Cogn Process (2018) 19 (Suppl 1):S1–S76
https://doi.org/10.1007/s10339-018-0884-3

PROCEEDINGS

SPATIAL COGNITION IN A MULTIMEDIA AND INTERCULTURAL WORLD
ICSC 2018 – 7th International Conference on Spatial Cognition – Rome, 10-14 Sept. 2018

Spatial Cognition in a Multimedia and Intercultural World

Proceedings of the 7th International Conference on Spatial Cognition (ICSC 2018)

Edited by Thomas Hünefeldt and Marta Olivetti Belardinelli

The conference program is available at https://www.icsc-rome.org/program/

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1. Abstracts of Keynotes

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

How visual spatial attention alters perception

Marisa Carrasco

New York University

Visual attention is essential for visual perception. Spatial attention allows us to grant priority in processing and selectively process information at a given location. In this talk, I will compare and contrast two kinds of spatial attention: covert (allocated to the target location, without accompanying eye movements) and presaccadic (allocated to the location of the upcoming saccade's target). First, I will highlight some behavioral and neuroimaging research on covert attention, which alters performance and appearance in many basic visual tasks. Second, I will review studies showing that presaccadic attention improves performance and alters appearance at the saccade target location. Further, these modulations change the processing of feature information automatically, even when it is detrimental to the task at hand. We propose that saccade preparation may support transaccadic integration. Third and last, I will discuss similarities and differences between underlying mechanisms of covert attention and presaccadic attention. Systematically investigating their common and differential characteristics has furthered our understanding of the pervasive selective processing of information, which enables us to make sense of our complex visual world.

Space, time and language

Michael C. Corballis

University of Auckland, New Zealand

Cognition is heavily grounded in space. As animals that move in space, we travel both physically and mentally in space and time, reliving past events, imagining future ones, and even constructing imaginary scenarios that play out in stories. Mental exploration of space is extraordinarily flexible, allowing us to zoom, adopt different vantage points, mentally rotate, and attach objects and sense impressions to create events, whether remembered, planned, or simply invented. The properties of spatiotemporal cognition depend on a hippocampal-entorhinal circuit of place cells, grid cells and border cells, with combinations of grid-cell modules generating a vast number of potential spatial remappings. For example, we can easily imagine a spatial location, such as the Piazza del Duomo in Milan, from opposite ends, and zoom in to imagine a particular landmark such as the cathedral from up close, or even from inside. Our increased understanding of the flexibility of spatio-temporal imagination suggests a re-evaluation of the nature of language. The generativity of language, often considered one of its defining properties, may therefore derive not from the nature of language itself, but rather from the generativity of spatiotemporal scenarios, with language having evolved as a means of sharing them. Much of our understanding of the hippocampal-entorhinal circuit is derived from neurophysiological recording in the rat brain, implying that the spatiotemporal cognition underpinning language has a long evolutionary history.

Cross-cultural research on spatial concept development

Pierre R. Dasen

Université de Genève

I will first review cross-cultural research in the area of culture and cognition, with particular focus on the development of spatial concepts. I propose that the formulation best covering all empirical data is in terms of "cognitive style", i.e. spatial cognitive processes are universally available to all humans, but there are preferences for some spatial frames of reference over others. These cultural differences are under the influence of a number of eco-cultural variables, which are often confounded, but which careful cross-cultural quasi-experimental designs allow us to tease apart.

The second part will illustrate this general conclusion by research on the development of the "geocentric" frame of spatial reference, initially studied by Levinson (2003). This is a cognitive style in which individuals choose to describe and represent small-scale table-top space in terms of large-scale geographic dimensions. In Indonesia, India, Nepal and Switzerland, we explore the development with age of geocentric language as well as geocentric cognition, and the relationships between the two, as well as the environmental and socio-cultural variables that favour the use of this frame (Dasen and Mishra 2010).

Space, time and memory: Tales from a long road

Alan Dix

University of Birmingham

All roads lead to Rome: the Milliarium Aureum in the Forum marked the point from which distances were measured along the long roads that led in all directions. However, this is not simply a statement about one end point, it says *to*, not *from*. Roads are spatial, but journeys are temporal, with a beginning and an end. Furthermore, in Imperial times and for a millennium after, Rome was the centre of power temporal and spiritual; the 'to' makes clear that one's eyes should be cast towards its heart. Our conceptions of space and time are intimately interwoven with the social fabric of human life.

In 1996, at the AVI'96 conference in Gubbio, I gave my first keynote, which considered how sight, sound and smell create different cuts through space and time and call on memory in different ways to fill the void in current sensation. 20 years on, at Talis, I studied the changing nature of physical text in a digital world. The written word

takes a snaking line across the space of the page and through the volume of a book, preserving, prompting and promulgating memory.

During the Dark Ages, the laborious writing of Celtic monks on the Atlantic fringe was crucial to the continuity of knowledge. In 2013 I took my own winding route round the edges of Wales exploring viscerally the relation between space, time and memory. This talk will link lessons from that one thousand mile path and 30 years' study of time in user interaction.

Spatial cognition and architecture: From evidence to design

Christoph Hölscher

ETH Zurich & SEC Future Cities Laboratory, Singapore

Advances in digital media and computation have spurred renewed interest in modeling, anticipating and predicting the human experience of architectural spaces. But how does one capture the 'soft' factors of human behavior and human appreciation of a building design? How can psychological parameters be included as part of evidence-based design? I will provide an overview of how our spatial cognition research group tackles this with an emphasis on human movement pattern in complex, publicly accessible environments. We combine real world behavior observation with Virtual Reality simulation of building design options. This goes beyond traditional post-occupancy evaluation by providing pre-occupancy assessment opportunities. To capture the richness of human perception and environmental appreciation we engage volunteer participants in a series of interaction tasks in a real or virtual setting, measuring their reactions with behavior—and path-tracing, eye-tracking and physiological measures of stress and arousal. This helps us identify points of misfit between the architect's intentions and the present—or future—patrons' reaction to the building design. Digital tools provide the basis for immersive virtual reality experiments to compare design alternatives, as well as for agent-based simulations of patron behavior, both for individual wayfinding analysis and development of cognitively enriched crowd movement simulations.

Visual and acoustic space in the digital age

Robert K. Logan

University of Toronto

Marshall McLuhan introduced the notion of visual and acoustic space in his development of media ecology. Visual space arose with literacy and was reinforced by the Gutenberg printing press. Acoustic space which is characteristic of the oral tradition was retrieved according to McLuhan by electrically configured information and according to this author further amplified by digitally configured information via the Internet and the World Wide Web. McLuhan suggested that we use the eye as an ear when we watch television and the same is true of the screen-based Internet. Paradoxically there is a lot more visual content to the Internet compared to print-based books and purely text-based media like Twitter and Instagram have all added visual components to their respective services. The spatial cognitive dimensions of various multimedia venues are examined including, in addition to the Internet and Web, television and cinema both of which are now digital media.

East of West, West of East: A matter of global and local identity

Ernst Pöppel

Ludwig-Maximilians-University Munich & Peking University

Research is a very personal matter. On the basis of experiences in different countries with researchers from different cultures over many years some observations will be described. The conceptual frame of this attempt is to look for anthropological universals and cultural specifics. Much can be learned from spatial representations in the arts. Whereas in the West since Renaissance time the central perspective has become dominant in visual art, in Eastern landscape paintings the "floating view" is typical. The claim that the central perspective corresponds to geometric laws and matches how we see the world is misleading for at least two reasons: It violates mechanisms of size constancy, and the visual world is spatially reduced in pictures to the perifoveal region only. Research on spatial attention has disclosed two different attentional systems being responsible either for near-fovea vision or for the far periphery. This fundamental principle as a global characteristics of visual processing is neglected in Western art. In Eastern art with a floating view geometric laws are violated, and different potential perspectives are integrated within a holistic pattern. The semantics of what shall be expressed becomes important irrespective of physical parameters. The latter may also create the unique phenomenon of becoming subjectively part of the picture confirming personal identity. Cultural specifics like in the arts (what one might expect) can surprisingly also be observed in theoretical considerations about visual processing. Whereas in the tradition of Western science visual percepts are built up with local elements like feature detectors, in an important Chinese theory global topological features are analyzed first. An important task of the brain is to create the identity of a percept on the basis of spatially and temporally distributed neural activities. It is, thus, an important theoretical question how to deal with the challenge to create and maintain the identity of a percept for some time. It is suggested that one should leave behind a monocausal reasoning for such explanations but adopt for analytical strategies the concept of complementarity as a generative principle.

Attention is more important for visual cognition and reasoning than you think

John K. Tsotsos

York University

I will present a view of the breadth of activities, recently completed, ongoing or just hot off the presses, in my lab. The menu includes research projects in visual cognition, autonomous driving, visual psychophysics, active vision, visual saliency, eye fixation control and more. But that is not my main goal. Believe it or not, there is an underlying theme that connects all of it, whose presentation is my main point. That theme is that attention is a far more important player in how humans perceive, reason and react to visual stimuli than has been broadly appreciated, particularly in computational models. In our view, attention is the process by which the brain controls and tunes information processing, and this control enables functional generalization. Our work in developing a theory of attention has always had as its primary goal the ability to make testable predictions

for new knowledge of human visual processing, and in this regard, we have been quite successful. However, hand in hand with this goal has been the goal of developing a computational embodiment of the theory. As we look more and more into real-world scenarios and problems, this reveals a broader set of human abilities that must be examined. This predictive power coupled with the broader functionality points in the direction of new computational approaches.

2. Abstracts of Symposia

Symposia are listed alphabetically according to the first convenor's last name. 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 & 2: Minds. Movement. Moving image

Convenor: Mehul Bhatt

Örebro University; University of Bremen

This symposium—conducted in two parts—explores the confluence of empirically-based qualitative research in the cognitive and psychological sciences (focusing on visual and spatial cognition) with computationally-driven analytical methods (rooted in artificial intelligence) in the service of communications, media, design, and human behavioural studies. With a focus on architecture and visuo-auditory media design, the twin-symposia will demonstrate recent results and explore the synergy of research methods for the study of human behaviour in the chosen (design) contexts of socio-cultural, and socio-technological significance.

The symposium brings together experts and addresses methods and perspectives from:

- Visuo-Spatial Cognition and Computation
- Artificial Intelligence, Cognitive Systems
- Multimodality and Interaction
- Cognitive Science and Psychology
- Neuroscience
- Design Cognition and Computation
- Communications and Media Studies
- Architecture, Built Environment
- Design Studies (focus on architecture and visuo-auditory media)
- Evidence Based Design

The symposium particularly emphasises the role of multimodality and mediated interaction for the analysis and design of human-centered, embodied, cognitive user experiences in everyday life and work. Here, the focus is on multimodality studies aimed at the semantic interpretation of human behaviour, and the empirically-driven synthesis of embodied interactive experiences in real world settings. In focus are narrative media design, architecture and built environment design, product design, cognitive media studies (film, animation, VR, sound and music design), and user interaction studies. In these contexts, the symposium emphasizes evidence-based multimodality studies from the viewpoints of visual (e.g., attention and recipient effects), visuo-locomotive (e.g., movement, wayfinding), and visuo-auditory (e.g., narrative media) cognitive experiences. Modalities being investigated include, but are not limited to:

- visual attention (by eye-tracking), gesture, speech, language, facial expressions, tactile interactions, olfaction, biosignals;
- human expert guided event segmentation (e.g. coming from behavioral or environmental psychologists, designers, annotators, crowd-sensing);
- deep analysis based on dialogic components, think-aloud protocols

The scientific agenda of the twin-symposia also emphasizes the multi-modality of the embodied visuo-spatial thinking involved in "problem-solving'' for the design of objects, artefacts, and interactive people-experiences emanating therefrom. Universality and inclusion in "design thinking" are of overarching focus in all design contexts relevant to the symposium; here, the implications of multimodality studies for inclusive design, e.g., creation of presentations of the same content in different modalities, are also of interest. The symposium provides a platform to discuss the development of next-generation embodied interaction design systems, practices, and (human-centered) assistive frameworks and technologies encompassing the multi-faceted nature of embodied design conception and synthesis. Individual contributions/talks within the two symposia address the themes under consideration from formal, computational, cognitive, design, engineering, empirical, and philosophical perspectives.

SYMPOSIUM 1: Minds, movement, moving image (part 1): On spatial cognition and the built environment

Embodied architecture design: On people-centered design of visuo-locomotive cognitive experiences

Mehul Bhatt

Örebro University; University of Bremen

This presentation focusses on the analysis and design of human-centered, embodied, cognitive user experiences from the perspectives of spatial cognition and computation, artificial intelligence, and human-computer interaction research. Focusing on large-scale built up spaces (in particular hospitals), this presentation will particularly address:

'how can human-centered cognitive modalities of visuo-locomotive perception constitute the foundational building blocks of design education, discourse, systems, and the professional practice of spatial design for architecture'.

