asked to provide an oral spatial description they usually provide a body-centered narrative; they adopt a tour perspective, that is, an imaginary tour of the space rather than a map perspective, that is, a description focused on spatial relations as "seen from above" (Linde and Labov, 1975; Howald, 2009).
Aims: I conducted a pilot experiment to address the following questions: Does the formal knowledge of architects—their familiarity with plan drawings and maps-override the tendency to adopt the tour perspective? Does the tour perspective depend on the actual experience of space? How would the description change if someone were forced to take a tour perspective instead of a map perspective?
Method: Twenty-two graduate students in architecture were asked to respond to the following questions: (1) "Can you describe the layout of your apartment?" (2). "Can you describe the layout of an ideal apartment?" (3) "Can you walk me through the ideal apartment you had described?"
Results: In the responses to the first question most participants used the tour perspective. In the responses to the second question most participants used the map perspective. The third question led to more rich in sensory qualities spatial descriptions than the second question.
Conclusions: The results provide evidence that architects' formal knowledge does not override the preference of the tour perspective in descriptions of experienced space. Moreover, that the tour perspective is associated with the actual experience of space and when intentionally adopted it leads to embodied spatial descriptions.

Virtual collaboration: Effect of spatial configuration on spatial statements production

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Background: When guiding a remote collaborator in a virtual environment, people often take the addressee-perspective to give directions, which may have a high cognitive cost. In order to improve collaborative virtual environments, a better understanding of how operators share spatial information is needed.
Aims: This work aimed to study the cognitive workload linked to spatial statement production in situations in which the relative positions of a speaker, an addressee and a target were varied.
Method: 22 participants were asked to give—in one go—instructions to a virtual collaborator on how to find a target in a 3D environment. The scene showed an avatar in the centre of eight tables. 64 configurations of avatar orientation (eight possibilities) and target location (on the eight tables) were tested. We measured the delay to start the instruction once the target appeared, the instruction duration, and the subjective evaluation of the mental demand. Each instruction was classified according to the spatial reference frame that was used.
Results: The delay was influenced by the processing of spatial information in ego-centered and addressee-centered reference frames. All subsequent measures were determined by mental transformations in addressee-centered coordinates. One condition in particular, when the target was situated in diagonal behind the addressee, gave rise to a higher mental demand for the speaker, which points to the speaker investment in achieving the least collaborative effort.
Conclusions: Further work will aim to develop efficient tools to facilitate spatial communication in the situations that induce the most mental workload.

Detecting a pedestrian in the fog: The role of target expectation and visual exploration in perceptual decision making under uncertainty

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Background: Detecting a pedestrian while driving in the fog is one situation among many where the prior expectation about the target's presence is integrated with the noisy visual input. The disambiguation of the scene can occur through an active oculomotor behaviour reflecting the collection of bottom-up evidence.
Aims: We focus on how expecting a specific target influences the oculomotor behaviour in visual search in a static driving scene with varying fog density and how it is integrated within an underlying decision-making process.
Method: The participants had to judge whether the target of a high/low density fog scene contained a pedestrian or a deer by executing a mouse movement toward the corresponding response button. A road sign was primed and indicated which target will probably be part of the scene. We measured the timing and amplitude of the bias of the mouse trajectories toward the incorrect response. Conjointly, we distinguished the detection time (before fixating the target) and the identification time (fixations on the target) using an eye-tracker.
Results: The trials with low fog level or where target and road sign were congruent elicited both shorter detection times and identification times as well as lower movement deviation, directed earlier toward the correct response. The identification times mediated a small part of the expectations and a larger part of the fog effects on the mouse trajectories.
Conclusions: This study shows a clear effect of expectations on the target's identification and how it affects decision-making process through the collection of perceptual evidence.

I feel like you when you come close to me: Motor simulation and inter-bodies distances

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Background: Representing peripersonal space (i.e. near body space within arm reaching) is fundamental for interacting with objects and conspecifics (Lloyd, 2009). Research has shown motor effects when we encode an object placed within our and others' peripersonal space, but not extrapersonal space (Costantini et al., 2011). This interpersonal motor simulation would allow for a shared representation of our and others' peripersonal space. However, simulating others' action possibilities becomes more important as far as they approach our peripersonal space.
Aim: Investigate if the representation of others' peripersonal space is influenced by the distance between the subject and the other persons and by their respective action possibilities.
Method: Participants had to locate a manipulable object by assuming either their own (first-person) or avatars' (third-person) perspectives. The object was always in participants' and in avatars' reaching space. The avatar appeared near or far from the observer and was seated on a chair on the long side of a table (Exp. 1) or at different positions around a table (Exp. 2). When giving first-person localization judgments, participants had their dominant arm either at rest on a desk (free) as a control posture or crossed behind the back (blocked) as an interfering posture. Instead, when giving third-person localization judgments, participants had always their arms free while the avatar could have free or blocked right arm.
Results: From first-person perspective, subjects were slower when they had blocked rather than free arm; from third-person perspectives, subjects were slower when the avatar near (not far from) the subject had blocked rather than free arm.
Conclusions: when people are within our peripersonal space we "embody" their physical potentiality and we rely on a motor simulation mechanism to represent their peripersonal space.

Flex to the left, extend to the right: Disambiguating motor and spatial influences on valence judgements

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Background: Some studies found relationships between valence and physical space. For example, Casasanto (2009) found that right handed people tend to associate positive valence with the right space and negative valence with the left space. Other studies have found an association between arm movements and valence. Arm flexion movements are associated with approach, and therefore with positive

valence, whereas arm extension are associated with avoidance, thus with a negative valence (Cacioppo, Priester, & Bernston, 1993).
Aims: We aimed to examine which grounded dimension (i.e., motor or spatial) has more influence on valence judgements.
Method: Using a Multi-Touch Table, right-handed participants were instructed to move neutral pictures with their dominant hand either to their left with a flexion movement (spatial: negative; motor: positive) or to their right with an extension movement (spatial: positive; motor: negative). Afterwards, participants were asked to rate the pictures on a Likert scale ranging from 1 (negative) to 7 (positive).
Results: We found that pictures moved with an arm flexion to the left (spatial: negative; motor: positive) were evaluated more positive than pictures moved with an arm extension to the right (spatial: positive; motor: negative).
Conclusions: In line with other results in grounded cognition research (Rolke, Ruiz Fernández, Seibold, & Rahona, 2014) it seems that motor components have more influence than spatial elements on abstract concepts.

Abstract spatial coding and affordance influences on the object handle orientation effect

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Background: Spatial organisation of the hands can affect stimulus–response congruencies. For example, using lateral, bimanual responses, participants are faster to respond to object stimuli with the hand that matches the left/right, task-irrelevant orientation of the object's handle (Tucker & Ellis, 1998). Due to the lateral hand placement, and because the handle is both an action-relevant component and a visually salient, asymmetrical feature, this handle orientation effect is consistent with both affordance and abstract spatial coding (Simon effect) explanations.
Aims: This study aimed to disentangle affordance and abstract spatial coding influences on the handle orientation effect by controlling response location.
Method: Stimuli comprised lateralised object photographs. Stimulus and response locations were varied on a central, vertical plane (upper, lower). Participants responded with horizontally orthogonal, bimanual key presses to objects' inverted or upright orientation (Experiment 1), kitchen or garage category (Experiment 2) or colour, as in a traditional Simon effect (Experiment 3, yet to be conducted).
Results: In Experiments 1 and 2, which employed tasks eliciting object knowledge, participants were faster to respond to object stimuli with the hand that matched the left/right handle orientation. We expect this compatibility effect to disappear in Experiment 3 when participants respond to colour.
Conclusions: Results have implications for object affordance theories. If Experiment 3 produces the expected results, findings will suggest that the handle orientation effect is not analogous to a Simon effect and therefore not solely explained by abstract spatial codes. Results also highlight the complex interplay between spatial processes and visual object recognition.

Language cues in the formation of hierarchical representation of space

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Background: The formation of hierarchical representation of space can be induced by the spatial adjacency of landmark objects belonging to the same semantic category (Wiener & Mallot, Spatial Cognition and Computation 2003), as was demonstrated by preference of routes crossing fewer region boundaries.
Aims: Using the same paradigm, we tested linguistic cues with various hierarchical categorization principles in regional structuring.
Method: In a virtual environment, subjects performed 18 navigation tasks, 12 of which allowed for equidistant, but region-sensitive alternatives. Decision points were marked (i) with landmarks of different semantic categories ("Landmarks"), (ii) with superordinate fictive proper names ("Arbitrary"), (iii) with superordinate prototypical names ("Prototypes"), (iv) with elements from different linguistic semantic categories ("Semantic") and (v) with members from multi-component institutions (e.g. farm house, barn, staple, silo: "Whole-Parts").
Results: The results of the landmark-condition confirmed the earlier findings. Among the linguistic conditions (ii–v), a significant region-based preference was found only for the "Whole-Parts" condition.
Conclusions: In the "Arbitrary", "Prototypes" and "Semantic" conditions, language-mediated hierarchies are non-spatial. Although the names were presented at adjacent places, no representational hierarchy was induced. Only in the "Whole-Parts"-condition, a dense semantic network was established through the prototypical parts of each complex, resulting in a hierarchical representation of space. We suggest that for the language-based induction of hierarchies, place names within each region must have an intrinsically spatial relation, while non-spatial similarity relations have been shown to suffice in object-based induction.

Developmental trajectories of path integration: The influence of concurrent task

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Background: Efficient daily navigation is underpinned by path integration, the mechanism by which we use self-movement information to update our location in space. Although this process is well-understood in adults, few studies have addressed the development of path integration in children. In particular, it is unclear whether children apply a cognitive strategy to perform the task, as has been shown in adults.
Aims: We will present developmental data from a triangle-completion paradigm. During the task children were required to perform a concurrent verbal task—we are interested in whether the nature of the task affected their path integration accuracy (for both distance and heading calculations).

Method: Children aged 6–11 years were blindfolded and led two legs of a right-angled triangle. They were then asked to walk along a final trajectory back to the starting position, completing the triangle. In a between-groups design, we manipulated concurrent verbal task: one group counted their steps aloud, another group performed an articulatory suppression task (repeating nonsense syllables), and a final group performed no concurrent task.
Results: Analysis of heading error revealed a significant effect of the length of the outgoing path and of age, whereas distance error was only affected by age. Neither measure was related to the concurrent task.
Conclusions: These data illustrate a dissociation between heading and distance calculations, with heading being more susceptible to influence from the outgoing path. More interestingly, the absence of a difference between experimental groups suggests that children may not adopt a cognitive strategy for path integration.

Thoughts in space: On quantifying the impact of environmental surround on cognitive processing

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Background: The embodied cognition perspective has provided a formalization of the idea that the motor state is a characteristic of being that permeates all human processing. The motor behaving human moves within various spaces, each affording different actions. We can throw a ball in a field but not in an elevator. Space, so much as it constricts our behaviors, may too influence our thought.
Aims: To examine the effect of surrounding space on the type of thought and speed of processing.
Method: A "shrinking room that converts from large to small space has been used. In a typical experiment, participants stand in the center of one of the spaces and complete a variety of tasks. For example, in the multiple uses tasks, participants are given an object and asked to generate as many uses for the object as they could within 1 min. For the object shoe, the responses may be "footwear, to smash something, to hold dirt, as a pretend telephone," and so on. In a math subtraction task, participants are asked to sequentially subtract from a given number. For example, participants would hear "subtract three, beginning with 922", and, begin subtracting until twenty transactions were complete.
Results: The size of space influences type of thoughts and speed of processing. Smaller spaces appear to offer greater focus, as revealed through quicker processing times while larger space appear to offer greater flexibility in thought.
Conclusions: Cognitive processing performs best when given the appropriate amount of surround, suggesting that thoughts, inasmuch as they may be tied to our surround and need to move within it, require time but also space.

The effect of understandability on wayfinding through survey- and route-based expressions

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Background: When telling others the way, one expresses spatial information verbally. In doing so, two types of spatial expressions for providing direction are available. One is survey-based expression (e.g., north, south, east, and west) and the other is route-based expression (e.g., front, back, right, and left). A previous study revealed that route-based expressions are rated more effective, and led to better wayfinding performance than survey-based expressions (Padgitt & Hund, 2012). However, another study showed that survey-based expressions promoted wayfinding performance (Hund & Nazarczuk, 2014).
Aims: Previous studies have produced contradicting performance results through the use of survey-based and route-based expressions. We hypothesized that this performance discrepancy is caused by the effectiveness difference (i.e., the tendency that participants tend to evaluate route-based expressions as being easier to understand than survey-based expressions), and investigated a link among effectiveness, performance, and types of expression.
Method: In Experiment 1, participants evaluated the understandability of survey-based and route-based expressions. In Experiment 2, participants undertook a wayfinding task using either survey-based or route-based expressions, the understandability of which were controlled and equivalent to each other
Results: In Experiment 1, participants evaluated route-based expressions as being easier to understand than survey-based expressions. In Experiment 2, participants who followed survey-based expressions were as accurate in wayfinding as those who followed route-based expressions.
Conclusions: These results revealed that the performance difference caused by the two types of expressions resulted from understandability. Route-based expressions were easier to understand and therefore, led to better wayfinding performance than survey-based expressions.

Too close for comfort: The effect of interpersonal proximity on spatial attention

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Background: Strangers in close proximity can elicit behavioral responses such as physiological arousal and decreased cognitive performance. These interpersonal responses are modulated by the perceived discomfort of a social situation. Although most people try to avoid crowded situations, in instances where close interpersonal proximity is unavoidable, people seek to withdraw their attention from others and retreat into their own personal space.

Aims: This study investigated the relationship between social discomfort, as indexed by electrodermal activity, and the withdrawal of spatial attention.
Method: Shifts in spatial attention were measured by a line bisection task and physiological discomfort was measured by an electrodermal activity wrist monitor. Participants performed a radial line bisection task in two conditions: alone or facing a stranger. In the together condition, participants stood in close proximity of each other at a distance of 600 mm apart and coordinated their responses in a turn-taking paradigm.
Results: A regression analysis showed the relationship between shifts in spatial attention and physiological discomfort. Participants with high physiological arousal displayed attentional withdrawal away from the other person, whereas participants with low physiological arousal demonstrated an attentional attraction towards the other person.
Conclusions: Perceived discomfort in a social situation can influence people's situational attention. Those who are uncomfortable in the close proximity of strangers show an attentional withdrawal, which we propose serves to increase the perceived distance between themselves and others. These results suggest that individuals who found the close proximity of a stranger uncomfortable withdrew into their own personal space.

The effects of spatial discrepancy on peri-personal space in virtual environments

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Background: Due to the rapid increase in virtual reality training (VR), it is vital that we understand how the brain adapts to novel sensorimotor environments that lack a direct 1-to-1 correspondence between performed actions and sensory feedback. Ownership of the limb under such circumstances is important as it supports the ability to preferentially process stimuli near to the body—known as the Near Hand Effect. The near hand advantage may be lost if a limb is spatially displaced in VR so the present research investigated the effect of limb displacement using a mediated reality system called MIRAGE which allows real-time manipulation of the visual, spatial and temporal characteristics of the real limb.
Aims: To investigate to what degree a virtual hand can be displaced without severely disrupting sensory processing of peri-personal space.
Method: Following a short period of exposure to a virtual environment incorporating various levels of spatial perturbation, peri-personal space was assessed using the Near Hand Effect—a naturally occurring phenomenon in which we process information within peri-personal space faster than stimuli further away. Motor control and ownership was also assessed.
Results: It was predicted that with higher spatial perturbations, the strength of the Near Hand Effect would decrease or nullify the way peri-personal space is processed, compromising sensory integration in a virtual environment.
Conclusions: The effects of spatial discrepancy on peri-personal space, ownership and motor control in a highly realistic virtual environment will be discussed.

How preparation to touch or grasp alters visual size perception

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Background: Many prior studies have suggested that visually-guided actions are resistant to the effects of some pictorial size illusions, e.g., the maximum grip aperture component of a grasp for an element of the Ebbinghaus illusion display. We present four experiments demonstrating that when participants prepare to grasp, imagine grasping, or watch others grasp, the reduction in illusion magnitude observed for action components is also present for conscious perceptual judgments.
Aims: Our studies characterize how visual size perception changes when we choose to engage in different size-mediated behaviors. Even when the stimuli used are identical for two different tasks, we found that available information is processed differently.
Method: Participants always selected which of two targets was larger. In some conditions, the context in which the targets were presented induced a visual illusion of size. We varied the sizes of target pairs to assess the magnitude of these visual illusions. In some tasks, participants indicated their size choice verbally. For other tasks, participants reached to grasp or touch the target that they perceived as larger.
Results: Differences in the pattern of choices produced for different response tasks revealed a shift in the process of size perception. Illusion magnitudes were smaller when participants engaged in actions directed at a target, or when participants imagined performing those actions. This shift in visual processing persisted for several minutes after participants switched back to a verbal, non-grasping, non-touch task.
Conclusions: Preparing to grasp a target alters how the size of that target is perceived.

Body schema, size and gender: A motor imagery study

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Background: The body schema (BS) is an internal representation of the body's spatial configuration, and is believed to store and continually update information on the position-and-size-of-the-body-and-its-limbs. Accordingly, an accurate BS is essential to our successful navigation through space, as it informs us of which actions our body affords relative to environmental obstacles.
Aims: The-aim-of-this-research-was-to-explore-the-correlates-of-BS integrity,-and-to-investigate-whether-the perceived-spatial-requirements-for-navigating-horizontal-and-vertical-apertures-differ.
Method: Ninety-eight participants were asked to mentally simulate their passage through a series of projected doorway-like apertures. Half of the apertures varied in their horizontal dimensions, and those remaining varied in their height. For these two sets of apertures, participants judged whether they could successfully pass through without turning their bodies or ducking their heads, respectively. To explore BS integrity, buffer values for the two aperture types were subsequently determined. This was done by calculating the

difference, in millimetres, between participants' actual and perceived bodily dimensions.
Results: Both male and female participants judged that they required significantly more space for successful passage through horizontal than through vertical openings. An exploration of the correlates of participant buffer values, however, revealed intriguing sex differences. For the horizontal apertures, a significant negative correlation between shoulder width and buffer values was observed only for females. Similarly, for the vertical apertures a significant negative correlation between body height and buffer values was observed only in males.
Conclusions: The findings raise the intriguing possibility that the correlates of BS integrity differ for males and females. Further, the results put into question previous findings that BS integrity is scale-dependent.

Spatiality of shared intentionality and language universals: A philosophical reflection

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Background: The theory of universal grammar, long advanced by Chomsky and Pinker, has recently come under fierce criticism. Tomasello and Everett contend that language is not innate but constructed. The former has even pronounced the universal grammar 'dead' (Tomasello, 2009). The functional-cognitive model takes a spatial-situational approach to explain language in terms of shared intentionality. Language is thus seen as a by-product of such inter-subjective interactions that underlie it.
Aims: This contribution raises the question as to whether such an explanation sufficiently accounts for our relations to language at large. This contribution aims to demonstrate that both views on language are lacking.
Method: By examining the recent contributions in the aforementioned fields in light of the phenomenological–hermeneutical tradition, it will attempt to situate the recent debate in context while offering original insights from a phenomenological perspective. This contribution offers a conceptual reflection on the linguistic phenomena, enabling one to see the larger set of issues that are involved in the discussion.
Results: The functional-cognitive model is not satisfactory because it does not address one of the profound mysteries about language, namely that every child is capable of learning every human language. It is precisely this question that motivated Chomsky to invoke a universal grammar. Both views in the debate are insufficient for understanding human language.
Conclusions: Language is essentially not an a posteriori phenomenon but an a priori. The question is thus: what makes a language a human language? This question transcends the realm of shared-intentionality and human interaction.

Space first: A spatial inference model for multi-sensory perception

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Background: Understanding the relation between action and perception requires discovering the underlying structure of multi-sensory neural representations. Building upon the idea that space is the primary representational model for integrating multi-sensory input, we hypothesize that the perception of space acts as a causal filter, through which other modalities are conditioned and thus organized.
Aims: The dynamics of place-learning discovered in the "place cells" of the rat hippocampus, show that even in the absence of visual or auditory cues, a cognitive spatial map is at work. We seek to find evidence of these dynamics in human perception. We suggest that distance measurements is conditional given an a priori primary spatial perceptual construction.
Method: In order to be able to modulate the spatial surroundings as well as vital and auditory cues we staged our experiment in a virtual reality environment. We designed three virtual spaces with different visual environmental constructs, where a set of objects presented in varying distances accompanied by sounds produced by the speakers placed in the space. We then asked the subject to report on the distances of objects and whether the sound was causally linked to the object. We developed a model of the ideal Bayesian observer to generate predictions based on the collected data and compared the behavioral data with the model's results.
Results: We found evidence of a shift in visual distance judgments based on the provided aural cue, even when cues were not correlated.
Conclusions: Unpacking the perception of space reveals rich information processing interactions which are conditioned first and foremost on a dynamic structure of an environment in space.

Being the body: A computational approach to human experience of space

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Background: Understanding the human experience of space is an important inquiry in a broad range of scholarly disciplines where humans are the subject of study, whether as biological, social, or cognitive entities. The human body plays a central role in this challenge both in terms of biological complexity of human cognitive apparatus and the diversity of environmental, cultural and social contexts it is situated.
Aims: Building upon a cross-disciplinary literature review on the evolution of body-centric approaches we aim at developing a computational model of spatial experience that accounts space-sense as an independent component of perception that allows emergence of multi sensory contingencies and provides a common medium of representation for actions and senses. We hypothesize that space —as a

sensory modality, unifies and organizes otherwise disperse sensory stimuli, and thus must be utilized as the main driver of such computational model.

Method: We developed a body-centric computational model that integrates sensory data captured from a wearable device worn by human subjects into a spatio-temporal representation. Through a set of experiments we explore the potentials of this representation detecting multi-sensory action patterns, localization of the subject in a given environment and transformation of allocentric and egocentric sensory cues.

Results: Our experiments provide empirical evidence to our initial hypothesis that the spatial sense works as unifying component of perception. Using spatial sound recordings and eye trackers we have demonstrated how space can be attended in a multimodal way as well as how the perception of it altered based on sensory inputs.

Conclusions: Provided model opens up a way of representing the actions and perceptions in the same medium. We had a chance to observe diverse actions performed by subjects, which provided a rich contextual background to our experiments. Using body-centric temporal representations, we discovered the dynamics between actions and senses bridged by a spatial mediator.

6. Abstracts of Posters

Abstracts are listed alphabetically according to the first author's last name.

Environment Impact based on functional and aesthetical features: What is their influence on spatial features and rewarding mechanisms?

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Background: Neuro-architecture is an emerging discipline which uses neuroscientific methods to measure the brain and body's responses while the subjects are immersed in physical or virtual environments. The environment is made of different factors, implicitly and explicitly assessed because of their functional and aesthetical characteristics.
Aims: This study explores the influence of functional (such as lightness, size and ceilings height) and aesthetical features (such as colors, shapes and design elements) on rewarding response. Furthermore, we investigate the cognitive (attentional mechanisms) and emotive (rewarding) engagement in sixty healthy subjects in relation to different domestic environments.
Method: The participants were chosen by gender, age and level of expertise (naïfs/architects). We adopted a combined electroencephalography (EEG) and NIRS (Near Infrared Spectroscopy) measurements to record the brain activity; biofeedback to estimate psycho-physiological responses and eye-tracking to measure (eye movements) during the vision of videos of real domestic environments. These items are divided into four groups: functional/aesthetic, functional/unaesthetic, uncomfortable/aesthetic and uncomfortable/unaesthetic.
Results: Previous studies suggested that the computation of aesthetic preferences for objects predominantly relies on the activity of cortical areas implicated in the processing of reward. We expect the regions associated with the processing of reward (prefrontal cortex) to be modulated by expertise and we suppose that different cognitive (more focused attention by eye-tracking-measures) and emotive (more rewarding prefrontal areas) engagement is related to age (adults more engaged by functional aspects) and gender (women are more attracted by beauty).
Conclusions: The neuro-architecture research can guide experts to design environment by serving better spatial orientation.

Developing compensatory augmentations for aging and navigation

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Background: The normal aging process is associated with changes to spatial abilities that affect many tasks of daily life for elders, e.g. driving. According to the U.S. Census Bureau, 20 % of the population will be over 65 by 2050. Lifespan changes create safety concerns, increase the risk of getting lost, and reduce driver confidence in elders. This is particularly challenging in rural areas where public transportation is often non-existent yet elders strongly desire to remain in their home.
Aims: The current study explored how age affects driving ability. It combined a driving simulator with immersive virtual reality technology in order to test real driving scenarios with elders in a highly controlled, yet safe environment
Method: During testing, participants reacted to typical driving events: such as stopping at an intersection, entering and leaving a highway, and avoiding objects in the road.
Results: Performance was measured by rate of completion and reaction time for the specific driving events. Older adult performance was consistently lower than the younger adult group for both completion rate and reaction time. Post-study survey data suggested that all participants were able to easily interact with the driving simulator, with current results matching those of real-world accident data.
Conclusions: Findings from this research will be used to create compensatory augmentations, or navigational aids, and enrich the understanding of lifespan cognition. The end goal of this work is to increase safety, confidence, and independence for the country's fastest growing demographic.

Understanding architectural types

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Background: Traditionally, architecture blends knowledge, doing and context in ways that largely anticipated the situated cognition movement. Within this area, the notion of architectural type has been proposed to help organize and communicate interesting patterns across the variety of spatial entities. Types have been isolated looking at different aspects like the relationship between architectural entities and the surrounding space, the form and/or functionality of the entities, and the interactions among entities and users. This led to different understandings of what types are with arguments often driven by the architects' background perspective and their historical motivations.
Aims: To collect and review notions of architectural type that have been particularly influential to highlight how they have been motivated, to show their similarities and dissimilarities, and to discuss the elements that can be taken as unifying across the different views.
Method: We apply techniques of applied ontology to develop a cognitive framework for the understanding of architectural types and in particular their cognitive elements. We then use this framework to analyse the different notions in the literature. We also discuss advantages and limitations of our approach.
Results: The analysis is ongoing and we have partial results at the moment. We can show that some types are constant across time and cultures and that over time new types are introduced as merging/transformations of previous types. The comparison of the different definitions in the literature allows also to clarify how the notion has been understood in different historical periods.