The presentation will emphasize evidence-based multimodality studies from the viewpoints of visuo-locomotive (i.e., pertaining to vision, movement, and wayfinding) cognitive experiences. Modalities being investigated include: (1) visual attention (by eye-tracking), gesture, language, facial expressions; (2) human expert guided event segmentation (e.g., coming from behavioral or environmental psychologists, designers, annotators); (3) deep analysis based on dialogic components, think-aloud protocols. We demonstrate (1–3) in the context of a large-scale study conducted at the Old and New Parkland Hospitals in Dallas, Texas.

This research (and symposium) calls for a tightly integrated approach combining analytical methods (rooted in AI and computational cognition) and empirical methods (rooted in psychology and perception studies) for developing human-centered architectural design technologies, and technology-mediated (architectural) design synthesis.

Precedent-based parametric design: Computationally generated spatial morphologies satisfying behavioral-based design constraints

Vasiliki Kondyli

Design Space Group, University of Bremen

Parametric design systems serve as powerful assistive technologies in the design process by providing flexibility and assisting at the generation of a vast number of design alternatives. However, parametric systems currently are focusing more on low-level engineering and structural forms and less on people-centered aspects of design. We propose a precedent-based design approach for parametric systems that introduces people-centered criteria rooted in empirical behavioral evidence. We present examples from a list of precedents defined through a behavioral multi-modal analysis of a wayfinding study conducted in two healthcare environments, and we formulate design constraints that can be embedded into parametric design systems, such as free CAD and Python-Grasshopper. Finally, we present a number of morphologies generated in parametric design systems that satisfy people-centered design rules for wayfinding.

On the relations between cognitive maps and images of cities

Juval Portugali

Department of Geography, Tel Aviv University

Tolman's "Cognitive maps in rats and men" and Lynch's The Image of the City are two of the seminal works at the foundations of studies on spatial cognition and the built environment. The apparent similarity between the notions 'Cognitive map' and 'Image', has deceived many scholars in this domain to erroneously assume that the 'Image' (of the city) is a synonym of, just another name for, a 'Cognitive map' (of the city). Approaching the processes of cognitive mapping and imaging from the conjunctive perspective of SIRN (synergetic inter-representation networks) and IA (information adaptation), I show that while cognitive maps and images ontologically differ from each other, they are still interrelated in several interesting ways. For example, humans construct their cognitive maps partly directly by means of movement in the city and partly indirectly by consulting maps, which are, in fact, images.

Cross-cultural differences in visualizations

Barbara Tversky

Columbia University; Stanford University

As the world becomes increasingly mobile and increasingly pixelated, visual communications become more ubiquitous and more important. They map meanings to marks in space and place in space and are consequently more transparent than words, whose mapping to meaning is arbitrary. The built world itself has become a source of information, in particular, the design of cities, essentially a self-describing diagram. Both use icons, arrange things in lines and segment with boxes. Despite their ubiquity, cultural differences are evident in their design, differences that could lead to misunderstandings. Here we present research showing effects of culture and language in a variety of visual communications including the built environment, comics, covers of children's books, and math diagrams.

SYMPOSIUM 2: Minds, movement, moving image (part 2): On visuo-auditory perception and the moving image

Cognitive media studies: Potentials for spatial cognition and AI research

Mehul Bhatt

Örebro University; University of Bremen

Cognitive media studies has developed as an area of research at the interface of disciplines as diverse as aesthetics, psychology, neuroscience, film theory, and cognitive science. In this context, the focus of this talk is on the foundational significance of artificial intelligence and visuo-spatial cognition and computation for the design of integrated analytical–empirical methods for the (multi-modal) analysis of human behaviour data vis-a-vis a range of digital visuo-auditory narrative media (e.g., narrative film). The presentation focusses on the methodological foundations and assistive technologies for systematic formalization and empirical analyses aimed at, for instance, the generation of evidence, establishing and characterizing correlates between principles for the synthesis of the moving image (e.g., from a cinematographic viewpoint), and its perceptual recipient effects and influence on observers.

In the backdrop a range of completed and ongoing experiments, we emphasize the core results on the semantic interpretation of human behaviour vis-a-vis narrative film and its visuo-auditory reception. We demonstrate the manner in which AI-based models for machine coding of narrative, and relational inference and learning serves as basis to externalize explicit and inferred knowledge about embodied visuo-auditory reception, e.g., using modalities such as diagrammatic representations, natural language, complex (dynamic) data visualizations.

Demonstration: The presentation will particularly showcase methods and tools developed to perform perceptual narrativisation or sensemaking with multi-modal, dynamic human-behaviour data (combining visuo-spatial imagery such as film/video, eye-tracking, head-tracking during a perception task) for a chosen set of experimental material based on existing films, as well as lab-developed experimental content.

Multimodal rhetoric in online media communications

Kay O'Halloran

Curtin University

The aim is to investigate how the proliferation of media channels enables political sub-communities to manage and control the creation

and dissemination of alternative rhetorical discourses that are increasingly supplanting traditional consensus based media frameworks to perpetuate various viewpoints. The approach involves tracking and analyzing the re-use of images and videos from online mainstream news media sources across selected media (e.g. social media, blogs and other sites) to investigate how these new informational configurations are organized. An integral component of these investigations are the ideational formations that are supported and resisted (e.g. nationalism, popularism, humanitarianism and racism). The key question is how meanings arising from the integration of language, images and videos can undercut or repoint lines of rational argument in the interest of such formations. The methodology uses multimodal discourse analysis, which is the study of the meaning arising from the integration of language, images and other resources in texts, interactions and events, to enhance the results obtained from social network theories, computer vision, machine learning and natural language understanding systems. The expected outcomes are (a) an evidence-based assessment of the multimodal strategies (text, images and videos) in online media reports and how the global community responds in terms of re-using the images and videos for various purposes and (b) Proof of Concept for theoretically informed empirical techniques for the (semi-) automated contextual analysis of text, image and video relations in online communications. The dataset consists of articles featured on the homepage of major online news sites in Europe.

Designing game-based narratives and interactive worlds for cultural engagement

Lissa Holloway-Attaway

University of Skövde

Games have long been recognized as powerful tools to mediate complex stories connecting players to material and virtual worlds through strategic narrative design and complex modes of embodied, critical play. Digital games are increasingly used outside the 'entertainment only' sector: For example, to explore and activate social change, in diverse educational contexts (in schools, healthcare and military practice), and to support cultural stakeholders (in museums and heritage sites). Designing the narrative structures to support such interactions requires a nuanced understanding of their complex interfaces structures that work across and among these intra-active material and virtual domains. New compositions and configurations that bring technological devices, bodies, and socio-cultural contexts for use together can benefit from deeper consideration of their embodied, affective, performative and storytelling dimensions.

In my talk, I will focus on narrative-based game design for cultural applications (within heritage sites and museum settings). With reference to Mixed Reality projects developed in my research group (Media, Technology and Culture), I will demonstrate the ways in which multimodal and multisensory design aesthetics can enhance user experience. Drawing on principles of 'postdigital play' and focusing on 'locative,' 'augmented,' 'pervasive' and 'affective' dimensions of performative game-based narrative structures, I illustrate an interdisciplinary framework for socio-cultural/technical development with the embodied user/interface at the center.

How people represent space and events while viewing cinema

Daniel Levin

Vanderbilt University

Recent research on event perception has made excellent progress not only by specifying how perceptual changes signal new spaces and new events but also by exploring the representational basis of event segmentation and spatial representation. One key question that remains unanswered is the degree to which intensive visual representations of spaces and events are generated by default, or are generated only when they are functional. Previous research may have overestimated the degree to which visual representations are typically useful because many lab tasks either explicitly or implicitly force viewers to create representations that they might not rely upon in more naturalistic settings where their goal is to understand events instead of create representations in preparation for a test. I will discuss several lines of research suggesting that visual representations of event sequence and space may not be created by default in the naturalistic task of film viewing. In addition to suggesting that visual representations may be more sparse that previously assumed, this work also develops filmmakers' insights about perceptual continuity to help understand when visual representations are created and compared across views. Thus, visual cognition research inspired by the art of cinema can not only provide evidence about the representational efficiency of visual cognition, but it can also inspire novel hypotheses about when, exactly, visual represents do become important in naturalistic settings.

Machine coding of narrative structures in visuo-spatial imagery

Jakob Suchan

University of Bremen

Background: We present our research on computational models for representation and interpretation of narrative structures in dynamic visuo-spatial imagery.
Aims: The primary goal is to develop declarative models describing the semantics of visuo-spatial dynamics in the moving image, focusing on perceptual sensemaking in terms of abstraction, reasoning, and learning with dynamic visuo-spatial imagery.
Method: The computational models are based on (declarative) qualitative abstractions of visuo-spatial dynamics, encompassing space, motion, objects and interactions. High-level interactions and events are represented using motion patterns defined as relational structures between semantic elements of the visual imagery. These semantic elements, representing the scene, are grounded in perceptual structures (e.g., cinematographic tools, such as cuts, character placement, camera movement, shot types, symmetry) extracted from the visual imagery based on state-of-the-art computer-vision methods (e.g., people/object detection/recognition, optical-flow based motion analysis, pose estimation, etc.). The overall model is implemented in

constraint logic programming, such that the semantic structure of the visual imagery becomes directly queryable as first-class elements within the framework.

Results: We demonstrate the work in the area of cognitive film studies investigating attention and recipient effects in observers vis-à-vis the moving image. We present select case-studies from a large-scale cognitive film study (including 16 movie scenes and eye tracking data from 32 participants), showcasing how the model serves as a backbone for grounding narrative structures of the moving image in low-level visual elements, and thus facilitate deep semantic analysis aimed at high-level question-answering. In this context, the model is evaluated based on its Q&A abilities.

Actions, intentions and environmental constraints on biological motion perception

Paul Hemeren and Vipul Nair

University of Skövde

In many ways, human cognition is importantly predictive. We predict the sensory consequences of our own actions, but we also predict, and react to, the sensory consequences of how others experience their own actions. This ability extends to perceiving the intentions of other humans based on past and current actions. We present results that show that social aspects and future movement patterns can be predicted from simple kinematic patterns in biological motion sequences. The purpose of this presentation is to demonstrate and discuss the different environmental (gravity and perspective) and bodily constraints on understanding our social and movement-based interactions with others.

In a series of experiments, we used psychophysical methods and recordings from interactions with objects in natural settings. This includes experiments on the incidental processing of biological motion as well as driving simulator studies that examine the role of kinematic patterns of cyclists and driver's accuracy to predict the cyclist's intentions in traffic.

The results we present show both clear effects of "low-level" biological motion factors, such as opponent motion, on the incidental triggering of attention in basic perceptual tasks using a flanker paradigm and "higher-lever" top-down guided perception in the intention prediction of cyclist behavior.

We will use our results to stimulate discussion about the interplay between expectation mediated and stimulus driven effects of visual processing in spatial cognition in the context of human interaction. Discussion will include the role of context in gesture recognition and to what extent our visual system can handle visually complex environments.

SYMPOSIUM 3: Cross-cultural, cross-modal and cross-species' spatial perception and action in virtual and real environments

Convenors: Francine Dolins[1], Mark Lindquist[2] and Brent Chamberlain[3]

[1]Department of Behavioral Sciences, University of Michigan-Dearborn, Dearborn, Michigan; [2]School for Environment and Sustainability, University of Michigan, Ann Arbor, Michigan; [3]Department of Landscape Architecture and Regional & Community Planning, Kansas State University, Manhattan

Background: Exploration of multi-modal perception and navigation in virtual and real environments provides important insight into numerous perceptual and cognitive areas of research. Insights generated from these studies help us understand how a broad range of variables such as culture, species, physical environment, visual and auditory information influence perception of, and agency within, space. Many studies of navigation in virtual and real environments rely exclusively on visual information, yet auditory and olfactory information can significantly influence preference for types of landscapes, spatial memory and efficient wayfinding. Likewise, cross-cultural and cross-species studies of spatial perception and cognition reveal how information exchange, linguistic differences and environmental factors may affect spatial understanding and memory. For example, experience in different environmental settings such as dense rainforests compared with built environments, may provide an understanding of what factors shape the formation of internal representations in conjunction with unique/discrete landmarks, landmark arrays, and/or the geometry of places. Cross-species comparisons with nonhuman and human apes allows for investigations of how species, which are genetically closely related, perceive and encode spatial information. Investigations also improve our understanding of how different species' use that information to problem-solve spatial, social and food-related challenges in their environments in parallel or unique ways.

Aim: The general goal of this symposium is to encourage discussion across disciplines about common themes of investigation, to engender greater collaboration amongst the practitioners, and to identify new questions and methods, which may further enhance our understanding of spatial processing and spatial perception. Given that the invited speakers draw upon ideas and experimental design from a diverse range of disciplinary training in anthropology, computer science, landscape architecture, psychology and others, a second goal is to provide a forum to share best practices and experience in developing experiments and the subsequent outcomes that have relied on using virtual and augmented reality. Additionally, a further objective is to discuss opportunities to build upon this work to expand possibilities in experimental design and processes underlying spatial cognition in a broad range of populations. More specifically, spatial knowledge and behavior do not exist in a vacuum. They are influenced by the context and perceptual systems by which they are learned and expressed. It is our goal to examine the effect that the mode(s) of learning and expression have on spatial abilities in humans and nonhuman primates.

Approach: Our presenters use a variety of methods to study spatial perception of multiple modalities (vision, olfaction and audition) involved in navigation, and across cultures and species, as well as in virtual reality compared to the real world. They also test a diverse set of participants, ranging from populations of hunter-gatherers in Africa

and Asia, to populations of individuals raised in built environments, to captive apes. The common theme is an interest in examining how different groups interact with and perceive their environments to better understand the process of how these characteristics influence the formation of internal spatial representations supporting navigation and enhancing survival.

Spatial cognition and mobility among children in two traditional and transitioning populations, the Tsimane of Bolivia and the Twe of Namibia

Helen Elizabeth Davis and Elizabeth Cashdan

University of Utah

Gender differences in range size and spatial ability are widely reported, but there is disagreement about the age at which these differences emerge. Variation in ecology, patterns of mobility, and modes of learning may be critical to spatial cognitive outcomes. This project seeks to determine the developmental processes that underlie spatial learning in two non-Western societies with vastly different ecologies, the Tsimane of Bolivia and the Twe of Namibia. We focus on two main questions: (1) What is the age and gender patterning of spatial abilities among children and adolescents in non-Western populations? (2) How do novel socioeconomic changes in subsistence, modes of mobility, and education shape these differences?

We collected behavioral data on daily mobility (GPS), navigational ability (dead reckoning and perspective taking tasks), and computerized mental rotation. We also collected self-report data on harm avoidance, spatial anxiety, and lifetime mobility. Prior work with adults showed a sex difference in wayfinding and perspective taking only among the Twe, a difference that may be due to habitat differences between the two areas.

Preliminary comparisons of Tsimane and Twe child data suggests that gender differences in range size and spatial ability are small to nonexistent in both populations at younger ages, but that these differences increase with age among the Twe. Our initial findings suggest that environmental and social variation play a significant role in the degree of difference found between sexes within both populations, and that generalizations based on Western populations should be made with caution.

What do the hands reveal about spatial language and cognition: Insights from gesture and sign

Asli Ozyurek

Radboud University and Max Planck Institute

Speakers as well as users of sign languages use iconic and analogue expressions of space as they communicate about space. Exploiting such visual resources language users have at their "hand" I will address whether and how visual modality expresses spatial relations as different from those of spoken modality and if this has consequences for cognition. Thus, I will present studies asking (1) whether and what do gestures reveal about different conceptualizations of space in users of different spoken languages (2) how do signers express space as different from users of spoken languages and whether this tunes signers to attend to spatial relations differently and (3) whether in children spatial concepts emerge earlier in their hands (as co-speech gesture or in sign languages) than in their spoken language expressions. In general, I will argue that representing space with bodily articulators provides a new window into language users' conceptualizations of space, one that might be more directly accessible than the arbitrary labels of the spoken languages—albeit this might show cross linguistic and cross cultural variability.

Sensory mapping

Daniele Quercia

Bell Labs Cambridge UK

Despite their importance, olfactory and aural perceptions have been crucially overlooked by urban planners and scientists alike, not least because they are difficult to record and analyze at urban scale. In 2014, we have started to explore the possibility of using social media data to reliably map the smells and sounds of entire cities. To this end, for both Barcelona and London, we collect geo-referenced picture tags from Flickr and Instagram, which contain more than 1 billion tags in London alone. We match those tags with the words in our newly created smell and sound dictionaries. In so doing, we are able to map the smellscapes and soundscapes of more than ten cities around the world. All the maps are available under goodcitylife.org. We then study: (1) how the urban smellscape and soundscape change over time and space; (2) which emotions people share at places with specific smells and sounds (by simply matching emotion words and sensory words in our pictures); and (3) what is the color of a smell, if it exists. Without social media data, insights about those three aspects have been difficult to produce in the past, further delaying the creation of urban restorative experiences.

The influence of visual presentation mode and auditory fidelity on spatial perception and cognition

Mark Lindquist, Francine Dolins, Bruce Maxim, Jennifer Proctor, Evan Granito, Ruby Issa, & Jay Sands

University of Michigan

3D digital visualizations have been shown to be a robust tool for communicating future scenarios and supporting decision-making in a variety of contexts. While beneficial, they lack the multisensory experience of the real-world and, as such, may not provide all information needed to make reliable decisions. In addition, how visual information is presented likely has a significant impact on perception, however to date there is mixed empirical evidence on the impact of presentation modes. The research described here aimed to fill a perceptual and procedural knowledge gap for using multisensory simulation in environmental decision-making. Participants were presented with 3D visualizations via a conventional screen and virtual reality headset, as well as varying three sound conditions (no sound, generic sound, detailed sound) with the impact on perceived realism, preference and biodiversity evaluated. The results are presented along with a discussion of how multisensory tools can be improved in order to contribute to more accurate evaluation of environmental change, and how perceived biodiversity may influence decision-making.

Cue the space: The role of landmarks and navigational aids in spatial memory and recall

Brent Chamberlain[1,2] and Conner Bruns[2]

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GPS-based navigation influences the spatial information we collect and process. Evidence shows using these devices decrease our reliance on observation and spatial memory when in a new environment. With navigational aids the typical reliance on landmarks, physical boundaries, and key reference points becomes insignificant. As designers, we ask: to what extent are these elements still able to influence sense of place? The aims of this study are: (1) investigate an individual's ability to recall the environment after using an assistive wayfinding aid, (2) assess how different "immersive" technologies influence recall, and (3) determine the extent to which certain landmarks and influence recall.

We created a novel virtual environment with a wayfinding aid to address our questions. Different groups are given different controls; one is guided on a fixed route, another is given route choice. For the first two aims, spatial elements and routes are highly controlled. Users are exposed to the same elements in the same location. For the third aim, landmarks are randomized by location. Following a self-guided walk through of the environment, participants complete a series of assessments, questionnaires, and map-drawing exercises to measure spatial memory through landmark, route, and survey knowledge. We have found that some landmarks are more memorable than others, but individuals struggle with recalling where landmarks are located. Route choice is shown to increase recall, while using virtual reality decreased recall scores. Valid results will provide the first evidence of how route choice influences memory recall, and extent to which landmarks influence spatial memory.

Where the wild things are…and how they get there: Bonobo, chimpanzee and human use of visual spatial information to efficiently navigate in virtual reality

Francine Dolins[1], Matthias Allritz[2], Kenneth Schweller[3], Karline Janmaat[4,5], Charles Menzel[6] and Josep Call[2]

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What kinds of spatial information do individuals attend to? How does this knowledge form the basis of intelligent spatial behaviors? We tested 5 bonobos (1 juvenile, 4 adults), 6 adult chimpanzees and 10 humans (children, adults), to compare their performance on virtual touch-screen navigation-foraging tasks. Multiple food/objects were located in a simulated outdoor environment (apes: apples, bananas, grapes; children: frog, monkey, unicorn stickers; adults: multi-colored chips). Experiment 1 was divided into two tasks in Real Life (RL) compared to Virtual Reality (VR): Quality (preferences) and Quantity (3 vs. 1 of each type). In real life, individual's preferences for these foods/objects were determined. In VR, subjects were required to navigate to food/objects to receive rewards: auditory ("ding"); visual (object glows, disappears); and tactile/gustatory. Our goal was to compare these species' spatial strategies in localizing the food/objects to determine whether their selection of food/object were in order of individual real-life preference. In the Quality task, Kanzi (bonobo) outperformed others. The results, however, for the chimps on Quality were non-significant (correlations between RW vs. VR: 0.71, .31, .42 at $p = .116$, .551, .42 respectively). In the Quantity task, in RL all subjects showed clear preferences ($p < .001$) while these were non-significant in VR. We also evaluated subjects' ability to project spatial knowledge gained virtually to solve spatial problems in the real world in a one-to-one correspondence (Experiment 2). Results are discussed with attention to performances of the young bonobo and children, and the role of maturation in human and nonhuman ape navigation and spatial strategies.

SYMPOSIUM 4: Spatial and non-spatial representation of number magnitudes

Convenors: Fabrizio Doricchi[1] and Wim Fias[2]

[1]Sapienza University of Rome; [2]Ghent University

One of the most debated topics in numerical cognition is the functional origin of the spatial coding of number magnitudes. In several task set there is evidence that numbers can be mentally coded along a mental number line printed from left to right. Nonetheless, whether this coding is inherent to number representation or whether it is triggered by specific task conditions is debated. Along this line, several investigators have highlighted systematic dissociation between spatial attentional mechanisms and the representation of number magnitudes. The symposium brings together the contributions of authors that have addressed the problem of the space–number relationship with different theoretical and methodological approaches and that have reached different conclusions. The symposium will offer an important chance for debating the relationship between spatial and non-spatial mechanisms regulating the representation and cognitive manipulation of number magnitudes.

The temporary nature of number–space associations

Wim Fias[1], Jean-Philippe van Dijck[2] and Elger Abrahamse[3]

[1]Ghent University; [2]Thomas More University College; [3]Basque Center on Cognition, Brain and Language

There are clear indications that the processing of number is tightly related to the processing of space. This is evident from the fact that small numbers are typically associated with left and large numbers with right. This is expressed in reaction time experiments with lateralized responses or lateralized stimuli, as well as in the performance of hemineglect patients who show a bisection bias when asked to indicate the middle of a numerical interval. Classically this association is interpreted as deriving from the fact that the long-term semantic representation of number magnitude takes the form of a mental number line. We will review evidence that puts this interpretation to question. We begin with an overview of evidence showing that the number–space associations are more flexible and variable than what one would expect from a long-term representation. From this, the hypothesis is derived that it are temporary associations in working memory that link number to space. We report a series of results confirming the hypothesis that it is position in working that is

related to space and that many of the phenomena classically interpreted as indication of a long-term memory mental number line representation can be produced by position in working memory.

The link between visuospatial abilities and mathematical abilities

Francesco Sella and Roi Cohen Kadosh

University of Oxford

One of the most prevalent metaphors in numerical cognition is the mental number line, which is assumed to play a critical role in representing numerical information. Such idea also reflects the view that visuospatial abilities play an important role in numerical cognition and the building block for more complex abilities such as arithmetic and maths. In this talk, we will present several findings from studies with children and healthy adult volunteers, non-mathematicians and mathematicians, and cognitive training studies. We will present the tight link between visuospatial abilities, as well as mental imagery, and mathematical performance. Such findings will be discussed within the context of mathematical development and intervention.

Left-to-right coding of number magnitudes: Inherent or not?

Fabrizio Doricchi

Sapienza University of Rome

One of the issues of major interest in numerical cognition is the relationship between the brain representation of space and that of numerical magnitudes. Space–Number interactions have been variously ascribed to the inherent spatial coding of number magnitudes, to the verbal coding of space determined by the use of contrasting left/right spatial codes in the task at hand or to the use of the same spatial codes in the selection of motor responses associated with numerical features such as magnitude or parity. In my talk, I shall review the results gathered from behavioral, neuropsychological, electrophysiological and fMRI investigations run in our lab. Through the use of different behavioral paradigms like the mental bisection of number intervals, the SNARC and Attentional-SNARC tasks (both in their original and modified versions) we demonstrate that the use of spatial codes in the numerical task at hand is crucial in determining the Space–Number interaction when numerical information are recovered from LTM knowledge. This happens both when spatial codes are directly associated with number stimuli and when the same codes are indirectly associated with numbers through the selection of motor responses. These findings outdate the idea that numbers have an inherent spatial representation or that, vice-versa, the mere perception of numbers determines spatial orienting in the left or right side of space according to number magnitude. Critical comparisons with the results and hypotheses from other labs will be also provided and future lines of investigations will be sketched during the talk.