Case study in rehabilitation with SaM method (sense and mind): A proposal and analysis

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Background: Traumatic brain injury (TBI) is an heterogeneous disorder that could be associated with cognitive and behavioral impairments. The clinical complexity of TBI patients requires a specialized and integrated approach that involves several rehabilitation experts (Mazzucchi, 2012). SaM Method (SaMM) (Risoli, 2013) is a new rehabilitation approach based on "Embodied cognition" theory (Gallese, Lakoff, 2005) and has the aim to improve spatial abilities through structured body exercises.
Aims: Aim of the present case report is to describe a new rehabilitation approach for TBI.
Method: The patient was a 35-year male who had TBI 9 months before. The patient was evaluated, before and after the treatment, with Rey Test copy and reproduction, Elithorn Test, Trail Making Test, Rey Auditory Verbal Learning Test. The patient was treated with SaMM for 4 months, three times a week.
Results: Several of the executed neuropsychological tests showed an improvement after SaMM treatment. The patient also reported an amelioration in some daily activities, such as swimming.
Conclusions: Further investigation is necessary but the SaMM appeared to be a useful complementary restitutive approach for TBI patients.

Perception of affordances during long-term exposure to weightlessness in the International Space Station

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Background: On Earth, visual eye height (VEH)—the distance from the observer's line of gaze to the ground in the visual scene—constitutes an effective cue in perceiving affordance such as the passability through apertures, based on the assumption that one's feet are on the ground.
Aims: In the present study, we questioned whether an observer continues to use VEH to estimate the width of apertures during long-term exposure to weightlessness, where contact the floor is not required.
Method: Ten astronauts were tested in preflight, inflight in the International Space Station, and postflight sessions. They were asked to adjust the opening of a virtual doorway displayed on a laptop device until it was perceived to be just wide enough to pass through (i.e. the critical aperture). We manipulated VEH by raising and lowering the level of the floor in the visual scene.
Results: We observed an effect of VEH manipulation on the critical aperture. When VEH decreased, the critical aperture decreased too, suggesting that widths relative to the body were perceived to be larger when VEH was smaller. There was no overall significant session effect, but the analysis of between-subjects variability revealed two participant profile groups. The effect of weightlessness was different for these two groups even though the VEH strategy remained operational during spaceflight.
Conclusions: This study shows that the VEH strategy appears to be very robust and can be used, if necessary, in inappropriate circumstances such as free-floating, perhaps promoted by the nature of the visual scene.

Does posture or gravity influence the perception of affordances?

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Background: Exposure to weightlessness induces important postural and environmental changes that could influence the way observers perceive affordances.
Aims: The objective of this study was to better understand the role of posture versus gravity in the perception of passability through apertures during acute exposure to weightlessness.
Method: Participants were asked to adjust the opening of a virtual doorway displayed on a laptop until it reached the critical aperture. Ten participants participated in a first experiment carried out in parabolic flight and on the ground to test for an effect of gravity. But during the free-floating condition, posture changed from standing to lying prone, in addition to the change in gravity's pull on the subject. A second experiment involved twenty other participants tested solely on the ground, while standing and lying prone, to test for an eventual effect of posture versus an effect of gravity.
Results: The results showed an effect of gravity condition: the critical aperture was diminished during short-term exposure to weightlessness. The second experiment did not show an effect of lying prone condition compared to standing posture. Changes in posture cannot, therefore, entirely explain the lowering of the critical aperture observed in weightlessness.
Conclusions: This finding suggests that modifications induced by weightlessness on aperture judgments were more related to gravity than to postural changes, indicating a role of graviceptor information in the perception of affordances.

The effects of space and time interactions on the Corsi Block Tapping Test: An investigation of the motor aspects of the task

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Background: The Corsi Block Tapping Test (CBTT) is a powerful experimental tool extendedly used to assess visuo-spatial working memory. The complexity of the task together with the lack of standardization that characterize the CBTT makes the understanding of which cognitive abilities are involved in the execution of it still unclear. In particular, little attention has been given to the motor aspects of the task.
Aims: The specific aspect we focused on is the investigation of the effects of the spatio-temporal characteristics of sequence presentation in shaping the performance during sequence reproduction.
Method: Forty-eight healthy subjects took part in this experiment. A digital version of the CBTT for tablets named eCorsi has been used. During the sequence presentation three timing manipulations were used. In the Proportional condition, the spatial distance between the blocks and the interstimulus interval during sequence presentation followed a proportional relation. In the Incongruent Condition, the timing never reflected the spatial configuration of the blocks. In the Isochronous condition, the timing always corresponded to 1 s. Accuracy and reaction time results were analyzed.
Results: The results showed the presence of an automatic spatio-temporal binding and a performance enhancement in the Proportional condition.
Conclusions: We suggest that when recalling sequences in the proportional condition, the subjects were facilitated in their motor response because of its similarity with the spatio-temporal characteristics of the sequence presentation. In designing future research of the CBTT the motor aspects of the task should be taken more into account.

An implicit spatial memory alignment effect

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Background: The memory alignment effect is the advantage of reasoning from a perspective aligned with the references frame used to encode the environment in memory. It usually occurs when participants have to consciously adopt a perspective to perform the spatial memory task.
Aims: The present experiment assesses whether the memory alignment effect can occur without requiring a conscious perspective taking, when the misaligned perspective is only perceptively provided. In others words, does the memory alignment effect arise when it is only implicitly prompted?
Method: Thirty participants learned a sequence of four objects' positions in a room from a north-up survey perspective. During the testing phase, they had to point to the direction of a target object from another object ("the source") with a fixed north-up orientation. The background behind the source object displayed either a uniform colour (control condition) or a misaligned ground-level perspective. This later displays either object's position information which was congruent with the studied environment (congruent misaligned condition) or incongruent (incongruent misaligned condition).
Results: Mean pointing errors were higher in the congruent misaligned condition than in the control condition whereas the incongruent misaligned condition did not differ from the control one.
Conclusions: The present study shows that the memory alignment effect can arise without requiring a misaligned conscious perspective taking. Moreover, the perceived misaligned perspective must share the same spatial content as the memorized spatial representation to induce an alignment effect.

Perceptual biases in the horizontal and vertical dimensions are driven by separate cognitive mechanisms

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Background: Perceptual attention in healthy young participants is characterised by two biases, one operating in the horizontal plane which draws attention leftward and the other operating in the vertical plane which draws attention upward. That these two biases are reliably found in the same participants has led previous researchers to search for a relationship between them. However, these investigations have failed to find any such association.
Aims: One reason that previous studies may have failed to find a relationship between the vertical and horizontal biases is that one dimensional vertical and horizontal stimuli were presented separately rather than being measured from a single, two dimensional stimulus.
Method: Across three experiments, two dimensional stimuli were presented and participants were asked to mark the centre of the stimuli. In addition, the shape of the stimuli was manipulated to determine if this produced the same modulation of the two biases.
Results: The results were consistent, across the thirteen stimuli used in the three experiments there were no correlations between the vertical and horizontal biases. In addition, manipulations of stimulus shape which effected biases in one dimension did not affect the biases in the other dimension. There were however, consistent correlations between the degree of bias within each dimension across the different stimuli.
Conclusions: This study found converging evidence that horizontal and vertical biases in spatial judgements are separate cognitive mechanisms in healthy young participants. The implications for our understanding of spatial neglect will be discussed.

Contextual auditory stimuli are helpful on virtual spatial navigation in patients with visual neglect

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Background: Topographical disorientation is often described in brain-damaged patients. Virtual reality is helpful to explore spatial navigation in this population, particularly in the presence of sensorimotor or cognitive disorders.
Aim: We investigated how contextual auditory stimuli (spatial vs. semantic cues) influence the performance of brain-injured patients in a navigational task, particularly those with unilateral visual neglect.
Method: We used the virtual action planning supermarket (VAP-S) with the addition of contextual auditory stimuli: a sonar effect (bips whose pitch increased when the subject was approaching a target) and the name of products' statement (name of target in the vicinity of which the subject was). Twenty-two patients with a first unilateral hemispheric brain lesion and seventeen healthy age-matched control subjects were tested without and with contextual auditory stimuli. In patients, neglect assessment revealed anomalies on a cancellation test in 32 % and self-assessment on the Catherine Bergego Scale was over or equal to 5/30 in 50 %.
Results: Patients with neglect symptoms and right hemisphere damage benefited from the "sonar effect" cues. The worse the neglect symptoms, the higher was the gain in performance score ($rs = 0.64$, $p = 0.01$ regarding the correlation with the behavioural assessment of neglect; $rs = 0.61$, $p = 0.02$ regarding the correlation with the self assessment).
Conclusions: These results support the use of auditory cues for navigation in patients with visual neglect, and suggest that additional stimuli might be helpful for neurorehabilitation. Further studies could be done to evaluate the impact of lateralizedor non-lateralized auditory stimuli on the neglect field exploration.

A cognitive robotics approach for the study of unilateral spatial neglect

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Background: Unilateral Spatial Neglect (USN) is a pathological condition characterized by patient's inability to perceive stimuli in spatial locations contralateral to the damaged cerebral hemisphere. The most direct methods to explore these issues are neurophysiological studies in humans. Computational models can complement these methods by constraining hypotheses about the normal and disordered function of attentional and spatial processes. In this view, cognitive robotics is a new and effective tool for better understanding of human cognitive functions.
Aims: To derive a model of the USN pathological condition in a cognitive robot, replicating a previous study with humans (Bisiach, Capitani, Porta 1985). We present preliminary results of a cognitive robotic approach to the computational modelling of human cognitive dysfunctions like USN.
Method: We designed an artificial neural network (ANN) to control the iCubplatform, and to simulate damages in the artificial hemispheres by cutting neural links. The ANN was also trained to replicate the particular phenomenon of the "specialization" of the right hemisphere for spatial attention. The experimental setup had four different conditions, for placing objects and for orienting longitudinal axes of the head and eyes. Finally, the network is re-trained to simulate the rehabilitation after the damage.
Results: We found that the sagittal mid-plane and line of sight contribute significantly to the omissions, as in the previous study we are replicating. The analysis of the recovery capability shows different behaviours in the four conditions.
Conclusions: Cognitive robots can be a useful tool for the study of pathological conditions as the USN and for preliminary testing of possible rehabilitation strategies.

Execution, observation and mental simulation of upper limb gesture for transitive and intransitive action: A fNIRS study

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Background: Since decades, human functional neuroimaging studies have investigated the functional equivalence between execution,

observation and mental simulation of upper limb movements such as grasping, reaching and performing meaningful actions. Although these tasks have showed recognizably differential areas of activation (e.g. M1 and S1 for execution, STS for observation), numerous fMRI studies have reported widespread overlapping activations over a fronto-parietal network, known as action observation network and including mirror neurons. Nevertheless, the focus of the majority of these studies was on the representation of transitive object-related actions, while the analysis of intransitive ones provoked relatively less attention.
Aims: The aim of the present study is to investigate patterns of cerebral hemodynamic activity during execution, observation and mental simulation of transitive gesture (object use, e.g. manipulating a brush) and intransitive gesture (only with communicative content, e.g. waving goodbye).
Method: Healthy subject (N = 18) were asked either to execute, observe or mentally simulate transitive and intransitive right upper limb gestures. During the three conditions, NIRS event-related signals were recorded over the frontal, parietal and temporal cortex using eight infrared optode emitters and eight optode detectors.
Results: Preliminary data analysis conducted on oxy-hemoglobin changes revealed similar activations within motor tasks (M1) but also differential patterns of hemodynamic activity (parietal areas). Moreover, transitive versus intransitive gestures showed different hemodynamic modulation, with increased M1 activity for transitive gestures.
Conclusions: These results were discussed taking into consideration the role of semantic information in gesture representation.

Effect of central vision deficit in reach and grasp task

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Background: Vision is paramount for motor actions directed towards objects (reach and grasp task for instance). Vision allows to identify the object, its shape and spatial location, but also to adapt our movement when arrived on the object (i.e. grip aperture). Therefore, vision deficits, as in Ageing Macular Disorder (AMD), could lead to motor deficits. Few studies have investigated reaching and graspingin patients with AMD.
Aims: The purpose of this study is to understand the difficulties encountered by people with central vision loss in sensorimotor tasks.
Method: We compare performance of 17 patients with AMD and 17 controls in two reach and grasp tasks. In the first task, participants had time to look at the object before performing the task (as in daily life). In the second task, objects were displayed only when the participant had to reach and grasp the object (as in previous studies).
Results: The results show that the kinematic parameters of reach and grasp movements do not differ between groups in the first task. In contrast, AMD patients show a higher time to maximum velocity and time to maximum grip aperture and lower maximum velocity than control participant, in the second task.
Conclusions: These findings suggest that the motor deficits in AMD result from difficulties to identify objects and not to execution of motor action itself. We discuss these results in the context of rehabilitation training.