Representations of space with ordinal information

Wim Gevers and Sophie Antoine

Université Libre de Bruxelles

Numbers are not only characterized by their magnitude information but also by their ordinal relations. During the last couple of years, convincing evidence accumulated that ordinal relations, even non-numerical, are spatially coded in the brain. If this is true, then patients having problems with spatial information processing should also demonstrate difficulties judging the ordinal relation between items. This is what we tested in neglect patients. What we observed is that neglect patients have no problems memorizing item information (e.g. was this item present in the memorised list?) but, as expected, have important deficits in processing ordinal information in working memory (were these items presented in the same or different order in the memorised list). Interestingly, and contrary to our predictions, this deficit was not lateralized. Neglect patients had equal difficulty, regardless of whether the ordinal relation was at the beginning or at the end of the sequence. On the basis of these findings, we further investigate how ordinal relations are represented in the brain. The results and theoretical implications of these and other studies will be discussed during this talk.

Spontaneous perception of numerosity in children and adults

Guido Marco Cicchini[1], Giovanni Anobile[2] and David Charles Burr[3]

[1]CNR Neuroscience Institute, Pisa, Italy; [2]Scientific Institute Stella Maris, Pisa, Italy; [3]NEUROFARBA, University of Florence

Humans—including infants—and many other species have a capacity for rapid, nonverbal estimation of numerosity. However, the mechanisms for number perception are still controversial: some maintain that the system calculates numerosity via density estimates—similar to those involved in texture—while others maintain that more direct, dedicated mechanisms are involved. We will present a series of experiments showing that provided items are not packed too densely, human subjects are far more sensitive to variations in numerosity than in either density or area. In a three-alternative forced choice task requiring discrimination along a two-dimensional space spanning density, area and numerosity, subjects spontaneously show far greater sensitivity to changes in numerosity than either area or density. We have extended this line of research with a novel reproduction technique in which subjects match by trackpad as closely as possible the size and density of a sample dot-array. This task is quick and user-friendly, lending itself to developmental and clinical studies. The results are similar to those of forced-choice psychophysics, showing fewer errors along the numerosity than the area or density axes. Children as young as five show similar effects, with greater overall errors but similar selectivity to numerosity. Dyscalculics similarly show a preference for numerosity, but with lower precision. The series of experiments strongly supports the thesis that humans extract number information, directly and spontaneously, via dedicated mechanisms.

SYMPOSIUM 5: Spatial cognition in engineering problem solving

Convenors: Gavin Duffy[1] and Sheryl Sorby[2]

[1]Dublin Institute of Technology; [2]University of Cincinnati

Background: The problems of the future are complicated and interconnected. How do we ensure an increasing world population has access to clean, plentiful water? There are many competing needs for the water itself, there are impacts on the environment to be considered as well as societal impacts between developed and developing countries, not to mention many technical issues. Engineers are expected find a path through the complexity and interconnectedness of this and the many other grand challenges of the future. They are expected to be creative, insightful problem solvers.

Engineers are also known for excellent spatial skills. In tests with more than 30,000 professionals, engineers demonstrated the highest level of spatial skills, followed closely by architects and other STEM professionals. A recent study showed a strong correlation between spatial visualization skills, creativity and technical innovation.

It is posited that possessing advanced spatial abilities allows an individual to construct robust mental representations of problems, critical in solving all manners of problems but particularly in the case of "insight" problems where overcoming an impasse through re-representing the problem is necessary. Recently, the cognitive approaches STEM educators utilized in conceptualizing problems was investigated to find a distinct advantage in utilizing spatial visualization processes in conceptualizing the tasks. Students who adopted spatial approaches, as opposed analytical reasoning, were able to gain broader access to different types of memory systems, which facilitated more adaptive problem solving behaviour.

It has been widely established that improving spatial skills among engineering education students has significant benefits for a variety of aspects of their study. A number of research studies have demonstrated significant gains in learning and higher retention and graduation rates among students within engineering following the implementation of a course designed to improve individuals' spatial competencies. However, the cognitive mechanisms underlying these improvements are not well understood. It is also unclear what specific benefits spatial skills provide in terms of learning within engineering education.

Aim: The purpose of this symposium is to synthesize different strands of research on the role of spatial cognition in problem solving in engineering and related contexts and, through bringing these together, explore common patterns and differences so that we can learn more about this phenomenon from the various ways it has been investigated. We aim to develop a clearer understanding of the importance of spatial cognition to engineering problem solving.

Approach: This symposium will present results from several studies examining the link between spatial cognition and engineering problem-solving. It will begin with a talk regarding the link between spatial cognition and fluid intelligence before proceeding to presentations on the link between spatial cognition and success in solving typical problems in mathematics, electrical engineering and chemical engineering. It will conclude with presentations on efforts to improve access to and interest in STEM education among school children through spatial skill development. This symposium approach will allow the participants to identify the common threads that link their different studies and identify opportunities for future collaboration.

Examination of the gender differences in spatial visualisation skills and their impact on success and engagement in STEM education

Brian Bowe and Rachel Harding

Dublin Institute of Technology

Despite the buoyant technological environment in Ireland there is a significant imbalance between the number of women working in STEM careers compared to men. The many initiatives aimed at attracting more female students to STEM have had limited success as they rarely address cognitive causes but instead focus on making STEM more attractive. The research study describe here addresses a fundamental cognitive barrier to STEM: spatial ability. Research studies have shown that spatial skills are a key indicator in how students perform in STEM across all levels of education and significant gender differences favoring males have been consistently observed. The aim of this research is to measure spatial skills at primary and secondary education levels in Ireland and determine the impact these skills have on success in STEM education and perceptions of STEM subjects and disciplines, with a particular focus on female students. Working with the Professional Development Service for Teachers, large-scale quantitative data of spatial skills levels, demographic data, student profile data, perceptions and attitudes is being acquired and analyzed to identify relationships and trends. The impact of education interventions and learning activities specifically aimed at developing spatial skills is also being evaluated. While the study will use existing validated tools and resources to measure and develop spatial skills at post-primary levels, new tools and resources are being developed for primary level. This is the first large scale research study to examine spatial skills and their impact across Ireland.

Problem representation characteristics of engineering students with low and high spatial ability and implications for engineering education

Gavin Duffy

Dublin Institute of Technology

While spatial ability has been shown to be highly relevant to STEM learning its development is often ignored in STEM education. A rationale for this research is that a greater understanding of its role in STEM learning is required to more fully inform curriculum design. In this study, the role of spatial ability in engineering problem solving was examined using samples of first year engineering students in Ireland and the US. A set of word problems in mathematics, an accompanying set of math core competency questions and the PSVT:R, a test of spatial ability, were administered to 115 first year engineering students. Spatial ability was found to be significantly related to the problems but not the questions indicating it was predominantly relevant to the problem representation phase. Further analysis of all problem solutions revealed differences in representation adopted by participants with low and high levels of spatial ability. For one problem, which could be solved either through guess and check or algebraic modelling, each representation revealed a different relationship with spatial ability. These findings indicate that cognition in problem solving is complex: spatial ability is relevant to problem representation but not always and is irrelevant to the solution

phase. Memory models of cognition offer a way of explaining this complexity. Problem representation should be considered as a learning outcome in STEM curriculum design given its particular cognitive demands and the challenges it presents for those low in spatial ability.

Investigating the relationship between spatial ability and electrical circuits problem solving in an engineering degree program

Thomas Delahunty, Lance C. Perez, Presentacion Rivera-Reyes, Eric Psota and Dennis Molfese

University of Nebraska-Lincoln

Educational research in Science, Technology, Engineering, and Mathematics (STEM) has consistently demonstrated links between students' spatial ability and academic success. Moreover, there is evidence that spatial ability is a better predictor of achievement for STEM students than traditional verbal or mathematical abilities (Wai et al. 2009). Well known associations between spatial ability and academic performance have been found in STEM competency areas such as calculus (Sorby et al. 2013), mechanical reasoning (Casey et al. 2001), and mathematical problem solving (Boonen et al. 2014). While questions surrounding the exact role of spatial skills in STEM educational success remain (Delahunty et al. 2016), the beneficiary nature of spatial skills is generally accepted. Furthermore, while researchers have studied the relationship between spatial skill and more imagistic engineering disciplines such as mechanical engineering, other disciplines such as electrical engineering remain under-researched.

This contribution discusses a research study of the relationship between spatial skills and performance in electrical circuits problem solving within an undergraduate electrical engineering curriculum. Two separate experiments are described where undergraduate students from an electrical engineering programme were given a series of electrical circuits problems and a well-known spatial test. Findings indicate that there exists a statistically significant association between students' spatial skill level and their ability to successfully solve electrical circuits problems. The conclusion of the study discusses the posited role of spatial ability in electrical circuits problem solving and presents some implications for engineering education curricula and future research.

Understanding the link between spatial skills and chemical engineering problem-solving

Norman Loney and Sheryl Sorby

University of Cincinnati

Background: Spatial skills are important to success in STEM fields, including engineering. In chemical engineering, not only do students need to visualize molecular structures needed for fundamental chemistry applications, they must also be able to visualize, how, the processing equipment (pipes, reactors, distillation columns) fit and work together to result in the desired chemical compound.
Aims: In this study, we investigated whether or not there were certain classes of problems within chemical engineering where spatial skills play a role and if high visualizers were more adept at solving problems than low visualizers.
Method: Approximately 60 undergraduate students in chemical engineering were administered a test of spatial cognition. They were also given 12 "typical" chemical engineering problems to solve. Problem sets were administered during a class in a third-year course in the program. Since students all had the same amount of time, those who were better at problem-solving would likely solve a larger number of problems compared to weaker students.
Results: A strong positive correlation ($R = 0.59$, $p < 0.00001$) between spatial skills test scores and the number of problems successfully solved by the students was found. Problems where spatial skills appear to play a role were identified and will be further described in the presentation.
Conclusions: Previous studies have shown links between spatial skills and overall success in engineering. Through this work, specific types of problems in chemical engineering were identified where spatial skills appear to play a role in solving them. This has implications in curriculum design within undergraduate chemical engineering programs.

SYMPOSIUM 6: The roles of multimodality in spatializing reasoning and learning

Convenors: Kenneth Forbus[1], Dedre Gentner[1], Susan Levine[2] and Anthony Cohn[3]

[1]Northwestern University; [2]University of Chicago; [3]University of Leeds

Background: An important function of spatial cognition in humans and machines is to provide support for reasoning and learning. People routinely use spatial language, gesture, sketching, and action to learn, communicate, and reason. Understanding how these multiple modalities support cognition will help shed light on human cognition, and help create machines that can interact with us multimodally.
Aim: This symposium brings together researchers from cognitive development and artificial intelligence to examine how different modalities impact spatial learning, i.e. using space to reason and learn.
Approach: The symposium speakers will address learning and reasoning in different domains and bringing to bear different sources of evidence, in ways that will enable us to compare and contrast:

1. Spatial analogies in complex relational learning: Evidence from spontaneous gestures. Presented by Dedre Gentner (Northwestern), this talk will provide evidence that gestures are used to construct spatial analogies, which support learning new relational patterns.
2. Gesture helps learners learn, but not merely by guiding their visual attention. Presented by Susan Goldin-Meadow (U. Chicago), this talk will provide evidence, using eye-tracking data, that the beneficial effects of gesture on learning also come from helping learners glean more from speech.
3. Mental transformation skill in young children: The role of concrete and abstract motor training. Presented by Susan Levine (U. Chicago), this talk explores how different forms of embodied instruction, i.e. recruiting motor movements, impact learning in children.
4. Natural language learning and grounding for embodied robotic systems. Presented by Anthony Cohn (Leeds), this talk will describe experiments in enabling robots equipped with physical bodies and vision systems to learn spatial and other aspects of natural language.

5. Connecting language to space via sketching. Presented by Ken Forbus (Northwestern), this talk will describe experiments in using sketch understanding of simple comic strips to enable an AI system to learn spatial and other aspects of natural language.

Spatial analogies in complex relational reasoning: Evidence from spontaneous gestures

Dedre Gentner[1], Kensy Cooperrider[1] and Susan Goldin-Meadow[2]

[1]Northwestern University; [2]University of Chicago

Research has shown that people spontaneously gesture during explanation and discourse. Often, these gestures express concrete spatial information. We hypothesized that people also use gesture in a more abstract way—to support analogical thinking about inherently nonspatial domains. To test this, we asked college students to explain causal systems involving positive or negative feedback—an important topic in STEM learning and reasoning.

Participants read a passage that explained the difference between positive and negative feedback (without these labels). Then they explained the lesson to another 'student' (actually, a confederate). We analyzed their speech and gestures, focusing on representational gestures—both deictic gestures that establish a referent's location, and iconic gestures that depict some property or event. We found that the representational gestures were abstract in nature—that is, they used location, movement, and spatial arrangement to depict abstract factors with no inherent spatial properties. These gestures were largely unaccompanied by spatial words, and they occurred even when no spatial language appeared in the initial passage. We analyzed these gestures in terms of four key elements of feedback systems: (1) the factors involved in the system; (2) changes those factors undergo; (3) causal relations between changes; and (4) the behavior of the whole system. We found that participants' gestures often cohered into larger analogical models of relational structure. We conclude that people spontaneously use gesture to support abstract representation and reasoning. Gesture thus provides a way to observe people's mental models that may not appear in their overt language.

Gesture helps learners learn, but not merely by guiding their visual attention

Susan Goldin-Meadow[1], Elizabeth Wakefield[2], Miriam Novack[3], Eliza Congdon[4] and Steven Franconeri[3]

[1]University of Chicago; [2]Loyola University; [3]Northwestern University; [4]Bucknell University

Teaching a new concept through gestures—hand movements that accompany speech—facilitates learning above-and-beyond instruction through speech alone. Here we use eye tracking to explore a potential mechanism for this phenomenon—gesture's ability to direct visual attention. We taught 50 children, ages 8–10, how to solve mathematical equivalence problems through either Speech + Gesture (14 females, 12 males) or Speech Alone (14 females 10 males). Children performed significantly better at posttest after learning through Speech + Gesture than through Speech Alone. Using eye tracking measures, we found that children who watched the math lesson containing gesture allocated their visual attention differently from children who watched the lesson without gesture—they looked more to the problem, less to the instructor, and were more likely to synchronize their visual attention with the instructor's speech (i.e., to follow along with speech) than children who watched the no-gesture lesson. These looking patterns positively predicted learning outcomes but, importantly, they did not mediate the effects of training condition on posttest success. We found instead that following along with speech predicted learning only for children in the Speech + Gesture condition, not for children in the Speech Alone condition. In other words, following along with speech was effective only when it was accompanied by gesture. Gesture's beneficial effects on learning thus come not merely from its ability to guide visual attention (i.e., to get children to move their eyes in synchrony with speech), but also from its ability to influence what learners glean from that speech.

Mental transformation skill in young children: The role of concrete and abstract motor training

Susan Levine[1], Susan Goldin-Meadow[1], Matthew Carlson[2] and Naureen Hemani-Lopez[1]

[1]University of Chicago; [2]The Pennsylvania State University

There is increasing evidence that spatial thinking is an important predictor of achievement in the STEM disciplines. Such findings raise important questions about how we can effectively support the development of spatial thinking. To address this question, we compared gains in kindergarteners' mental transformation skill in three different motor training conditions: training the involved making concrete motor movements relevant to the transformations (action training), training that involved making abstract motor movements relevant to the transformations (move-gesture training), or a control condition involving an irrelevant point gesture. We tested children prior to training, immediately after training (posttest) and 1 week later (retest). We found greater improvement in mental transformation skill in the relevant movement conditions—action and movement gestures—than in the control condition at both posttest and retest. Gains in the action condition were fully realized by the posttest, whereas gains in the relevant gesture condition unfolded more gradually. At retest, there were no significant differences in gains in the Action versus Move-Gesture Condition, but these findings open the possibility that with longer time spans, gains realized with gesture training might out-strip those realized with action training.

Natural language learning and grounding for robotic systems

Muhannad Alomari, David Hogg and Anthony Cohn

University of Leeds

In this talk, the problem of bootstrapping knowledge in language and vision for autonomous robots is addressed through novel techniques in grammar induction and word grounding to the perceptual world. The learning is achieved in a cognitively plausible loosely-supervised manner from raw linguistic and visual data and is validated on four datasets.

The learning framework is divided into three processes: (1) perceptual raw data is clustered into a number of Gaussian components to learn the 'visual concepts'; (2) frequent co-occurrence of words and visual concepts are used to learn the language grounding; (3) the learned language grounding and visual concepts are used to induce probabilistic grammar rules to model the language structure.

Language grounding is enabled by seeking frequent co-occurrence between words and learned visual concepts using integer programming. Probabilistic CFG rules are generated to model the language by mapping sentences to learned visual concepts, as opposed to traditional supervised grammar induction techniques where the learning is only made possible by using manually annotated training examples.

Although individual aspects of this work have been addressed in previous work, we believe that this is the first time that, in a single system, it has been shown how a string of words with no preassigned syntactic categories, or semantics assigned, these can be grounded to automatically learned perceptual concepts, both static and dynamic, and also to learn a grammar of the language. Moreover this is shown to be possible in an online framework, i.e. incrementally, and without storing all previous examples.

Connecting language to space via sketching

Kenneth Forbus

Northwestern University

Sketching provides a powerful means for people to communicate with each other, and is now becoming a modality that can be used to teach AI systems about human spatial concepts and spatial language. This talk will summarize experiments with CogSketch, an open-domain sketch understanding system, that show it can be used to learn aspects of spatial language by sketched examples. Specifically, it can learn spatial prepositions (which vary between cultures) from sketched examples to learn how to appropriately use prepositions from English and Dutch. Moreover, by automatically breaking up Kinect video data into qualitative segments, thereby creating a sketch graph, analogical generalization can also be used to learn terms for human behavior actions.

SYMPOSIUM 7: The body in the space

Convenor: Xaver Fuchs

Faculty of Psychology and Sports Science, University of Bielefeld

Background: In order to interact with the environment, our nervous system gathers, maintains and retrieves information about the spatial extension, position and posture of the body. This information is sometimes referred to as "body representations" or "body maps". Body representations have gained increasing attention in the field of neuroscience and psychology. Previous research has shown intricate relationships between sensory input and body representations. Recent models assume a sensorimotor loop, in which information about the body influences action and prediction of sensory outcomes. Deviations of sensory feedback from predicted sensory outcomes then update body representations, thereby closing the sensorimotor loop.

Research on bodily illusions has highlighted the plasticity of body representation by integration of spatiotemporally correlated stimuli on the body and non-body objects. For example, presenting simultaneous touch on an artificial hand and a participant's hidden real hand in the so-called rubber hand illusion leads to touch being perceived on the artificial hand and feelings of body ownership. This embodiment of artificial limbs is also reflected in behavior such as protection of the limb from "threat" or biases in limb localizations.

Research on localization of body parts or estimation of distances between stimuli on the skin has shown that, in the absence of vision, spatial body representations are distorted in a characteristic manner (e.g., hands are perceived as shorter and broader). These distortions also depend on posture. Studies using localization of stimuli on the body have shown that the brain combines different spatial reference frames (e.g., anatomical and external) when localizing touch on body parts. These studies indicate that even the body representations involved in basic tasks of tactile perception are more dynamic, contextual and multimodal than previously thought.

Furthermore, neuroimaging methods have been used to study how stimuli on the body or motor behavior are coded in neural body maps (e.g., in the primary somatosensory and motor cortices). It is known that Penfield's somatosensory and motor homunculus can be reorganized in specific populations due to loss or disorganization of sensory afferents and due to long-lasting training effects (e.g., in amputees or in professional musicians). Recent research, however, indicates that neural body maps might even be more rapidly adapting, context-dependent and multimodal than it has been assumed before.

Aim: The symposium will report recent research on bodily illusions, tactile perception, and neuroimaging. We will (1) present studies on the relationship between multisensory integration of vision, touch and other modalities and plasticity of body representations in body ownership illusions, (2) discuss how body representations influence both sensory integration and prediction of action outcome, and (3) present work on the relationship between body representations and tactile localization. Finally, we will present new findings on how perceptual body maps relate to neural body maps and how body representations can be shaped in specific contexts such as in virtual—and augmented realities.

Approach: In the symposium, we will combine contributions from the fields of behavioral neuroscience, neuroimaging and computational neuroscience and discuss their contribution to understanding the relationships between sensory input, motor behavior and their neural underpinnings.

The rubber hand illusion induced by visual-thermal stimulation

Jörg Trojan[1], Xaver Fuchs[2], Sophie-Louise Speth[1] and Martin Diers[3]

[1]Department of Psychology, University of Koblenz-Landau; [2]Faculty of Psychology and Sports Science, University of Bielefeld; [3]Department of Psychosomatic Medicine and Psychotherapy, LWL Universitätsklinikum, Ruhr-Universität Bochum

Background: In the rubber hand illusion (RHI), synchronous touch of a real hand and an artificial hand leads to the feeling of the artificial hand belonging to one's own body.

Aims: This study examined whether the RHI can be induced using visual-thermal instead of visual-tactile stimulus patterns and to which extent the congruency between temperature and colour of the visual stimulus influences the RHI.
Method: In a within-subject design, we presented cold versus warm thermal stimuli to the participants' hidden hand combined with red versus blue visual stimuli presented synchronously versus asynchronously at a fake hand.
Results: The RHI could be induced using visual-thermal stimuli, yielding RHI vividness ratings comparable to the visual-tactile variant. Congruent (warm-red, cold-blue) synchronous stimulus patterns led to higher RHI vividness than incongruent (warm-blue, cold-red) synchronous combinations; in the asynchronous conditions, an inverse effect was present. Temperature ratings mainly depended on the actual stimulus temperature and were higher with synchronous versus asynchronous patterns; they were also slightly higher with red versus blue light, but there were no interactions with temperature or synchrony.
Conclusions: we demonstrated that the RHI can be induced via visual-thermal stimuli, opening new perspectives in research on multisensory integration and body representations.

Computational principles of the attenuation of self-generated touch

Konstantina Kilteni and H. Henrik Ehrsson

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Why can't you tickle yourself? Previous behavioural and neuroimaging evidence suggests that when we move one hand to touch the other, the resulting tactile sensation is perceived as less intense compared to identical touches of external origin. This somatosensory attenuation phenomenon is hypothesized to arise because our brains use internal information about the motor command (efference copy) to predict the tactile consequences of the movement and attenuate the tactile feedback based on these predictions. However, little is known about how the brain produces this somatosensory attenuation. I will present behavioral data from three recent studies we conducted to investigate the attenuation under different spatial configurations: when using a handheld tool, when experiencing the rubber hand illusion or when performing motor imagery. I will also present data from our fMRI study on somatosensory attenuation and its spatial principle. All our data suggest that somatosensory predictions based on self-generated movements include a robust spatial component.

Bidirectional cause-effect relations between multisensory integration and body ownership illusions

Antonella Maselli

Laboratory of Neuromotor Physiology, Santa Lucia Foundation

During body ownership illusions external objects, like surrogate bodies or body parts, are experienced as belonging to the own body. Extensive experimental evidence suggests that this "erroneous" self-attribution relies on the multisensory integration of truly independent stimuli applied on the physical and surrogate bodies, with coherent spatiotemporal patterns. For example, in the rubber hand illusion, ownership of a rubber hand is experienced when seeing the rubber hand being touched while receiving synchronous and spatially aligned touch on the real hand. Otherwise, body ownership illusions have been shown to have a significant impact on perception of bodily signals and on behavior.

I will present a general overview on the multisensory mechanisms that underlie the onset of ownership illusions and on how ownership illusions affect the processing and integration of multisensory stimuli. I will discuss how it is possible to account for the experimental evidence from previous studies with a model based on Bayesian Inference. According to the model the sense of body ownership arises when attributing all incoming bodily stimuli, from both the real and the surrogate body, to the same one cause, i.e. the own body. Next, I will discuss how the inferred assumption of a common cause, at play during ownership illusions, could relax the common spatiotemporal constraints for multisensory integration. In particular, I will present results from an experiment based on psychophysical temporal-order judgment task showing how the temporal window for the integration of visuotactile stimuli applied on the hand expands as the level of illusory ownership increases.

Active tactile search strategies improve localization of touch

Xaver Fuchs and Tobias Heed

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Background: Visual localization of out-of-view objects often follows a two-step strategy: Gaze is first guided to the vicinity of the target; a second saccade then uses online visual information to correct the remaining error. Whether the tactile system uses similar localization strategies based on online tactile input is unknown.
Aims: We aimed to uncover potential localization strategies for touch. We asked whether humans improve localization by active search strategies on the skin.
Methods: Fifty-three participants received brief touches on the left dorsal forearm and were instructed to localize this position with their right index finger. They were allowed to touch the skin and to correct the position by moving the finger on the skin. Their eyes were closed during stimulation and localization. The movements were recorded using a video camera. Target positions and trajectories on the arm were extracted from the videos using image-processing software.
Results: Active search strategies of different types were observed in about 75% of the trials. Most search paths (70%) were directed towards the correct target location and improved localization. Some participants regularly explored seemingly random directions, leading them away from the target initially, but mostly corrected their search, ultimately resulting in improved localization.
Conclusions: Search strategies in the tactile system resemble those in vision in that an initial target representation appears to provide only coarse resolution and guide a first, approximate motor response; the final target location is then assessed in a second step through online use of tactile information.