Contextual versus numeric visuo-spatial reorientation during cancellation tasks

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Background: Numbers have the peculiarity to reorient the humans' attention towards the left/right according to their magnitude (Fischer et al., 2001). This effect has recently even been documented in cancellation tasks, allowing participants to freely explore the space in which targets are displayed among distracters (Di Luca et al., 2013).
Aims: However, these last results were obtained with horizontally oriented rectangular display areas. Therefore, it remains to be determined whether they can also be obtained when the visual context does not provide such a strong horizontal reference frame.
Method: Consequently, we ran an experiment in which participants were presented with numerically adapted star cancellation tasks (i.e. using digits 2 and 8 as distracters), that were displayed as horizontally and vertically oriented rectangular surfaces. Besides, we presented square-shaped cancellation tasks within which digits were tilted 90° left- or rightwards.
Results: Independently of the orientation of the display area, numbers induced a left/right spatial orientation bias as a function of their size [small digits were associated to more omissions on the right, the reversed for large digits: $F(1,37) = 4.183$, $p < .05$]. Moreover, when numbers were tilted left-/rightwards, they had an addictive effect of bottom-up and top-down spatial bias.
Conclusions: Results show that the left/right biasing effect previously found can be considered as a pure effect of numbers and not of the visual context. Moreover, when numbers are titled in a neutral context, they can induce additional vertical visuo-spatial biases, that are function of the Mental-Number-Line orientation to which they make reference.

To fly or not to fly? The automatic influence of negation on language-space associations

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Background: Embodied models of language understanding propose a close association between language understanding and sensorimotor processes. Specifically, they suggest that meaning representation is grounded in modal experiences. Converging evidence suggests that words automatically activate spatial processing. For example words such as 'sky' ('ground') facilitate motor and visual processing associated with upper (lower) space. However, very little is known regarding the influence of linguistic operators such as negation on these language-space associations. If these associations play a crucial role for language understanding beyond the word-level one would expect linguistic operators to automatically influence or modify these language-space associations.
Aims: The aim of the present study was to analyse the influence of a negation operator on language-space associations.
Method: Participants read sentences describing an event implying an upward or a downward motion in an affirmative or negated version (e.g. 'The granny looks to the sky (ground)'/'The granny does not look to the sky (ground)'). Subsequently participants responded with

an upward or downward arm movement according to the colour of a dot on the screen.
Results: The results showed that the motion direction implied in the sentences influenced subsequent spatially-directed motor responses. For affirmative sentences, arm movements were faster if they matched the movement direction implied in the sentence. Most interestingly, this language-space association was modified by the negation operator.
Conclusions: Our results show that linguistic operators—such as negation—automatically modify language-space associations. Thus, language-space associations seem to reflect language processes beyond pure word-based activations.

Posture and imagery in the memory of manipulable objects

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Background: Numerous studies have shown that a manipulable object potentiates the motor program of the acts we typically perform on it. In a previous study, we have shown that a position that prevents hands to move decreases the memory of manipulable objects—but not of non-manipulable ones—compared to when the hands are free. It suggests that memory of manipulable objects is situated in contextual bodily state (Dutriaux & Gyselinck, in preparation).
Aims: To see whether the posture interferes with an automatic motor simulation phenomenon, or whether it depends on the strategy of the participant.
Method: In two experiments, the instruction (silent naming or visual imagery strategy) and the delay of presentation of the stimuli were manipulated between participants. The name of 36 manipulable (e.g. mug) and 36 non-manipulable objects (e.g. antenna), distributed in six lists, were presented to the participants. In the interfering condition, they had to keep their hands behind their back. In the control condition, they had to keep their hands on the desk. After each list, participants had to perform first a distractive task, and then an oral free recall.
Results: As in Dutriaux & Gyselinck, the memory of manipulable objects should decrease with the interfering posture compared to the control posture, but posture should not have any effect on the memory of non-manipulable objects. If the postures interfere with an automatic phenomenon, we should not observe any effect of the strategy, if not, the interference should be modulated by the strategy.

The "Near extrapersonal space" (NES): A subjective space affected by the individual's physical and personality characteristics

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Background: The extrapersonal space (ES) is known as the space beyond reaching distance. It has been shown that the motion potentialities that are intrinsic to our body, as well as to the body of other observed agents, influence distance estimation within ES. However, the categorization of this space is still controversial.
Aims: To investigate the portion of ES that, despite being beyond reaching, is subjectively defined as "Near" (NES). Moreover, to investigate whether the NES extent is affected by the individual's recent physical activity and by her/his personality characteristics.
Method: Twenty subjects (7 males; mean age = 23.7, range 18–30) were asked, both in a 3D-virtual and in an ecological environment, to verbally categorize as "Near" or "Far" a target located at different increasing or decreasing distances (2–16 m) according to the limits method, which allowed the calculation of an average NES threshold (see Fini et al., 2015, Cognition, 134: 50). The subjects also completed the International Physical Activity Questionnaire (IPAQ), the Interpersonal Reactivity Index (IRI) and the Schizotypal Personality Questionnaire (SPQ), and performed a blindwalking of the following distances: 4, 6, 8, 10, 12 m.
Results: We observed a significant positive correlation between the NES calculated in real and virtual space and an influence of the level of physical activity, of personal distress and of disorganized behavior on the NES extension. At the blindwalking the subjects were more accurate in reproducing the distances below 10 m, that is around our average ecological NES ($m = 7.44$, SD = 1.59 m).
Conclusions: The NES seems to be a subjective, motor-codified space, affected by personality variables, thus binding the ES categorization to physical and social contexts.

The right TPJ plays an active role in maintaining an internal representation of verticality: An interferential continuous theta burst stimulation study

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Background: Perception of the subjective vertical is strongly based on our ability to constantly integrate signals from visual, vestibular, proprioceptive, tactile and even visceral modalities and matching them with an internal representation of the vertical. An important

multisensory integration cortical region is the right temporo-parietal junction (rTPJ) which is also involved in higher-order forms of body- and space-related cognition.
Aims: Test the hypothesis that TPJ is specifically involved in the integration of multisensory information necessary for establishing the subjective visual vertical.
Method: We combined a psychophysical approach based on Rod-and-Frame task with transient inhibition of the right TPJ via continuous theta burst stimulation (cTBS). A gabor patch orientation detection task and cTBS of V1/V2 were used as control task and area respectively.
Results: Inhibition of rTPJ activity impairs the ability to evaluate the rod verticality when no contextual visual information is provided. Conversely, transient inhibition of V1/V2 disrupts the ability to visually discriminate gabors' orientation.
Conclusions: This anatomo-functional dissociation supports the idea that rTPJ plays a causal role in maintaining an internal frame of reference against which contextual information is compared.

Imagined and actual movement through the environment and the reference frame orientation in survey knowledge recall

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Background: Spatial relations are stored within an oriented frame of reference in long-term memory. However, experiments asking participants to draw sketches or maps while imagining walking towards a target found sketches' and maps' orientation varying with the viewing/imagined walking direction.
Aims: Two experiments were designed to assess whether imagined (Experiment 1) or real (Experiment 2) viewing direction or locomotion direction is responsible for this effect.
Method: In both experiments, participants mapped familiar locations within their city of residence by arranging named magnets on a metal plate. No emphasis on speed was given. To isolate viewing direction from locomotion direction, participants were asked to imagine travelling in a tram facing backwards through the target area (Experiment 1) while performing the task. In Experiment 2, participants performed the task while physically travelling the route in a tram facing backwards. As resulting map quality and map orientation may vary with mental rotation ability and sense of direction, both were assessed (by mental rotation test and Santa Barbara Sense of Direction Scale) after the mapping task.
Results: In both paradigms, most of the resulting maps were oriented along the viewing direction. Neither map quality nor map orientation were related to mental rotation ability and sense of direction.
Conclusions: Results suggest that allocentric spatial memory is recalled into working memory by taking the visually perceived relation between navigator and target space into account.

The link between number-space associations and visuospatial abilities depends on cognitive style

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Background: Evidence for number-space associations comes from the spatial-numerical association of response-codes (SNARC) effect, consisting in faster RTs to small/large digits with the left/right hand respectively. However, the cognitive origin of the effect remains elusive. Previous studies suggested that it might depend on visuospatial processes, since individuals with better performances in 2D (but not 3D) mental rotation tasks displayed weaker number-space associations (Viarouge et al., 2014).
Aims: Given the high inter-individual variability of number-space associations, we determined whether the SNARC effect always relies on visuospatial processes or whether its cognitive origin varies with visualization preferences.
Method: We distinguished between object-visualizers ($n = 42$, 23 female, age = 22.93) and spatial-visualizers ($n = 42$, 15 female, age = 23.9) using the Object-Spatial Imagery Questionnaire (Blajenkova et al., 2006). All participants performed the parity judgment task, a 2D visuospatial test and a 3D mental rotation task.
Results: In object-visualizers, weaker SNARC slopes were associated with better performances in the 2D ($r = 0.46$, $p = 0.004$), but not 3D ($r = -0.04$, $p = 0.79$) task, thereby replicating previous observations. Conversely, in spatial-visualizers, the performances in both visuospatial tasks were unrelated to the SNARC effect (2D: $r = 0.02$, $p = 0.89$; 3D: $r = 0.2$, $p = 0.22$).
Conclusions: These findings suggest that in object-visualizers, number-space associations and 2D performances underlie common visuospatial processes. Conversely, in spatial-visualizers, number-space associations seem to result from cognitive mechanisms other than those recruited during the aforementioned visuospatial tasks (e.g., verbal-spatial coding mechanisms). All in all, we were able to further unravel the mechanisms underlying number-space associations and could highlight visualization preferences as an additional explanation for the great inter-individual variability of the SNARC effect.

Architecture and spatial cognition to enhance learning

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Background: History is paved with mnemonic devices that make use of human spatial cognition to memorise sequence of information. Humans are able to visualise in their mind's eye previously visited spaces and use them to store sequences of information that can be retrieved later. Neuroscience and cognitive psychology are making good progress at understanding those mechanisms. How does architecture influence this ability? What features will help to build meaningful spaces for learning?
Aims: Based on the method of loci, this research explores the potential of architecture to enhance the way humans memorise sequences of information.

Method: A set of experiments invites participants to complete a basic memory task immersed in different 3D virtual environments. Each environment consists of a different style of architecture with its features and properties. The design of the experiment is twofold: the architecture supports the storage of a sequence and the framed pictures support the creation of strong associations between locations, images and the information to remember.
Results: Partial results indicate that, although each participant is able to draw a cognitive map of the visited space after the test, they were not all able to restitute the exact sequence of information. There is a correlation between architecture style and a participant's performance which will be explained in detail in our presentation. Quantitative and qualitative methods in a broader online panel will be used to understand better participants' choices and path the next couple of month.

The influence of anxiety and personality factors on comfort and reachability space: A correlational study

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Background: Although the effects of several personality factors on interpersonal space (i.e. social-space within personal comfort area) are well documented, it is not clear if they also extend to peripersonal space (i.e. reaching-space). Moreover, some research reported controversial effects of anxiety on near body space. Iachini et al. (2014) recently suggested that peripersonal and interpersonal spaces share a common motor nature and are affected by social-emotional factors. However, no study has compared these spaces in relation to personality and anxiety factors.
Aims: Verifying if, and to what extent, anxiety levels and personality dimensions are associated with the reduction/extension of the reaching and comfort distances between people.
Method: 70 students (35 F) were administered the Big Five Questionnaire (Caprara et al., 1993) and the State-Trait-Anxiety Inventory (Spielberger 1989). Afterwards, they had to provide reachability-distance and comfort-distance judgments towards human confederates while standing still (passive) or walking towards them (active).
Results: The correlation analyses showed that the extension of both reaching/comfort spaces increased as the level of Trait Anxiety increased. The more participants rated themselves as dynamic the more they reduced the size of both reaching/comfort spaces in the active condition. Moreover, a high emotional stability is related to a reduction of passive comfort-distance, while a high Cognitive Openness is associated with a reduction of passive reachability-distance.
Conclusions: Both spaces are related to trait anxiety and this may reflect the need of controlling the social context by extending protective body area. By contrast, cognitive and emotional personality components seemed to have differential association with the two spaces.

Duality of emotion approach in case of flanker task performance: An attempt to understand emotion–cognition interactions from new perspective

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Background: This study was based on the emotion duality model (Jarymowicz & Imbir, 2014) suggesting the existence of so called automatic and reflective emotions stemming from different origins: nonverbal biological value (Damasio, 2010) providing a sense of criteria enhancing survival, or evaluative standards (Reykowski, 1989) based on verbalized criteria of what is bad or good. In both cases, emotions may have different sources, namely internal processes and external stimulation.
Aims: The current study sought to examine if this proposed distinction modulates the processing of the flanker task, which measures interference of surrounding objects (especially when they share similar perceptual features) in decisions concerning the central object (Eriksen & Eriksen, 1974).
Method: To elicit emotions of different origins and sources of positive or negative valence, eight different sets (each containing six items) of sentences describing prototypical situations for each manipulation condition were used. Participants were instructed to read each sentence separately and imagine the described situations happening to them. Valence of imaginations and their intensity were measured to ensure validity of manipulation. Then the flanker task was applied. This task is sensitive to visual interference and three levels of difficulty were utilised in terms of distance between flanker letters.
Results: Accuracy varied according to the difficulty of the task, whereas response times were varied according to the origin of emotion. In automatic origin manipulation, participants took more time to answer than in reflective origin conditions. Interactive effects for source of emotion and task difficulty as well as source and valence in response times were found.
Conclusions: Origin of imagined affective state shaped processing speed of an attentional task involving visual space. Automatic emotions captured attention and had longer reaction times compared to reflective emotions.