Neural correlates of distorted body representations underlying tactile distance perception

Luigi Tamè[1], Raffaele Tucciarelli[1], Renata Sadibolova[1], Marty Sereno[2] and Matthew Longo[1]

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The ability to localize touch on the body, and in particular tactile distance perception, has been largely used as a tool to investigate how the somatosensory system contributes to body representations. Nevertheless, there is little evidence about the neural basis of this phenomenon. Recent studies found that on the perceptual level, tactile configurations, at least in the case of the hand, are highly distorted with the hand dorsum represented as wider and squatter than it actually is. Here, we aim to define the neural basis of this phenomenon. In a behavioral experiment, participants estimated the distance between touches delivered on the hand dorsum. Using multidimensional scaling we reconstructed a perceptual map of the skin space. Analysis of spatial distortion showed that the skin space was stretched in the mediolateral hand axis. To determine the neural correlates of these body distortions, we performed an fMRI study in which we delivered nine tactile stimuli, organized as a 3×3 square grid, on the dorsum of the right hand. Within pre-defined regions of interest, we computed the pairwise Euclidean distances between the neural patterns associated with the tactile stimulations and we then compared the neural dissimilarity matrices to the model obtained from the behavioral study. We were able to reconstruct the shape of the skin space in the contralateral primary somatosensory (SI) and motor cortices, with a distorted profile that emerged only in SI. This suggests that SI, rather than higher level brain areas, is critical to process tactile distance perception.

Evoked phantom sensations in amputees: A link between neural processing of body illusions and altered body perception

Christopher Milde[1], Martin Diers[2], Jamila Andoh[3], Susanne Becker[3], Robin Bekrater-Bodmann[3], Jörg Trojan[1], Xaver Fuchs[4] and Herta Flor[3]

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A disturbed body perception is characteristic of various neurological and mental disorders and becomes particularly evident in phantom phenomena after limb amputation. Most amputees continue to perceive the amputated limb and some perceive sensations in their missing limb, when body parts adjacent to or remote from the amputated limb are stimulated (evoked phantom sensations). The neural correlates of non-painful phantom sensations remain to be elucidated. We hypothesized that non-painful evoked phantom sensations can be linked to neural circuitry underlying body illusions with comparable phenomenological aspects such as illusions inducing the percept of having a third arm. Using functional magnetic resonance imaging, we investigated 12 upper-limb amputees who reliably perceived non-painful evoked phantom sensations and 12 yoked controls. We used painful electrical and non-painful tactile stimulation to elicit non-painful phantom sensations and also stimulated at control sites that did not elicit phantom sensations. All sites were remote from the amputation site to avoid interference of local amputation-induced changes. In the controls, we stimulated at anatomically matched body sites.

Using a conjunction analysis we found increased brain activation in the left ventral frontal (BA44/45), insula and premotor cortices during the elicitation of evoked phantom sensations compared to both control conditions. Regressive psychophysiological interaction analyses further revealed a widespread network showing significant fronto-parietal connectivity. The present findings associate non-painful phantom sensations with a fronto-parietal network similar to that reported in body illusions and altered body perception. These data emphasize the role of crossmodal body illusions in normalizing dysfunctional body representations.

SYMPOSIUM 8: How do we make sense of space through its artistic representation? Space and embodiment in visual art

Convenors: Joanna Ganczarek[1] and Nicole Ruta[2]

[1]Pedagogical University of Cracow; [2]CSAD, Cardiff Metropolitan University

Background: Human communication technology relies increasingly on images and pictures. However, picture perception and interpretation is often mistakenly assumed to be immediate and univocal. As psychological research has shown in the last few decades, perception is always mediated by a range of factors, including the viewing context and our embodied experience of space. In visual art, more than many other fields, the question of visual space is of primary concern, and the experience of art is one of the ways we can enhance our awareness of the way we experience space. According to the artist Frank Stella: "After all, the aim of art is to create space–space that is not compromised by decoration or illustration, space in which the subjects of painting can live. This is what painting has always been about" (Stella 1986, p. 5).

Aim: The main purpose of this symposium is to bring together recent research that uses novel and creative ways to investigate the relationship between viewers and artistic representations of space. We propose that the experience of a pictorial space involves interrelated processes that go far beyond the perception of depth cues. While interacting with an artwork, viewers actively organize their experience of space moving around and/or in front of it, thus eliciting constant changes in perspective and distance and shifts in the location of gaze and alterations of body postures. All of these influence representations of space and relevant associations, memories and emotions.

Approach: Individual differences in the way we read and imagine pictorial space are critical aspects of this process and still a largely unexplored field of research. Therefore, we welcome experimental studies on perception, imagination, memory and bodily experience of pictorial spaces, especially those that employ neurophysiological

measures (e.g. eye tracking, neuroimaging, EMG and body sway) or paradigms exploring the embodied reactions of viewers.

Manipulating complexity in pictorial space through artistic means

Joerg Fingerhut

Berlin School of Mind and Brain, Humboldt-Universität

I will present research on perceived complexity and aesthetic evaluations of artworks. In one study we manipulated the complexity of artworks by manipulating the amount of different objects, amount of textures, and the amount of empty space. Our participants (32 German, 30 Japanese) preferred highly complex images. Yet we also found cross-cultural differences regarding the evaluation of empty space (empty space is more appreciated in the Japanese sample). I will discuss the concept of complexity with respect to filled and empty space, perspective, and salience in artworks. I will relate this discussion to the idea that we highly value artworks that are sensory engaging, cognitively challenging and that to some extent invite veneration.

Out of order: Syntactic inconsistencies in pictorial space

Joanna Ganczarek and Karolina Pietras

Pedagogical University of Cracow

Background: Syntax in verbal language refers to the relative positioning of words within a phrase. Similarly, relative positioning of objects within a scene is seen as a visual analogue of verbal syntax. However, syntax in visual art might also reflect the way the whole pictorial space is composed. Contemporary paintings offer an excellent testing ground for studying the (dis)order of visual syntax because they frequently contain multiple inconsistencies such as vague definitions of forms, imprecise spatial contexts and juxtapositions of different, often contrasting, styles.
Aims: Whereas the effect of semantic inconsistencies on eye movements is well researched, the impact of syntactic inconsistencies is less explored. Therefore, the main purpose of our study was to investigate the contribution of syntactic information to eye movements and evaluations of contemporary paintings. It was hypothesized that syntactic inconsistencies would be associated with numerous, short, dispersed fixations and long viewing time which reflect managing the conflicting information.
Method: Participants' eye movements were recorded while they freely viewed digital copies of 20 contemporary paintings differing in presence/absence of syntactic inconsistencies. Afterwards, participants rated images on several dimensions.
Results: Syntactically inconsistent images were rated as more complex and associated with more numerous but shorter fixations and longer viewing times than syntactically consistent images. However, contrary to our predictions, these fixations were less dispersed than in the case of syntactically consistent images.
Conclusions: Our findings suggest that processing images where pictorial space is distorted through syntactic manipulations is associated with a particular viewing strategy i.e. sampling strategy.

Medieval representation of pictorial space? A study investigating an alternative hypothesis from art history

Nicole Ruta, Alistair Burleigh and Robert Pepperell

CSAD, Cardiff Metropolitan University

Prior to the discovery of linear perspective, Western artists varied figure size in compositions, often dramatically. The standard 'hierarchical scaling' theory explains these variations as reflecting the figures' status (White 1973). But the art historian Wulff (1907) offered an alternative, as yet untested, hypothesis: that figure size was determined by 'inverse perspective' used by artists to elicit empathy and direct visual attention. We think that the composition of these medieval paintings might also reflect the structure of imaginary space.

To test these hypotheses, we selected 10 medieval paintings and altered each to approximate the rules of linear perspective (using Adobe Photoshop). We subjected the original and altered versions of the paintings to a series of experiments to measure preference, empathy and imagined space. The original version of the paintings did not affect liking, but significantly influenced preferences for artistic composition [$t(78) = 8.828$, $p < .001$]. In a free viewing task, participants fixated for longer the bigger character if viewing the original version ($M = 2.96$, $SE = .267$) compared to the altered one ($M = 2.78$, $SE = .256$). We also investigated qualitative differences in empathy in participants' descriptions of each painting. Finally, a drawing task revealed a pattern that closely matched the composition of the original Medieval paintings [$t(21) = 3.147$, $p = .005$].

We conclude that medieval artists' composition of pictorial space was more sophisticated than standard art histories allow, and representative of imaginary and visual space than previously recognised (Ruta et al. 2016; Pepperell and Haertel 2014).

Natural imaging media

Robert Pepperell, Alistair Burleigh and Nicole Ruta

CSAD, Cardiff Metropolitan University

Most current imaging technologies rely on rectilinear perspective, which describes the physics of light rays projected onto a flat surface. However, this often results in perceptually unnatural distortions, especially in the periphery. We have developed a new imaging technology that emulates the natural subjective appearance of human vision, including the first person embodied perspective, and matches aesthetic patterns observed in art history (Ruta et al 2016: Pepperell and Haertel 2014). This is achieved by computationally modelling a number of complex psychological processes occurring in visual perception.

This approach results in a new non-linear projection framework that has been implemented in real-time 3D graphics code and experimentally tested. When asked to directly compare the experience of being in front of a physical space to different pictures of the same space, participants significantly preferred our novel projection compared standard fisheye [$t(25) = 3.528$, $p < .05$] and rectilinear [$t(25) = 3.398$, $p < .05$] projections. We also measured a range of different psychological variables, including sense of presence, comfort, and ecological validity. Here our image projection was rated as being equally immersive [$t(5) = 1.044$, $p > .05$] and liked [$t(5) = .889$, $p > .05$] when compared to a large format 180 degree cylindrical projection screen.

We will discuss the potential applications of this technology in all those fields in which a more perceptually realistic representation visual space would be beneficial, such as medical imaging, architectural visualization, gaming, photography, and cinematography.

The effects of space and movement on visitor attention

Martin Troendle

Zeppelin University

Background: This presentation demonstrates results from an in-depth visitor analysis conducted in the St. Gallen Museum of Fine Arts. For a full project description, see www.mapping-museum-experience.com.
Methods and sensitizing concepts: Using the latest tracking technology, exact visitor positions and movement paths inside the exhibition were recorded. Based on the psychological concepts of "valence" (Lewin), "standing patterns of behavior" (Barker) and "affordance" (Gibson), the analysis of the movement data is an explorative and descriptive investigation of the "raw material".
Results: We investigated how architectural and curatorial settings influence visitor attention given to various artworks and how the visitors' move within the spaces of the museum. The tracking technology revealed visitor streams alongside so-called "space-cells", which were found to influence the rhythmicity of the museum visit. Space-cells can be characterized by a reference point attracting visitor attention that produces a "stopping-moment", followed by cell-specific movement patterns in relation to the composition of the cell. Furthermore we will discuss our findings on viewing distances (the proximity and distance); the effects of hanging arrangements (curatorial effects); and text-artwork-arrangements.
Discussion: The data reveal the influence of the architectural space and objects on the museum visitors' behavior with high precision. Practically speaking, these results are of relevance to curators, whose work it is to implicitly guide visitors attention throughout an exhibition.

SYMPOSIUM 9:
The nature of the space around the body: A comparison of real and virtual environments

Convenors: Tina Iachini and Gennaro Ruggiero

Department of Psychology, University of Campania Luigi Vanvitelli

The portion of space around body is our first interface with the external world. Recent debate in the literature has investigated the effect of several dynamic action and socio-emotional factors on the representation of peripersonal space, i.e. the multisensory and motor zone near our body. Within this special boundary, we are able to act with static and dynamic objects in the here and now, we are ready to defend our integrity and we express the emotional quality of social interactions with other people. Some recent literature has suggested that visuomotor, socio-emotional and dynamic factors may affect the representation of the peripersonal zone (Cléry et al. 2014; di Pellegrino and Làdavas 2014; Iachini et al. 2016). However, the mechanisms and limits of this influence require a deeper exploration and comprehensive theoretical models still have to be proposed. Is space near the body represented by a unique multi-purpose mechanism or by distinct mechanisms possibly cooperating at different levels? Moreover, much research has been carried out in Immersive Virtual Reality (IVR) and this raises the question as to whether and to what extent the results obtained in IVR can be generalised to real-world contexts. This is important because virtual technologies are becoming widely used in everyday life and we should ask ourselves what their effects on natural cognition might be.

The aim of this symposium is to discuss a hot topic in the recent literature: what is the nature of the portion of space surrounding the body. In particular, we seek to explore the relationship between visuomotor, socio-emotional and dynamic factors in the regulation of the peripersonal boundary in virtual and real environments. Moreover, we will analyse possible similarities and differences between virtual environments and real-worlds contexts.

In this symposium, some contributions will discuss the effect of sensorimotor and social factors on peripersonal space with healthy adults; peripersonal action space and interpersonal social space will be compared in a clinical population of children with autism. Finally, the safety value of peripersonal space and the effect of dynamic spatio-temporal factors will be debated.

Close is better: Evidence from real and virtual realities

Alessandro Farnè, Elvio Blini, Ivan Patanè, Alessandro Zanini, Marie Martinuzzi, Clement Desoche, Romeo Salemme, Claudio Brozzoli and Fadila Hadj-Bouziane

ImpAct Team Lyon Neuroscience Research Centre

Close objects are invariably seen bigger than farther ones, and are therefore easier to detect and discriminate. This is so deeply grounded in our daily experience that nobody actually questioned whether the advantage for near objects depends on their size (larger), or mere physical distance (smaller). Objects located close to our body (in peripersonal space, PPS) may benefit from processing by specialised mechanisms: visual responses in multisensory regions are specifically tuned to close stimuli in both human and non-human primate brains. Here we show that discrimination of a fundamental feature of objects, such as shape, critically depends on the distance from the perceiver. By reversing the natural distance-scaling of size in favour of the farther object, which thus appears bigger, we demonstrate that human ability to distinguish cubes from spheres is better when they are closer, despite looking smaller. This PPS advantage for close shapes was consistently present in a series of 5 experiments and was independent from availability of real stereoscopic cues: we found such advantage in both 3D virtual environments and 2D real images based upon the Ponzo illusion, further revealing that depth perspective cues are sufficient to elicit this new perceptual phenomenon. We will then report further findings allowing a direct comparison between PPS object discrimination advantage in 3D real and virtual environment. These findings shed light on a fundamental, so far overlooked spatial dimension of human shape perception and pave the ground to future depth-aware studies in vision research.

The space surrounding the body: Functional dissociation between social and action space in ASD children

Francesca Frassinetti[1], Giuseppe di Pellegrino[1], Virginia Giuberti[2], Erica Santelli[2] and Michela Candini[1]

[1]Department of Psychology, University of Bologna; [2]Centre for Children with ASD, Reggio Emilia

The space around the body has defined as an action space, peripersonal space, and as a social space in which the interactions with others occur, interpersonal space. These spaces are plastic: the peripersonal space can be extended by tool-use, and the interpersonal space can be shrunk following a social interaction. Recent studies revealed that interpersonal space is larger and less plastic in children with autism (ASD) than in children with typical development (TD).

An intriguing question is whether autism affects the regulation of the space around the body as a whole or, alternatively, it selectively affects the interpersonal but not the peripersonal space.

To this aim, TD and ASD children were submitted to the Reaching- and Comfort-distance tasks adopted as index of peripersonal and interpersonal spaces, respectively. Participants moved toward a confederate or toward an object of similar size. They were asked to stop when they could reach stimuli (Reaching task) or when they felt comfortable with stimuli's proximity (Comfort task). Both tasks were performed before and after a cooperative tool-use training in which participant and confederate actively cooperated to reach tokens placed behind the reaching distance.

Interestingly, in TD children, following the cooperative tool-use training an extension of peripersonal space and a selective reduction of interpersonal space with the confederate were found. Conversely, in ASD children, peripersonal space was extended whereas interpersonal space did not change after training.

These results demonstrate a functional dissociation between action and social spaces and a deficit restricted to social space regulation in autism.

The social dimension of peripersonal space

Yann Coello[1], Maria Francesca Gigliotti[1], François Quesque[2] and Patricia Coelho[1]

[1]SCALab CNRS, University of Lille SHS; [2]Lyon Neuroscience Research Centre

Peripersonal space is a multisensory representation of the environment around the body in relation to the motor system, underlying interactions with the physical and social world. Although changing body properties and social context have been shown to alter the functional processing of space, little is known about the effect of changing the value of objects in the environment on the representation of peripersonal space. By testing several experimental conditions, we found that modifying the distribution of rewards while performing an individual or social selection target task modified concurrently the amplitude of self-generated motor actions and the representation of peripersonal space. However, a decrease of the amplitude of motor actions caused a reduction of peripersonal space when participants performed the task alone, whereas it caused an increase of peripersonal space when participants performed the task in a social cooperative context. These findings extend our knowledge on spatial cognition and reveal that social interactions contribute to the specification of individual peripersonal space.

Semantic modulation of time-to-collision judgments

Matthew Longo[1] and Eleonora Vagnoni[2]

[1]Birkbeck, University of London; [2]Italian Institute of Technology

Defending the body from approaching threats is among the most fundamental functions of the visual system. Objects on a directly approaching path towards an observer produce a specific pattern of optical expansion (looming) that in theory exactly specifies the object's time-to-collision (TTC). Traditionally, looming has been interpreted as a purely optical cue, and studies have generally used simple geometric stimuli rather than intrinsically meaningful objects to investigate looming. Several recent studies, however, have demonstrated that the semantic content of stimuli modulates TTC judgments, with threatening stimuli (such as snakes and spiders) being underestimated more than less threatening stimuli (such as butterflies and rabbits). Moreover, the magnitude of this modulation is related to differences between participants in specific fears for these specific objects. In the present study, we investigated semantic modulation of TTC judgments using a wide range of familiar, everyday objects, varying widely in their physical properties. A separate group of participants rated each stimulus for size, hardness, and heaviness. Each of these dimensions significantly predicted TTC judgments. These results suggest that semantic modulation of TTC judgments is not specific to intrinsically threatening categories, but is affected much more widely by several basic physical properties of everyday objects.

The space near our body is special: The effect of socio-emotional dynamic factors

Tina Iachini and Gennaro Ruggiero

Department of Psychology, University of Campania Luigi Vanvitelli

The portion of space surrounding our body is the interface with external objects and people. In cognitive neuroscience, it is defined peripersonal space (PPS), i.e. a sensorimotor space within arm reaching where we can act in the here and now. In social psychology, it is defined interpersonal space (IPS), i.e. an emotionally tinged zone around the body that people feel like their private space. The deeper nature of the near body space is still debated and it is not yet clear whether PPS and IPS represent unique or selective mechanisms. A crucial test for addressing this issue is to assess the effect of fundamental social information such as emotional stimuli and moral evaluations on the size of PPS and IPS. In this work, we review previous evidence about this topic and present new data based on the combination of emotional and moral factors. Through Immersive Virtual Reality, we presented avatars with angry, happy and neutral facial expressions that were introduced by moral, immoral and neutral descriptions. Participants had to determine the comfort-distance (classic measure of IPS, distance at which people feel

comfortable with the other's proximity) and reaching-distance (classic measure of PPS, distance at which people think they can reach the other) from avatars. The results showed a similar effect of social information on both spaces; in particular, their size increased when perceiving threatening social signals conveyed by angry and immoral avatars. The theoretical meaning of the findings will be discussed in terms of defensive functions of both spaces.

SYMPOSIUM 10: Mental rotation, part 1: Developmental aspects of mental rotation

Convenors: Petra Jansen[1] and Claudia Quaiser-Pohl[2]

[1]University of Regensburg; [2]University of Koblenz-Landau

Mental rotation is the ability to imagine how objects would look like if they were rotated away from their actual presented orientation. It is still under discussion at which age children are able to mentally rotate pictures. Whereas according to the early study of Marmor (1975) children at the age of five are already able to mentally rotate pictures, some studies failed to replicate her results (Newcombe and Frick 2010). However, Moore and Johnson (2008) showed the mental rotation ability in 5 moths-old infants. Beside the question of the onset of the mental rotation ability, it is still under debate which factors influence or relate to the developmental course of mental rotation.

In this symposium, we would like to clarify the factors that influence the development of mental rotation in children aged between 7 months and 11 years.

The first two papers deal with the role of perception concerning the development of mental rotation: Röthlisberger and Frick in the first paper present a study, in which 7 months-old infants were tested with a new mental rotation test with 3- or 2-dimensional objects. Only in the 3D-condition the infants were able to differentiate between objects. Lütke and Lange-Küttner also introduce a newly developed mental rotation test. They varied the difficulty of the mental rotation stimuli amongst others by diversifying the set size of the rotated cube aggregate. Regarding the mental rotation performance in children aged between 4 and 11 years, they demonstrated a clear performance increase with age but also an apperception limit.

The third and the fourth paper deal with the relationship between motor processes, working memory and mental rotation. Zayed presents data on the relationship between academic performance, mental rotation and motor abilities among Omani children aged between 7 and 9 years. Lehmann and Jansen analyze the relationship of the development of mental rotation and working memory in children between 5 and 7 years. In the last paper, Fine and Constantine investigate gender dimorphism in pre-pubescent children on a computerized task of mental rotation. No gender differences were found in this age group.

The papers will be discussed with regard to the most important factors that influence mental rotation development and the relationship of mental rotation to other concepts like false beliefs, working memory and academic achievement.

The role of stereo vision and 3D presentation on infants' mental object rotation

Martina Röthlisberger and Andrea Frick

University of Fribourg, Switzerland

Past studies demonstrated mental rotation abilities in infants. However, the question has never been addressed how two- or three-dimensional presentation affects infants' performance—a crucial question in light of emerging stereopsis.

The aim of this study was to investigate the role of 3D presentation and stereopsis for infants' ability to recognize or mentally rotate objects.

Seven-months-old infants (N = 64) were assessed for stereopsis using the Lang Stereo Test® in a preferential looking paradigm. Object recognition and mental rotation were tested in a violation-of-expectation paradigm. On a puppet stage, an object rotated 180° in the picture plane and was occluded by a short blackout. It reappeared either as the original object or as its mirror version in one of three orientations: the final rotation position, rotated 60° further in the picture plane, or rotated 60° in depth. Half of the infants saw the presentation in 3D, the other half saw the same events in 2D video presentations.

An analysis of variance of the times infants looked at the objects after reappearance yielded a significant interaction of congruency and dimension. Detailed analyses showed that in 3D presentation, infants looked longer at the mirrored than the original object, mainly those classified as having stereopsis. In contrast, infants of the 2D group did not discriminate the original from the mirror object. The present findings indicate that the ability to recognize and rotate 3D objects is present at 7 months of age, but depends on whether 3D information is presented and perceived.

Understanding the relationship between motor abilities, academic performance, and mental rotation, among Omani children (7 to 9 years)

Kashef Zayed, Ibrahim Alharthy, Khalifa Aljadidi, Ali Tekin, Badriya Alhaddabi and Mahfouz Alkitani

Sultan Qaboos University

Background: Western studies approved that there were significant relationships between mental rotation, motor abilities, and academic performance, and there were significant gender differences in mental rotation.

Aims: This study aims to investigate the nature of the relationship between mental rotation, academic performance and motor abilities, as well as whether there are gender differences in mental rotation in Omani environment.

Methods: The children's Mental Rotation Test (MAT-K) and motor abilities (AST, General Motor Test for children between 6 and 11, Boes 2000) were administered on a selected sample of 95 Omani children from a public school (ages 8.05 ± 0.48 years; 48 males and 47 females).

Results: In contrast of Western studies, this study found that there are no significant correlations between mental rotation and motor abilities (all $p > .1$). It also showed that no significant gender differences in mental rotation $F(1,95) = 1.03$, $p = .31$). Furthermore, the motor overall score as well as the mental rotation ability correlates with the

grades in math (r = .311 and r = .425) and science (r = .352 and r = .295) respectively.
Discussions: The non-relation between motor abilities and mental rotation might be due to the fact that Omani children are not receiving sufficient amount of motor activities due to the lack of time for Physical Education classes (30 min/week), and to the hot weather conditions in Oman. The non-existing of gender differences in mental rotation can be interpreted in the light of the equal opportunities for males and females for motor and educational activities.

Relationship between mental rotation and working memory: Developmental aspects

Jennifer Lehmann[1] and Petra Jansen[2]

[1]University of Regensburg; [2]University of Koblenz-Landau

Background: So far, the relation between mental rotation and working memory has been only addressed in adults, while only one study exists, that has investigated this topic in young children. Lehmann, Quaiser-Pohl, and Jansen (2014) showed the involvement of working memory process in mental rotation in children as young as 3- to 4-years of age.
Aims: The present study investigates the involvement of working memory in mental rotation with regard to developmental aspects.
Method: So far 16 children aged 5–7 years of age performed in a randomized order a mental rotation test (Picture-Mental Rotation-Test, PRT), a cognitive processing test (Coloured Progressive Matrices) and working memory tests (digit span forward/backward, matrix test, object span, Corsi test).
Results: When analysing all children we only find a significant correlation between PRT and the object span task [r(17)=.517, $p < .05$], but no correlation between the other working memory tasks. Older children outperform the younger ones in mental rotation [F(1,15) = 5.282, py .05] and the CPM [F(1,15) = 5.282, $p < .05$], but in none of the working memory tasks. In congruence to existing literature we do not find gender differences in any tests.
Conclusions: This study should add to the understanding of the involvement of working memory processes in mental rotation tasks and therefore should contribute to the understanding of cognitive development in children.