Remember down, look down, read up: Does a word modulate eye trajectory away from remembered location?

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Background: Previous research (Theeuwes et al., 2005) showed that eye trajectory deviates away from a remembered visual location if a saccade is made in the same direction that the location. The data suggest that part of the process of maintaining the location in the working memory (WM) is mental simulation of the location so that the oculomotor system treats the location as a real one. Other stream

of research suggests that word meaning may also behave like a "real object" in space.
Aims: The aim of the study was to examine the effect of word meaning on the memory of a location during two processing stages: location recognition (Experiment 1) and location maintaining (Experiment 2) in the WM.
Method: Participants had to memorize the location of a dot and then to recognize the memorized location by pressing a button during a memory test (Experiment 1) or to execute a saccade (Experiment 2) depending on the direction of a presented arrow (up/down). Within the dot a word "up" or "down" was always present.
Results and Conclusions: Reaction time of location recognition was affected by the meaning of a word within the dot. However, the saccade data showed no impact of word meaning on the deviation of eye trajectory. Thus, mental simulation of irrelevant to the task space-related word meaning affects later stages of memory processes (location recognition) and not the earlier ones (maintenance of the location in the WM).

Visual expertise in immediate spatial localisation tasks

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Background: Spatial cognition is separated from visual memory; spatial localisation is a faculty of memory, which shows great variability depending on age and individual differences. Sequentially and simultaneously presented spatial localisation tasks are prevalent, combining what–where and when information.
Aims: The study investigates age and profession as important factors for basic spatial cognition. The main question, whether expertise affects localisation performance is examined by correct solution and response time.
Method: The study examines a sample (N = 94) of adult subjects grouped by age (18–63) and visual expertise in four spatial manipulation tasks of increasing complexity (3–9 span and preset exposition time) and tested online. Data were analysed by localisation performance and reaction time within and between groups. Task 1 is a modified Corsi where points are displayed sequentially and requires correct localisation and display order. Task 2 requires spatial recall of simultaneously displayed numbers in numeric order. Task 3 repeats Task 2 in self-paced timing (measured by inspection time.) Task 4 requires numeric interference-inhibition.
Results: Results show positive self monitoring and negative inhibition effect on localisation in both groups. Switching tasks and learning new ones is easier for the younger adults. The localisation performance of the expert group is not different, however both reaction and inspection time define fast and slow groups regardless of age and expertise.
Conclusions: The increase of task complexity correlates with the number of hits across the four tasks. Age and expertise affects basic spatial cognition and learning, reasoned by automatisation of memory processes. How basic and high level spatial abilities depend on each other and contribute to spatial cognition is subject to discussion.

Chunking by food type and spatial constraints in a virtual reality search task

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Background: Animal cognition studies often attempt to demonstrate the presence of human cognitive skills in animals. Chunking is a well-established data reduction strategy in humans. In spatial search tasks, chunking by food type in rats has been considered equivalent to human chunking in other domains. However, humans have never been tested in a similar paradigm to substantiate this claim.
Aims: We aimed to assess chunking by food type in humans' spatial search in comparison to strategies exploiting the spatial constraints of a foraging environment.
Method: Participants, who were not food deprived, navigated through a set of locations to find chunkable virtual food rewards. Experiment 1 featured a free search to assess spontaneous chunking or alternative spatial strategies. Experiment 2 required participants to chunk by food type, and assessed how their search performance transferred to conditions that compromised chunking to a different degree.
Results: A strong tendency to use the spatial constraints imposed by the structure of the search space was evident. However, participants could chunk by food type when required to do so, and performance deteriorated in transfer trials where learned chunks were compromised. Unlike rats however, this was only observed in the first transfer trials, suggesting that humans efficiently reorganise memories.
Conclusions: Albeit humans show a high flexibility in chunking by food type when induced to do so, they seem to use the spatial constraints of the environment as a preferential data reducing strategy. The equivalence of chunking by food type to human chunking in memory will be discussed.

Representation of impossible worlds in the cognitive map

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Background: Large-scale spatial environments are assumed to be represented in humans as cognitive maps but the exact features of these representations are still unclear.
Aims: We investigate the structure of this representation with the impossible worlds paradigm by testing whether the information provided by virtual environments (VEs) with arbitrary violations of geometrical rules is entered directly into the representation or whether it is adapted ("distorted") to become compatible with a map-like structure.
Method: The experiments were run with an omnidirectional locomotion interface (VirtuSphere), a rotatable sphere that allows subjects inside to walk in any direction, while immersed in a VE. Sphere and head movements were tracked to provide the view within a VE on a head-mounted display. The subjects' task was to explore seven possible and impossible VEs carefully to achieve a "full understanding". After each trial they had to "blindly" reproduce the path through the environment from memory by rewalking it in an empty VE without relevant visual cues.

Results: We have found no evidence for relevant distortions or alterations in the blind reproductions of impossible VEs. Furthermore, there is no indication for a difference in processing of impossible and possible VEs.
Conclusions: Blind reproduction shows that impossible VEs do not require a transformation into a "possible" format to make them fit into the cognitive map. This suggests that the representation may not be similar to a map in a bounded sense of interpretation but requires more generalized concepts for its understanding.

Prior knowledge of character locational stereotypes and representations during text comprehension

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Background: Previous research indicates that readers' prior knowledge of characters is processed during text comprehension, playing an important role in readers' construction of mental representations for text (e.g., Rapp et al., 2001; Filik, 2008; Filik& Leuthold, 2008, 2013). Therefore, certain character locational stereotypes might be part of a reader's prior knowledge, which affects representational constructions during text comprehension.
Aims: The present study examined whether readers' prior knowledge of character locational stereotypes affects the construction of these character representations during text comprehension.
Method: Two short stories were presented to participants. In one story, God and two people wearing blue and green (in that order) appeared in a room (God condition). In the other, three people in red, blue, and green (in that order) appeared (three people condition). The only difference between the two stories was the first character that entered the room. All participants were assigned to either the God or three people condition. Participants read the story and gave an account of their own mental representation as to where the three characters were located within the room. Participants then provided reasoning for their descriptions.
Results: In the God condition, most participants stated that God was in the center relative to the two people. In the three people condition, most participants stated that the person in red was located in front of or closest to the participant.
Conclusions: These results suggest that readers' prior knowledge of character locational stereotypes can affect where they assume character to be located during text comprehension.

Effect of nearby hand on visual processing in a 3D virtual environment

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Background: Visual processing is altered in perihand space. One explanation for this finding is based on the functionality of the hand: Visual processing is altered where action is more likely to occur. In a similar way, the possibility to act with virtual hands in a 3D environment should also alter visual processing close to these virtual hands.
Aim: To test whether the nearby hands effect could be extended to virtual hands in a 3D virtual environment.
Method: Participants had to perform a visual discrimination task in a 3D virtual environment. Three conditions were tested: an "active hands" condition where participants could control virtual hands and acted with them before performing the discrimination task, during which they placed their virtual hands near the display; a "passive hands" condition where virtual hands were disposed near the display but could not be controlled by the participant; and a "no hands" condition. The order of conditions was counterbalanced across participants. Thus, half of them performed the active hand condition before the passive one.
Results: Preliminary results showed no main effect of the hand condition, but revealed an interaction between hand and order conditions. We observed an effect of the order only on the passive hand condition with shorter RTs when performing the active condition at first.
Conclusions: It seems that after acting in a virtual environment, the potentiality of action associated with the virtual arms remains for a while, even if they do not offer the possibility to act anymore.

Gender differences when manipulating confidence during a first-person virtual maze learning task

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Background: Many studies have shown a persistent gender difference in spatial navigation.
Aims: The objective of this study was to determine if stereotype threat/boost may be a factor in determining the persistent gender difference in a maze learning task.
Methods: Participants ran through a navigation task consisting of a series of video tours paired with maze performances. Virtual mazes were adapted Hebb–Williams mazes, for a total of 30 mazes. Video tours were used which consisted of the same first person perspective as the maze performance. Metacognitive judgments were taken after each video tour and after each performance. Deception was used to manipulate confidence by mentioning to participants before the task one of three conditions: (1) Men are better at this navigation task than women, or (2) Women are better at this navigation task than men, or (3) That the genders do equally well. Self-reported questionnaires were filled out at the end: Spatial Anxiety Scale, Wayfinding Strategy Scale and the SBSOD. In addition to a questionnaire on social beliefs in relation to navigation strategies and gender differences.
Results: We hypothesize our results will indicate a sense of stereotype threat whereby belief in the stereotype that women perform worse than men would be correlated with lower performance among women but higher performance among men (stereotype boost/lift). We hypothesize participants in confidence condition (2) will exhibit less exaggerated stereotyped performances than those in condition (1) and (3). Discussions on metacognition, spatial anxiety, strategy and other social beliefs will also be taken into consideration.

The choice of intrinsic axis under multi-cue conditions

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Background: The intrinsic frame-of-reference system (IFORs) theory suggests people mentally represent a layout in terms of an intrinsic axis (Mou & McNamara, 2002). The choice of this axis depends on various spatial and non-spatial properties. Tamborello II, Sun, and Wang (2012) studied how people handled multiple conflicting IFORs, but they only focused on objects' different orientations in the scene, not different categories of spatial cues.
Aims: The main purpose is to investigate how people choose intrinsic axis in a virtual-reality environment with spatial cues from different categories.
Method: There were two within-subject design experiments. In each experiment, 32 participants learned a layout consisted of seven objects, in the format of two images captured from 0° and 45° first-person perspectives (the order of learning was counterbalanced), then completed 96 partial-scene-recognition experimental trials. Experiment 1 used non-orientation objects, and the directions of symmetric axis (45°) and the borderline (0°) of the scene were incongruent. Experiment 2 used avatars, whose orientations were all congruent with the borderline. Response patterns were analysed to determine participants' strategies for intrinsic axis choice.
Results: In Experiment 1, the axis along with the initial learning perspective was chosen as intrinsic axis, while in Experiment 2, 0° axis (the borderline and the coincident orientation) was chosen.
Conclusions: When there are two conflicting spatial cues of different categories, people would choose the intrinsic axis according to their original egocentric experience. When there are three or more spatial cues, the overlapping direction is more likely to be intrinsic axis.

Memory and visual search in immersive environments

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Background: It seems likely that memory is an important determinant of attention allocation during daily behaviors. Previous studies have shown that memory guides visual search in two-dimensional images. However, it is unclear how these findings extend to three-dimensional environments.
Aims: To what extent does memory for context benefit search in three-dimensional environments, and what is the role of task in the development of that memory?
Method: Eye movements were tracked in an immersive virtual reality apartment with two rooms. Subjects explored one room for 1 min and searched for targets in either room for 40 trials, including three repeated searches for eight geometric objects, and searches for 16 realistic context objects. We defined an object as being task-relevant when it became the target for a search.
Results: We found that 1-min exploration prior to search does not aid later search much in the same room regardless of whether targets were present during exploration or not. However, search efficiency increased rapidly when a target was searched for more than once. Even after 24 trials, there was no benefit of previous experience for search of context objects that had previously been task-irrelevant. Additionally, incidental fixations to objects before they became targets did not improve later search efficiency.
Conclusions: The results suggest that spatial memory facilitates search primarily when developed during task-relevant experience. More extensive experience may be required for memory for task-irrelevant context from exploration or incidental fixations on context objects to aid subsequent search.

Where was it? Object location memory depends on sensory modality

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Background: Remembering the location of objects is a crucial ability in human daily life. Contrasting findings in visual and auditory working memory debate upon the hypothesis whether associating the location and the identity of stimuli depends or not on the sensory modality of the input.
Aims: In this study, we tested the role of sensory modality in the incidental encoding of stimulus location during the voluntary memorization of the identity of a sequence of items.
Method: 70 students from Lawrence Technological University were asked to memorize sequences of either environmental sounds, spoken words, pictures or written words. Participants were then presented with new sequences including old and new items and asked to recognize the ones that have been previously presented. Crucially, they were also asked to indicate from which side of the screen (visual stimuli) or from which channel (sounds) the old stimuli were presented.
Results: The main results indicate that the accuracy in the object location memory task was significantly lower for the auditory stimuli (environmental sounds and spoken words) than for pictures.
Conclusions: We conclude that incidental memorization of object location is more effective for visual objects than for auditory ones. Our findings are consistent with evidence of visual dominance for spatial processing.

Coupled filtering in visual and motor spaces for reaching and grasping

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Background: For human adults, reaching a target feels like an easy task, but nevertheless involves many degrees of freedom and complex trajectories in the joint space. To fully understand human movement generation, as well as to develop efficient algorithms for humanoid or

dexterous manipulation robots (that share the same constraints), overcoming the limits and drawbacks of classical control approaches is required.
Aims: Without resorting to inverse kinematics (that may be excessively time consuming or lead to rough approximations), we want to show that it is possible to control high dimensional systems by simulating and predicting the outcome of local actions (forward model only), as long as the problem complexity is broken down into both the visual and motor spaces.
Method: We rely on a bio-plausible and probabilistic method for generating reaching movements in complex settings. Specifically, we apply (approximate) Bayesian filtering in the visual and motor spaces. Visual filtering permits to define an initial rough trajectory in the operational space (avoiding obstacles), which is then refined by motor filtering, allowing direct control in the joint space while respecting joint limits.
Results: The method was validated in simulation on a set of scenarios, with one or several targets (e.g. fingers on an object for grasping) to be reached with one or several arms/hands. With strong spatial constraints (e.g. obstacles), it succeeds in finding a trajectory where inverse kinematics methods fail.
Conclusions: Relying on the visual space seems promising to reduce the complexity of movement generation in the motor space.

Cultural spatial biases: Number generation is influenced by reading direction

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Background: Western participants associate small numbers with left and larger numbers with right space. A biological account proposes brain asymmetries lead to asymmetries in number space. In contrast, a cultural account proposes this association is shaped by reading direction.
Aims: We explored whether number generation is influenced by reading direction and compared number generation in participants from a left-to-right reading culture (UK) to participants from a right-to-left reading culture (Arab).
Method: Participants lay on the floor on their left, back (neutral) and right side. In each position participants generated 40 numbers randomly. All adults were also tested on a standardized arithmetic test and a parity judgement task: participants had to judge whether single Arabic digits were odd or even by pressing a left or right response button. The association of left/right response buttons to odd/even numbers changed halfway.
Results: We found a significant effect of body position on the mean size of numbers generated. This effect was determined by the cultural dominant reading direction. While Arab participants produced significantly smaller numbers when they were lying on their right side, British participants produced significantly larger numbers on their right side. Similarly, in the parity judgement task Arab adults responded faster to smaller numbers with their right hand while British adults responded faster to larger numbers with their right hand. The size of these two spatial-numerical effects was not correlated.
Conclusions: Our results of asymmetries in number space are more compatible with a cultural than a biological account.

Confirmatory factor analysis for indicators of perceived environmental quality of the stadium (IPEQS)

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Background: Studies conducted in the 1980s (see Canter et al., 1989) highlighted the prominent role of the spatial–physical features of football grounds in influencing users' perception of safety, comfort, and general satisfaction toward the stadium experience. In particular, it was shown the importance of fulfilling the spectators' needs of personal space (e.g., presence of an open view, proper distance between the seats) and movement opportunity.
Aims: The aim of this study is to confirm the factorial structure of a set of indicators—the IPEQS—concerning the perceived quality of an array of aspects (i.e. architectural, social, functional, and safety issues) related to the stadium design.
Method: Participants (N = 255), who were selected on the basis of their stadium experience, filled in a self-report questionnaire measuring a set of indicators developed on the basis of both validated tools (i.e., the Perceived Residenti al Environment Quality Indicators—PREQIs: Bonaiuto et al., 1999) and outcomes of semi-structured interviews. Confirmatory factor analyses (CFA) were performed for each scale, and reliability assessments were then carried out for each indicator.

Embodiment of peripersonal space perception: Does the level of phobia influence reachability judgments?

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Background: Needs, desires, and emotions have been proven to have an influence on space perception, partly because of their modulator and guiding role towards behaviour and action. Literature has already shown evidence that the sense of threat induced by danger or fear have an influence on perceived peripersonal space boundary. However, studies results are still contradictory.
Aims: The present study aimed at investigating whether and how one's level of arachnophobia could moderate the reachable space perception towards spider stimuli.
Method: In this experiment, participants were asked to make classic reachability judgments about static stimuli and appreciation of the moment moving stimuli entered or left their reachable space. Variables about threat (i.e., butterfly, diabolo, and spider stimuli) and

movement (direction (i.e., receding and approaching), speed, and animation) were also manipulated.
Results: While results about static stimuli didn't confirm our hypothesis, the ones about moving stimuli revealed a positive relationship between the level of phobia and an enlargement of perceived peripersonal space, especially for approaching stimuli (i.e. phobic participants estimated the entrance of stimuli in their peripersonal space earlier than the non-phobic participants). Furthermore, differences between the stimulus categories only emerged with moving stimuli in the non-phobic group.
Conclusions: Results suggest that space perception is a construct based on action capacity and body representations. In a context inducing a protective behavior, the more one is afraid or directly threatened, the more one's perceived peripersonal space will be extended and, thus, the closer (i.e. the more reachable) approaching bodies will seem in order to promote faster action preparation.

The mapping of emotion words onto space: A cross-modal study

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Background: Previous studies have reported evidence supporting a metaphorical mapping of emotion concepts onto a vertical spatial axis. Most of the work on this topic has used visual words as the typical experimental stimuli. However, to our knowledge, no previous study has examined the association between affect and vertical space by using a cross-modal procedure. In the present study, we examined whether auditory words with an emotional valence can interact with vertical visual space according to a 'positive-up/negative-down' embodied metaphor.
Aims: To investigate whether the mapping of emotion words onto visual space holds when those words are presented auditorily.
Method: In Experiment 1 participants passively listened to the emotion words prior to detecting the position of a target on the vertical axis. In Experiment 2 participants actively listened to the emotion words to determine their valence (emotional group) or identify whether the first letter of the word was a vowel or a consonant (non-emotional group) prior to detecting the vertical position of the target.
Results: While in Experiment 1 no reliable interaction between emotion concepts and bodily space occurred, such an interaction emerged in Experiment 2, only when participants were engaged in an emotion-focused task. Interestingly, there was no main effect of the between-subjects factor 'group' in that global RTs in both emotional and non-emotional tasks were similar.
Conclusions: The mapping of auditorily-delivered emotion words onto visual vertical space can ensue so long a purposeful processing of emotion is required.

The effect of body posture on power and space perception

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Background: Power is people's ability to influence the others to get what they want. Recent studies have suggested that power influence the perception of some action constraints like body size. The findings that perceived body size influence space perception suggests that power might influence space perception through its influence on perceived body size.
Aims: We aimed first at evaluating whether holding an expansive posture increases the sense of power compared with holding a contractive posture. We also explored whether an increase in power leads to an extension of peripersonal space.
Method: First, participants hold an expansive or a contractive posture before filling in a sense of power and a risk taking scales. Second, they bisected lines located at various distance from them. We used the spatial dependency of the line bisection bias as measure of peripersonal space.
Results: The data suggested that social power pre-activation by an expansive sitting posture increases the personal sense of power and increases the level of risk taking. In addition, we predict a more gradual rightward shift in bisection bias for participants who maintained an expansive posture rather than a contractive one. This would suggest that holding a posture increasing power results in an extension of peripersonal space.
Conclusions: Our preliminary results are consistent with the literature regarding the effect of body posture on sense of power and risk taking. If the second prediction is observed, our study would provide evidence supporting the effect of power on visual space perception.

The effect of repetition priming on spatial memory during backtracking in a novel environment

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Background: During wayfinding in a novel environment, we encounter many new places. Some of those places are encoded by spatial memory. But how does the human brain "decide" which locations are more important than other, and how backtracking or repetition priming enhances memorization of these scenes?
Aims: In this work we explore how backtracking improves encoding of encountered locations. We also check if repetition priming helps with further memory advancement. Finally, we examine the consistency between spatial locations remembered by different groups of the participants.
Method: We recruited 20 adults. Each participant was guided through an unfamiliar indoor environment. The participants were instructed to remember the path, as they will need to backtrack. Two groups were defined: the first group performed a spatial memory test at the goal destination and after backtracking; while the second group performed the test only after backtracking.
Results: The mean spatial memory scores of the first group at the goal destination was 49.8 %. After backtracking it improved significantly (60.8 %). The score of the second group was 62 %. No

difference, in after backtracking performance, was found between the groups ($t(18) = 0.18$, $p = 0.86$). Results show high correlations (rs = 0.71; 0.74; 0.80) between scenes memorized under different conditions.
Conclusions: Backtracking significantly improves spatial memory of visited places. The remembered locations are consistent across the participants. Surprisingly, repetition priming does not further enhance memorization of encountered locations. This result may suggest that spatial reasoning causes significant cognitive load that thwarts further improvement of spatial memory of locations.

Differences between right and left brain-damaged patients in perception of body position

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Background: After brain damage the representation of the body can be injured in many different ways. One aspect of the disruption of body schema can be that patients misperceive their position in space.
Aims: In our research we focused on how patients with brain damage organize their visual and proprioceptive experiences to perceive their body position.
Method: We applied a novel method (Body Portraying Method), which is suitable for measuring the evaluation of the body position in both visual and proprioceptive modalities. We investigated the body portrayal processes in a group of patients with right brain damage (N = 10) contrary to patients with left brain damage (N = 10) and healthy controls (N = 10)
Results: (1) Patients with right brain damage perceived their bodies with a significant horizontal shift to the right. In contrast to this, left brain-damaged patients and healthy controls tended to shift the subjective location of their body to the left. (2) Both patient groups perceived their bodies with a larger vertical shift than healthy controls. Furthermore our results also show that in the group of left brain-damaged patients (and only in this group) the visual evaluation of the body position was less accurate in the vertical dimension than the portrayal of body location based on proprioception.
Conclusions: Our results indicate, that the horizontal and vertical dimensions of the perception of body position might dissociate. Our results also suggest that the right and the left hemisphere might play different roles in this perceptual process.

The relation between navigation strategy and associative memory: An individual differences approach

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Background: The hippocampus supports both spatial navigation and associative memory. However, previous studies examining the relation between them have yielded mixed results. Some studies found better memory performance in individuals who use a hippocampal-dependent place strategy compared to those who use a caudate-dependent response strategy (Bohbot et al., 2011). Others have found that navigation experts actually performed worse than controls on some associative memory tasks (Woollett & Maguire 2009, 2012).
Aims: The current study examined how individual differences in navigation strategy relate to spatial and nonspatial associative memory in nonexpert young adults.
Method: The Dual-Solution paradigm was used to assess participants' relative use of a hippocampal-dependent place strategy (finding novel shortcuts) and caudate-dependent response strategy (route-following) in a virtual environment navigation task (Marchette, Bakker, & Shelton, 2011). Two associative memory tasks were also administered: object-location (spatial) and face-name (nonspatial).
Results: We found a significant correlation of navigation strategy with spatial associative memory performance. Individuals with a stronger preference for a place strategy performed better on the object-location task. No significant correlation was found between navigation strategy and nonspatial associative memory, even though the performance on the two associative memory tasks was significantly correlated.
Conclusions: The hippocampus' role in navigation may relate to its role in associative memory, but only when space is a central aspect of the memory task. Our findings also suggest that individual differences in spatial memory binding relate to variability in navigation strategy.

Sustained attention in smart transformable environments

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Background: Several researches have shown that visual perception and level of attention are strongly affected by lighting conditions of the environment. The combined effects of color temperature, light intensity and ambient lighting parameters seem to play an important role in cognitive tasks.
Aims: In this work we extend these hypotheses in the context of smart room environments that are able to adapt themselves in order to enhance the level of attention and the visual stimulation of people working in them. These transformable interior spaces are not only capable of changing the lighting conditions but also the spatial characteristics of the environment in real time.
Method: During the experiment we used a conference auditorium with three variations of ambient luminance conditions; one with high, one with low and one with continuously changing luminance. We used the oculus rift, a virtual reality headset, where the participants were able to interact with the conference auditorium. We examined the effect of ambient luminance in the room on sustained attention in two different scenarios; in the naturalistic one, we showed a 20 min lecture and in the more controlled one, we showed a pseudoword list. In both cases we used between-group design where the participants for each examined condition were instructed to press a button, for each target-word they had to identify.
Results: Initial results show that extreme lighting conditions might affect both attention and memory.
Conclusions: This research could help in the understanding and the design of smart learning and working environments.

The ability of visuospatial orientation: Similarities and differences

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Background: The term "spatial" is often linked to the ability to move around in space. However, defining visuospatial abilities as exclusively spatial orientation, or the ability to estimate the position of an object in space may be simplistic. Several researchers have attempted to classify the visuospatial abilities but the only fact that emerges is that spatial ability is not a unitary concept, but it can be divided into several factors.
Aims: The present study has been set out to examine spatial visualization skills as a reliable predictor of the performance in orientation and mental rotation tasks.
Method: 100 Ss aged between 19 and 25 years were administered the paper folding test (PFT), the perspective taking test (PTT), the test of bricks and the mental rotation test (MRT). Multiple regression analysis were performed where spatial visualization ability (measured by PFT) and gender were entered as VI, and performance at the MRT, the PTT and the Test of bricks as VD.
Results: Spatial visualization ability significantly predicted the performance in the first part and the second part of the MRT. The PTT was predicted by both PFT and gender. Finally, the score at the test of Bricks was predicted by both PFT and gender.
Conclusions: The visuospatial skills involved in paper folding tasks explained a greater amount of variance in the scores at PTT and the Test of bricks than in the rotations ability. This supports the hypothesis according to which in rotation ability significantly different mental processes come into play than in visualization tasks.

Situated navigational working memory: The role of positive mood

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Background: The perspective of situated cognition assumes that cognition is not separated from the context. Amongst other cognitive processes, memory poses a particular challenge to the approach of situated cognition, given that remembering often involves a mental condition that takes away the person from the social and physical setting in which he/she is embedded.
Aims: The extent to which visuo-spatial memory is situated was explored by manipulating participants' mood (positive, negative and neutral) while performing on two different tasks.
Method: College students were randomly assigned to the group of positive (Serenade No. 13 kV 525 G-Major by Mozart), negative (Adagio in G-Minor by Albinoni) or neutral music (The New World by Dvorak). Participants filled out the PANAS questionnaire before and after carrying out the Corsi Test, and the Walking Corsi Test (WalCT), that requires learning and recalling a path by moving to a series of places based on memorized locations. Both tasks were performed forward and backward. Music was played throughout the memory tasks.
Results: First, the manipulation check was performed to ascertain that music was successful in inducing mood effects in participants. Basically, after mood induction positive music produced higher scores, negative music lower scores, and neutral music produced no effects compared to pre-mood induction. Second, only the positive music produced higher scores at the WalCT.
Conclusions: Navigational working memory is situated being affected to some extent by positive mood induced by music, and opens to the idea that positive emotions may play a crucial role in enhancing navigational strategies.

The impact of emotional stimuli in biasing attentional selection during visual search in natural scenes

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Background: Previous literature demonstrated that emotionally-arousing stimuli tend to capture automatically attentional resources. However, the impact of task-irrelevant emotionally-arousing stimuli in "grabbing" attention is still largely unexplored.
Aims: To investigate at both behavioral and neural (fMRI) level the impact of emotional stimuli in biasing attention selection under different conditions of task-relevancy.
Method: We used a visual search task involving complex natural scenes (implying a high-level of competition among objects), in which positive and negative emotional items were in a task-relevant versus irrelevant position (i.e., they were or they were not the current target to be searched for). When emotional items were task-irrelevant, subjects were asked to search for a neutral object in the scene.
Results: At a behavioural level we found faster detection of task-relevant emotional objects as compared to neutral objects (i.e., in the presence of task-irrelevant emotional distracters). fMRI analysis revealed that scenes including negative objects, irrespectively to their task-relevance, produced activation of insula, a well-known area involved with emotional processing. By contrast, that task-irrelevant emotional distracters, irrespective of the valence, produced activation along the dorsal fronto-parietal (dFP) attention network. This indicates an effort in disengaging attention from emotional task-irrelevant objects and re-orienting attention to the rest of the scene.
Conclusions: Emotional elements in complex scenes, irrespective of valence, capture attention and affect attentional selection by diverting processing resource from other—neutral—elements in the scene. Top-down attention control (i.e., highlighted by the activation of dFP network) needs to be engaged to overcome emotional distraction.

Abstract planning over control primitives for robotic manipulation

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Background: Many robots designed for dexterous manipulation have been made available in the recent years. Despite tremendous developments in the control of such systems, breakthroughs are still required to handle their many degrees of freedom for complex manipulation tasks. But even for much simpler systems, coordinating actions through time and space remains a challenge, with precise grasping and movement often required.
Aims: We want to combine methods from artificial intelligence, allowing abstract plans to be elaborated to solve a manipulation task, with methods from control theory, able to parameterize or generate movement and grasping primitives.
Method: Each predefined control primitive is characterized by some context (e.g. fingers visually enclosing an object) and expectations (e.g. stable grasp achieved through tactile feedback), thus defining a prediction, grounded in the sensorimotor space. A* algorithm is then used to perform high level back-planning, using a task-relevant heuristics (admissible for optimality) and a cost estimate for each primitive. The originality resides in the use of sparse descriptions for the predictions associated to each primitive. The generated sub-goals states are thus locally binding conceptual, sensory, operational and/or joint spaces.
Results: The method was applied on the puzzle solving scenario of the qualifying stage of the European Robotics Challenges (EuRoC), where a camera/gripper equipped Kuka arm must localize and place pieces composed of small blocks in order to solve a puzzle.
Conclusions: Although some developments are still required to make the approach fully successful, generated plans seem adequate and allow control architectures to easily exploit robust primitives.

When abstract concepts get bound together through time and space: A case study on implicit stereotypes

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Background: Implicit stereotypes (e.g. association of male with math, or female with language), while strongly dependent on culture and individual's knowledge, may also be modulated by the immediate context of the task. Stereotypical associations between concepts (such as male and math) are posited to explain the faster responses observed for stereotype congruent trials in the implicit association test (IAT).
Aims: We provide and aim at validating an alternate explanation of the opposition of the male and female categories (or math-language) required for the IAT effect to emerge. This opposition may also occur in the sensorimotor domain (because typically mapped on opposite corners of the screenspace) and not only in the abstract domain, as usually postulated.
Method: To measure the sensorimotor components of the decision-making process, we used an adapted gender-math IAT where target categories were to be clicked on a computer display for each word stimulus (instead of keys pressed), and mouse movements continuously recorded (mouse tracking).
Results: Significantly larger deviations were observed for incongruent (female-math target) compared to congruent trials (male-math target), with mouse trajectories attracted toward the opposite target. This demonstrates that competition between hypotheses (and associated concepts) at least in part occurs in the visual and motor domain.
Conclusions: IAT effects could thus be reconciled with the flexible and dynamical binding of concepts observed in human decision-making tasks (e.g. male–female not opposed but united in the gender category). Nevertheless, additional experiments are required to determine the limits of the classical explanation.

Conditioned inhibition within a real and virtual watermaze task

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Background: Spatial learning has been show to follow associative rules by demonstrations of blocking and overshadowing in both real watermazes with rats and equivalent virtual tasks with human participants.
Aims: To examine whether conditioned inhibition (CI) can be demonstrated in a real and virtual watermaze task. In a typical CI experiment a stimulus (Y) is paired with a second stimulus which has been previously associated with a US (A+). In the presence of Y, A is no longer associated with the US (AY−), leading to Y becoming a conditioned inhibitor. CI of Y is demonstrated by a reduced response to a second conditioned stimulus (B+) in the presence of Y (BY) compared to in the presence of a novel stimulus Z (BZ).
Method: In separate training trials Beacons A and B marked the position of a platform in a circular watermaze (A+/B+). In subsequent inhibitory training trials, Beacon A was placed in quadrant Y with no platform present (AY−). To test for any CI of Y, in 2 probe trials B was suspended above either quadrant Y (BY) or novel quadrant Z (BZ). Time spent under B was recorded in both trials.
Results: During probe trials in both animal and human experiments less time was spent under B when it was suspended in quadrant Y than quadrant Z.
Conclusions: Results from both experiments suggested that quadrant Y had acquired inhibitory strength further strengthening claim that learning in the spatial domain follows the rules of associative models of learning.

Effects of gender stereotypic threat on a spatial orientation task in a real and virtual environment

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Background: Gender differences have long been shown in spatial ability. The current studies compare performance in a naturalistic spatial orientation task in a real and virtual environment. One explanation of gender differences is increased spatial anxiety in

females. The current study will manipulate anxiety via a stereotype gender threat.
Aims: To examine gender differences in spatial ability using a spatial orientation task within a real and virtual nested environment. The experiments also examined whether a stereotype threat influenced performance.
Method: Experiment 1 used a room within an actual building. Experiments 2 used a computer generated version of the building. In both experiments participants were led around the building and then to a room in the building with no view of external cues. Participants were given one of two statements, either males were better than females at spatial orientation or females were better than males. They were then asked to face a target cue which was outside of the building.
Results: In Experiment 1 males performed better than females, in Experiment 2 there was no difference. In both experiments Males that were told they should perform better than Females had a smaller orientation error than Males that were told they would perform worse than females. There was no difference between the Female groups.
Conclusions: Typical gender difference in spatial ability was only seen in real and not computer generated environment. Males' performance was more affected by the stereotype threat than females.

Switching frames of reference: Congenital blindness limits the allocentric to egocentric translation

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Background: Many everyday spatial abilities require the cooperation between egocentric (subject-to-object) and allocentric (object-to-object) reference frames that is based on the capacity of translating from one frame to the other (Nadel & Hardt, 2004; Avraamides & Kelly, 2008). This translation process implies a good functioning of reference frames and an efficient cooperation process. Literature investigating spatial cognition in blindness has reported that the absence of visual experience (congenitally blind) may limit the capacity to represent spatial information, especially when requiring allocentric frames (Cattaneo et al., 2008; Iachini et al., 2014). However, research has mainly focused on tasks assessing the selective involvement of egocentric and/or allocentric representations, not their translational processes.
Aims: investigate if, and to what extent, the absence of visual experience may alter blind individuals' ability to switch between egocentric and allocentric spatial representations.
Method: congenitally blind and sighted participants were submitted to a spatial memory task that required the capacity to use only-egocentric, only-allocentric, egocentric-to-allocentric and allocentric-to-egocentric verbal judgments about spatial relations between geometrical stimuli.
Results: congenitally blind participants revealed a difficulty, in terms of lower accuracy and longer processing time, in translating from allocentric to egocentric spatial representations but not the reversed process. Moreover, when not-translational processes were required, blind people did not show significant difficulty.
Conclusions: the absence of visual experience alters the translational ability between spatial representations. This effect seems due to a difficulty in adopting the allocentric frame as the primary spatial frame. Instead, when the primary frame is egocentric, a translational difficulty does not emerge.

The way people represent spatial information depends on the characteristics of the task: Effects of delay and stimuli manipulability

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Background: People represent abstract (*categorical*: e.g. left–right) or concrete (*coordinate*: e.g. distances in meters) spatial relations according to two frames of reference: *egocentric* (i.e. with respect to their body) or *allocentric* (i.e. with respect to another element in the environment). These components seem to have similar functions: egocentric and coordinate components should be important for action, whereas allocentric and categorical for recognition (Milner & Goodale, 1995; Kosslyn, 1987). Importantly, different task parameters should facilitate recognition- or action-oriented components. Manipulable 3D objects should favour the activation of motoric components (Tuker & Ellis, 2001), whereas immediate or delayed responses would favour egocentric and allocentric components respectively (Rossetti & Pisella, 2002).
Aim: Verify if the way people represent spatial information is influenced by more or less action-oriented components such as object manipulability and timing conditions.
Method: Participants learned the position of 3D objects (Experiment 1) or 2D images (Experiment 2) and then judged the distance (coordinate) and the relation (categorical) of a target stimulus with respect to themselves (egocentric) or with respect to another stimulus (allocentric). They gave spatial judgments by reaching (immediately or after 5 s) the exact position or the side previously occupied by the target stimulus.
Results: Egocentric-coordinate were always more accurate and faster than allocentric-coordinate judgments. Instead, no difference appeared between egocentric and allocentric-categorical judgments with 2D images and delayed response. Finally, the 5 s delay favored allocentric judgments.
Conclusions: The use of 3D stimuli and immediate response favored egocentric-coordinate representations, whereas the memory-driven response towards 2D images improved allocentric and categorical judgments.

Space influences evocation of structural and functional object-related gestures

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Background: Activation of object-related gestures during object visual processing may not be as systematic as previously thought. First, gesture evocation may depend on gesture type, since a single object can be associated with distinct structural (grasp-to-move) and functional (grasp-to-use) gestures. Second, gesture evocation may be function of visual space, either peripersonal (within reach) or extrapersonal (outside of reach).
Aims: This study aims at evaluating whether space influences cognitive and neural indices of structural and functional gesture evocation during object visual perception.
Method: 3D manipulable objects associated with distinct ("conflictual", e.g., calculator) or similar ("non-conflictual", e.g., bottle) structural and functional gestures are displayed in a virtual 3D environment at different distances. Participants have to judge whether the object displayed is reachable (action task) or whether it can be found in the kitchen (semantic task). Reaction times and EEG are recorded in separate experiments.
Results: We predict that in peripersonal space and when action is task-relevant, both structural and functional gestures will be activated and interfere with one another. In contrast, in extrapersonal space and when action is task-irrelevant, only functional gestures (more closely tied to object concepts) will be evoked. This should be reflected by (a) slower reaction times, (b) weakened motor simulation (reduced Mu activity) for conflictual objects than non-conflictual objects presented in peripersonal space during the action task. This difference should be less evident in extrapersonal space during the semantic task.
Conclusions: Consistent results will demonstrate that gesture evocation depends upon a combination of space, gesture type and task-related factors.

Route memory in an unfamiliar homogenous environment

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Background: Humans use many strategies for navigation. Strategies utilizing cognitive salience of landmarks have not been tested for application.
Aims: The objective of our study was to compare two strategies (with and without cognitive salience) while navigating in an unfamiliar homogenous environment to remember the route.
Method: Two videos, each having nine identical turns (3 right, 3 left, 3 straight) with no distinguishing feature at any turn, were developed using Trimble Sketchup© and shown to thirty two participants. The experiment was conducted in three phases. In the first phase, participants generated a list of personally known items to be used as landmarks. In the second phase they saw the first video and were required to remember the sequence of turns. In the second video they were required to imagine a landmark from the list generated in the first phase at each turn and associate the turn with the imaginary landmark. In both the tasks the participants were asked to recall the sequence of turns as it appeared in the video. In the third phase, the participants were again asked to recall the sequence of turns.
Results: Result showed that memory of route was better without landmarks compared to the imaginary landmark condition. This difference was insignificant when the participant were tested again 20 min later. However, route memory was still better for no-landmark condition.
Conclusions: The finding does not support earlier findings on route memory and is explained in terms of cognitive factors such as mental load.

The role of intrinsic motivations in the development of tool use: A study in infant robots

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Background: Empirical data about infants' tool use by Rat-Fischer et al. (2012) show that the capacity to solve difficult tool-use tasks, e.g. involving the retrieval of an out-of-reach desirable toy with a rake, emerges quite suddenly at about 18 months of age. The reasons why such capacity emerges, and why it does so suddenly, are currently unknown.
Aims: The aim of this work is to investigate, through "infant robots", the key role of intrinsic motivations (IMs) in the development of the capacity to solve the rake tool-use task. IMs are treated as the key force driving the robot to explore and learn possible object-object interactions forerunning the solution of the rake task.
Method: The iCub simulator was used to simulate infant participants. In detail, Dynamic Movement Primitives and Policy Improvement Black Box optimisation were used to simulate action primitives and the learning process in the infant robots. One robot group learned actions by trial-and-error driven only by the reward corresponding to the retrieval of the interesting toy, whereas a second robot group was also rewarded by a more sophisticated IM, in particular by the effects produced by movement on the tool-toy spatial relation.
Results: The results shows that the capacity to retrieve the toy using the rake emerges only when the IM system has become sufficiently sophisticated, mimicking possible corresponding changes in infants.
Conclusions: The model shows that infants might learn to solve the rake task when the IM system becomes capable of rewarding the exploration of tool-object relations.

Long-term memory for aerial photographs and maps

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Background: Previous studies have shown a remarkable capacity to memorize large number of objects (e.g., Brody, Konkle, Alvarez, & Oliva, 2008) or scenes (e.g., Konkle, Brady, Alvarez, & Oliva, 2010).
Aims: Our aim was to estimate the information capacity of visual long-term memory for stimuli that provide only limited information about scenes and objects within them and, moreover, this information is generally difficult to interpret. We further studied how perceptual expertise with these stimuli facilitates memory performance in a relevant domain.
Method: In a series of experiments, groups of professional geographers, first-year geography students, and first-year psychology students were presented with visual scenes which were displayed either as aerial photographs or as maps. The participants first viewed pictures. Afterward, they were shown pairs of images and indicated which of the two they had seen.
Results: The results showed that the observers who have been extensively trained in geography and who use maps and aerial photographs on a daily basis can significantly better extract domain-relevant information than the non-experts. Moreover, the experts not only better remember the gist of the scenes portrayed, but they also more efficiently encode and recall specific details about aerial photographs and maps. The same data pattern was found for all types of land use and for all scene scales. In comparison, there was no significant difference between both groups of students.
Conclusions: Expertise in analysing aerial photographs allows trained observers to extract richer and more distinctive features from an input compared to untrained viewers.

Does body motion influence arithmetic problem solving?

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Background: Recent evidence indicates that body movements influence number processing (Hartmann, et al., 2012) and arithmetic problem solving (Lugli et al., 2013). For instance, moving the arm right- and upward led to better performance during additions, while left- and downward facilitated subtractions. This was explained in terms of congruency effects between motion direction and arithmetic processes (Wiemers et al., 2014).
Aims: We investigated the influence of passive whole-body motion on arithmetic.
Method: Participants were sitting on a swivel chair. While they were rotated 180° towards the left or right with a pace of 49°/s, they were asked to orally solve verbal calculations. Calculations consisted in additions and subtractions that were composed of carry and non-carry problems and had two different levels of problems size (medium: 11–19; large: 21–89).
Results: ANOVA on response time for repeated measures with the factors Motion, Operation, Problem type and Problem size revealed a main effect of Operation ($F(1,33) = 171{,}604$, $p < 0.001$; additions: $M = 0.92$ s, $SD = 0.19$; subtractions: $M = 1.24$ s, $SD = 0.28$), Problem type ($F(1,33) = 196{,}345$, $p < 0.001$; carry: $M = 1.31$ s, $SD = 0.24$; non-carry: $M = 0.92$ s, $SD = 0.2$) and Problem size ($F(1,33) = 15{,}296$, $p < 0.001$; large: $M = 1.21$ s, $SD = 0.20$; medium: $M = 0.99$ s, $SD = 0.30$). We also observed a significant three-way interaction of Motion x Operation x Problem size ($F(1,33) = 6260$, $p = 0.017$).
Conclusions: As traditionally observed, participants solved additions faster than subtractions and this effect was stronger for carry and large problems. Moreover the latter problems generally yielded slower responses. In line with embodied number cognition calculation speed was also modulated by passive whole-body motion, but only when participants solved large subtractions.

Do pointing movements facilitate the recall of serial positions in visuospatial working memory?

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Background: Pointing towards to-be-remembered items in a visuospatial configuration can have both facilitatory and inhibitory effects on recognition memory (Chum et al., 2007; Dodd & Shumborski, 2009; Rossi-Arnaud et al., 2012, 2014). However, to date, the question of whether pointing enhances serial recall has not been investigated.
Aims: To determine whether pointing towards to-be-remembered items facilitates the recall of serial positions.
Method: Stimuli were 40 arrays containing 25 black squares arranged in a regular 5 × 5 matrix; to-be-remembered squares appeared in red and were presented sequentially at a rate of 1 square/s. Thirty-six participants were tested in a single experiment following a repeated 2 (Pointing Instruction: point vs. passively view) × 4 (Array Length: 5, 6, 7, or 8 items) design.
Results: For 5-, 6- and 7-item arrays, performance was significantly better in the passive-view than in the pointing condition, and the serial position curves showed both recency and priority effects. For 8-item arrays, no significant difference was found between the passive-view and the pointing conditions.
Conclusions: The present data provide no support for the view that pointing facilitates the recall of serial positions, but are in line with other evidence indicating that parsing the sequences into imageable chunks (e.g., a triangle) is the main strategy associated with increased accuracy in spatial short-term memory tasks (Ridgeway, 2006). This "pattern encoding" strategy is likely to be disrupted by pointing movements (Lecerf & de Ribaupierre, 2005; Rossi-Arnaud et al., 2012, 2014).

Is error monitoring a graded or an all-or-none process? An EEG study in immersive virtual reality

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Background: In immersive virtual reality, merely seeing an avatar from a first-person-perspective (1PP) induces the feeling of being the owner (Ownership) of the artificial body and of controlling its actions (Agency). Moreover, observing in 1PP errors in the avatar's actions elicits EEG signatures of error monitoring like error related negativity (ERN) and medial-frontal theta (MF-Theta) band power synchronization. What remains unknown is whether the error monitoring system activation is based on a graded or an all-or-none process.
Aims: We investigated whether the mere observation of erroneous grasping performed by an avatar induces different ERN amplitudes and MF-Theta power synchronization in the onlooker's brain.
Method: EEG was recorded in twenty healthy adults immersed in a virtual scenario (CAVE system). Participants observed correct o0r incorrect reach-to-grasp-a-glass actions. Small or large right-ward deviations from the to-be-grasped-glass could occur in incorrect trials. At the end of each trial, participants verbally rated how much they experienced Ownership and Agency over the virtual arm.
Results: While the rating scores of Ownership remained similar, the Agency was negatively affected by the magnitude of avatar's errors. ERNs and MF-Theta synchronization were elicited by observation of incorrect but not of correct grasps. Importantly, enhanced error signals occurred for large than small amplitude errors.
Conclusions: Amplitude of deviations modulates cortical signatures of error monitoring which seems to be a fine-grain, graded process.

Looking up and down: Semantic meaning automatically directs vertical attention

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Background: Spatial associations are often used to describe concepts. For example, something unknown is "up in the air", whereas a finalised plan is "nailed down". Embodied cognition–the idea that cognitive and sensorimotor processes are interconnected—can explain this result.
Aims: The study investigated whether the spatial association of words facilitated target detection, as measured by fixations.
Method: In Experiment 1, words were centrally presented. Participants then fixated a target in either upper or lower space and indicated whether the word represented a manufactured or a natural object. In Experiment 2, participants viewed the same words; however, in place of target detection, words manufactured and natural were presented, with one appearing in upper space and the other in lower space (counterbalanced). Participants fixated their response.
Results: In Experiment 1, the time taken to fixate upper space targets was quicker; however, time to fixate targets was not dependent on spatial association. In Experiment 2, when central words were associated with upper space, time taken to fixate upper field targets was faster. Similarly, lower space responses were faster when words were associated with lower space.
Conclusions: In Experiment 1, words were judged as manufactured or natural, in order to make word judgments orthogonal to the dimension of interest (spatial association). Participants did not show a relationship between spatial association and time to fixation, suggesting that this information is not automatically activated. Therefore, Experiment 2 integrated the judgment task and fixations were quicker for responses that were congruent with spatial association.

Mechanisms underlying reinvestment by older adults during walking

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Background: Older adults sometimes display a higher predisposition to consciously monitor and control their movements (i.e., reinvestment), which may reflect higher internal focus of attention (Wong et al., 2009). However, individual differences influencing the tendency to focus internally are under-examined.
Aims: This study investigated relevant variables that influence internal focus of attention in older adults with high and low reinvestment tendency.
Method: Fifty-eight older adults were divided into high and low reinvestors based on their scores on the Movement-Specific Reinvestment Scale (Masters et al., 2005). Among other measures, they completed the Hospital Anxiety and Depression Scale, Activities-specific Balance Confidence Scale, and performed verbal and visuo-spatial working memory tasks. Participants then completed 30 walking trials on a 5-m walkway, which included a stepping target and two obstacles, during which they answered internal focus questions (e.g., "was your left foot on the ground when you heard the tone").
Results: Significant differences were evident between high and low reinvestors when answering internal focus questions ($F(1,57) = 5.81$, $p = .019$), with high reinvestors answering more accurately. For high reinvestors anxiety and balance confidence significantly predicted 21.6 % of the variance when answering internal focus questions ($F(2,28) = 3.59$, $p = .042$). For low reinvestors, visuo-spatial working memory and balance confidence significantly predicted 30.5 % of the variance ($F(2,28) = 5.71$, $p = .009$).
Conclusions: The results suggest that internal focus of attention is explained by anxiety and balance confidence among high reinvestors, and by visuo-spatial working memory and balance confidence among lowreinvestors. These imply that individual characteristics need further examination to understand movement reinvestment in elderly.

Configurational salience of landmarks: An analysis of sketch maps using space syntax

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Background: Landmarks are a central element of human orientation and also frequently included in sketch maps. Whereas spatial cognition research has aimed to determine the relevance of landmarks for example in relation to a specific route or as a formalized salience function, the configurational properties of the environment surrounding a landmark has rarely been examined.
Aims: Using Space Syntax analyses, we assessed how spatio-configurational properties of an environment are predictive for the depiction of landmarks on sketch maps, and compared sketch maps produced in different exploration conditions.
Method: Participants explored an unknown virtual environment and drew a sketch map either parallel to exploration, or from memory after exploration with or without a topological map, respectively. We compared exploration behavior, quality and properties of sketch maps, as well as performance in several subsequent spatial tasks.
Results: Initial analyses suggest that Space Syntax properties of a landmark's position (e.g., its visibility or its relative centrality in the environment) predict the probability of depiction in sketch maps. In-depth analyses are currently performed to identify the crucial Space Syntax properties. Exploration with parallel sketch mapping resulted in more detailed sketch maps as compared to sketch mapping of the other conditions and somewhat better spatial task performance.
Conclusions: Our findings so far imply that the relevance of a landmark is indeed strongly affected by the spatial configuration of its surrounding environment (i.e., the configurational salience). Parallel exploration and sketch mapping presents a novel study condition which apparently benefits the encoding of spatial information.

Spatial orienting around the fovea: Exogenous and endogenous cueing effects

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Background: Recent studies have indicated that attention control in the visual field exhibits a functional dissociation with larger modulation for the periphery relative to the parafoveal visual field. However, it is unknown whether attention modulation around the fovea operates similarly as it does at the surrounding parafoveal region.
Aims: The present study aims to explore whether attention operates homogenously between the near fovea and parafoveal region of the visual field, and if so, whether the effects differ between exogenous and endogenous orienting conditions.
Method: Using a double-cue inhibition of return (IOR) procedure, we compared the magnitude of IOR elicited by an exogenous cue for the near fovea and parafoveal targets in Experiment 1. Endogenous orienting of attention elicited by a predictive central arrow cue was manipulated with a single-cue procedure in experiment 2.
Results: The results revealed an effect of both forms of cueing around the fovea. In the exogenous condition there was also a significant two-way interaction between eccentricity and cue validity, with the IOR effect getting stronger at the parafoveal relative to the near fovea region. In the endogenous orienting condition, similar facilitation effects were observed for targets appearing at both near fovea and parafoveal visual field.
Conclusions: The present study suggests an eccentricity effect of attention modulation with a smaller effect at the fovea relative to the parafoveal region, however, only when attention is exogenously captured. We conclude that exogenous and endogenous spatial attention subject to two independent attentional systems with distinct modulation patterns around the fovea.

7. List of Short Papers

The following Short Papers, listed alphabetically, have been included in the ICSC 2015 Supplement of ***Cognitive Processing—International Quarterly of Cognitive Science****, and can be downloaded gratis from:* http://www.springer.com/journal/10339.

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Numbers in brackets following a type of contribution indicate that an author is the first author of more than one contribution of the same type.
Numbers in brackets following the name of a first author indicate that an author is co-author of more than one contribution of the same first author.