Gender difference in mental rotation in young children

Jodene Fine and Kara Constantine

Michigan State University

Background/Aims: Inconsistent findings regarding gender differences among young children in mental rotation (MR) skills may be due to assessment methodologies. Many MR researchers have used adult stimuli with young children. Others have used more developmentally appropriate stimuli with motor construction demands. To address this issue, we constructed a computerized developmentally progressive block rotation task similar to, and including, Shepard & Metzler stimuli at the more difficult end, but extending the stimuli downwards for younger children. We provided a 3-choice response array. In this pilot study, we applied our experimental method to observe gender dimorphism in MR, and the relation of mathematics skills and MR, in children aged 15 and younger.
Method: The sample included 43 neurotypical children aged 6–15. Experimental computerized MR paradigm including a motor-speed test. Mathematics skill was sampled with the WJ-III Calculation and Fluency tests. TOVA omission/commission, WASI VIQ, and demographic variables were also included.
Results: No significant gender differences, even in a subset of older children. MR accuracy was related to mathematics calculation but not fluency with WASI VIQ and motor speed controlled. Conversely, MR decision speed was related to math fluency but not calculation. Mother, but not father education influenced MR skills. TOVA omissions/commissions and dPrime did not influence MR skills.
Conclusion: A child-appropriate MR computerized task revealed no gender differences in MR accuracy. The relation between mathematics and MR skills are specific and separable with respect to fluency and calculation.

SYMPOSIUM 11: New issues in attentional control

Convenors: Stefano Lasaponara[1], Maria Casagrande[2] and Fabrizio Doricchi[1,2]

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There is recent growing evidence that, rather than passively responding to sensory stimuli, the brain actively picks up and exploits the statistical regularities that govern the appearance of stimuli in space and time or their association with rewards. These regularities allow generating expectancies about incoming inputs, minimizing the discrepancy between predicted and observed sensory events and can significantly modulate conscious perception. In this symposium, the speakers will summarize recent behavioural, neuropsychological, electrophysiological and fMRI evidence highlighting how in the human brain the deployment of attention and conscious processing are adaptively modulated by the probabilistic distribution of sensory events and rewards.

Plasticity of spatial priority maps

Leonardo Chelazzi

University of Verona

We recently demonstrated that reward can alter the "landscape" of spatial priority maps, increasing priority for locations associated with greater reward relative to less rewarded locations. We have now begun to assess whether similar effects can be induced via statistical learning. In a series of experiments using variants of visual search through visual arrays shown on a computer monitor, unbeknownst to the participants, we manipulated the probability of occurrence of the sought target and/or of a salient distractor across locations. Results indicate that, analogous to the influence of reward, uneven probabilities of the critical items alter deployment of attention in a persisting fashion. In particular, a location with more frequent distractors engendered reduced distractor cost (capture) relative to a location with rare distractors. Importantly, the location with frequent distractors also led to deteriorated performance when it contained the target, compatible with the notion of a reduced attentional priority acquired by that location. Likewise, a location with more frequent targets engendered enhanced target selection relative to a location

with rare targets. Importantly, a location with frequent targets also led to deteriorated performance when it contained the distractor, which is compatible with the notion of an increased priority acquired by that location. As for reward, we argue that these effects reflect durable changes in priority maps of space, implementing "habitual attention". In summary, reward and statistical learning appear to be strong (and implicit) determinants of attentional deployment.

Facilitation and inhibition in the attentive brain

Heleen Slagter and Dirk van Moorselaar

University of Amsterdam

Over the past few decades, much insight has been gained into how spatial attention may filter information processing at the neural level, by directly boosting relevant information (target facilitation), and/or by suppressing irrelevant information (distractor inhibition). Yet, there is current debate as to how early these effects can occur and whether target facilitation and distractor inhibition are simply different sides of the same coin or whether they are controlled by distinct cognitive/neural mechanisms. Moreover, recent work indicates that distractor suppression only emerges when information about the distractor can be derived directly from experience, suggesting that suppression of distracting information is expectation dependent. This also raises questions as to how attention and expectation interact to bias information processing. In my talk, I will discuss recent findings from several behavioral and EEG studies that examined how visuospatial attention and expectation, separately and/or in interaction, influence target and distractor processing. Collectively, these findings shed novel light on how spatial attention and expectation interact to bias perception and indicate that target facilitation and distractor inhibition are controlled by different neural mechanisms.

Meta-learning foundations of (near) optimal cognitive control in the mammalian brain

Massimo Silvetti

Ghent University

Background: Obtaining environmental resources while minimizing energetic expenses is probably the most important problem that organisms need to solve. The mammalian brain is, in some way, just a solution that evolution found to face this problem. For many years neuroscientists have observed that the dorsal anterior cingulate cortex (dACC) plays a crucial role in making decisions, monitoring behavioural performance, controlling behavioural flexibility and regulating effort (both physical and cognitive) to acquire such environmental resources. So far, this heterogeneity prevented formulating a comprehensive theory about the computational role of dACC.
Aims: In this talk, I propose that investigating dACC interactions with neuromodulatory subcortical circuits is crucial to provide such a theory. We argue that the recurrent dialogue of dACC with neuromodulator nuclei in the brainstem allows the dynamic control over the functioning of both structures, providing autonomous learning on how to optimize both behaviour and internal variables (meta-learning) that influence behaviour, like attention allocation.
Method: We implemented this theory in a novel computational model (the Reinforcement Meta-Learner, RML).
Results: It was found that the model helps explaining data across a broad variety of research domains, including probabilistic learning, working memory, and classical and instrumental conditioning. In this talk, I will focus on how the RML model can provide a neurocomputational account for optimal cognitive/attentional resources allocation in different tasks involving working memory and visuospatial attention.
Conclusions: Modeling the dACC-brainstem ensemble provides a mechanistic hypothesis on how the mammalian brain flexibly optimizes cognitive resources in different domains.

Central and peripheral markers of attention and consciousness interactions

Ana B. Chica, María Cobos, Pedro M. Guerra and Jaime Vila

University of Granada

Although attention has been considered as the gateway to consciousness (Posner 1994), some forms of attention can be dissociated from conscious perception (Koch and Tsuchiya 2007). We have systematically manipulated exogenous and endogenous orienting, phasic alerting, and executive control and measure its impact on the conscious perception of near-threshold stimuli. Behavioral results have demonstrated that both exogenous orienting and phasic alerting modulate perceptual sensitivity to detect near-threshold stimuli (Chica et al. 2011; Kusnir et al. 2011), while executive attention mainly modulates response criterion (Colás et al. 2017). Each attentional system produces its effects throughout a particular brain network: the fronto-parietal network in the case of exogenous attention (Chica et al. 2013), a fronto-striatal network for phasic alerting (Chica et al. 2016), and a prefronto-parietal network for executive attention (Martín-Signes et al. in preparation). In addition to these central markers for attentional modulations of conscious perception, we present evidence of phasic alerting and consciousness interactions in the heart-rate, demonstrating the importance of brain-body interactions for conscious perception.

SYMPOSIUM 12: Spatial representations: New perspectives for studying age-related differences

Convenors: Veronica Muffato[1], Chiara Meneghetti[2] and Jan Wiener[3]

[1]University of Chieti; [2]University of Padova; [3]Bournemouth University

The ability to memorise the positions of relevant locations and landmarks in the environment is crucial for many daily activities including our ability to orient and navigate in space. In an aging society, the question of how cognitive aging affects spatial representations has therefore received increasing attention in recent years.

So far, aging studies have mostly demonstrated that spatial representation skills decline in older age. In the last decade, however, the growing body of research into spatial cognition in the young population (Denis 2018; Waller and Nadel 2013) has generated new methods and approaches to better investigate spatial representations

in older adults as well. Recent studies highlight the importance not only of identifying which spatial skills deteriorate in older age, but also of identifying which navigation and orientation abilities are resistant to age-related changes, with a view to finding ways to preserve independent orientation and navigation for as long as possible.

The main aim of this symposium is to thoroughly analyze age-related differences in spatial learning (even in the fourth age), taking into account individual abilities, such as memory and visuospatial abilities, and external aids. Cognitive and neurocognitive models (and the relationship between them) are used as a theoretical framework. Cognitive models identify allocentric (object-based) and egocentric (subject-based) frames for encoding and maintaining spatial information, and spatial representations can be learned using different inputs (layout, map, navigation, etc.) and assessed using different outputs, i.e. recall tasks consistent with the input or requiring spatial inferences (to assess the flexible management of spatial information). Neurocognitive models describe the brain's navigational network (with the hippocampus serving as the main hub), and regions which are susceptible to age-related degeneration. These models help to expand our knowledge in this domain, and to find factors capable of supporting older adults' losses in spatial performance.

In the symposium, the question of how ageing affects spatial learning will be addressed using different innovative approaches. Some contributions will examine the basic characteristics of mental representations, such as the development of allocentric and egocentric frames of reference, across the lifespan. This will involve analyzing the ability to learn the positions of objects in an environment, and the ability to recognize whether objects in a scene are in the same position as during learning or whether some have switched positions. Other contributions will explore age-related differences in mental representation on a larger scale. One contribution will examine environment representation when participants have completely learned a route; another will discuss how to help older adults navigate with external aids; and another will raise the question of how normal and pathological aging affects spatial (environmental) representation. To conclude, the symposium will present studies that offer new perspectives for understanding how spatial representations change in older age. The results will be contextualized within cognitive and neurocognitive frameworks to identify to what degree and how older adults can preserve their spatial representation abilities.

Development of reference frames and categorical/coordinate spatial relations from childhood to elderly age

Gennaro Ruggiero[1], Francesco Ruotolo[2] and Tina Iachini[1]

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Research has shown that allocentric (object-to-object) and egocentric (subject-to-object) spatial representations are intrinsically connected to coordinate (metric code, i.e. distance) and categorical (non-metric code, i.e. on the left/right) spatial relations. Although evidence has showed changes in spatial memory abilities during childhood and elderly age, no study has assessed how reference frames combined with spatial relations develop during the entire lifespan using the same task.

This study aimed at providing some preliminary data on the capacity to process reference frames and spatial relations in a large sample of healthy participants from 6 to 89 years of age (y.o.a.).

Based on their age, participants were assigned to 12 groups (ranging from 6 to 89 y.o.a.) as follows: 6–7, 8–9, 10–12, 13–15, 16–19, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, and 80–89. Participants had to memorize triads of 3D objects and to verbally provide spatial judgments about what was the object: closest/farthest to/from them (egocentric-coordinate); on their right/left (egocentric-categorical); closest/farthest to/from another object (allocentric-coordinate); on the right/left of another object (allocentric-categorical). The main goals were: tracing a baseline of the normal process of development of these intrinsically connected spatial components; and clarifying if reference frames combined with spatial relations are differently vulnerable to age-related effects.

Results revealed a symmetry between youngest children and oldest people as compared to all other age groups in processing some spatial combinations.

This symmetry is discussed in relation to the structural and functional changes due to incomplete maturation (youngest children) and deterioration (oldest adults) of underlying cerebral areas.

Age-related differences in the ability to recognize swapped positions of objects

Veronica Muffato[1], Christopher Hilton[2], Rossana De Beni[3] and Jan Wiener[2]

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Deciding whether a place is the same or different than places encountered previously is a common task in daily navigation. To successfully solve such place recognition, viewers need to develop knowledge about the locations of objects in the scene (object-location binding) and need to recognize places from different perspectives. While these abilities have been independently studied and been suggested to be affected by the ageing process, the question how they impact on place recognition in aging adults has not yet been studied. Thus, the aim of this study is to compare younger and older adults' ability to detect changes in scenes. We tested 40 young adults, 44 young-olds (60–70 years), and 32 old-olds (> 70 years) in a scene recognition task. Specifically, participants were presented with a scene consisting of 4 different objects in the encoding phase. In the test phase they were then presented with a second scene and had to decide it was the same or different. Test scenes were presented from different perspectives (0°, 30°, 60° of scene rotation from encoding) and two object manipulations were used to examine object-location binding: two objects swapped locations or one object was substituted. As expected, sensitivity for detecting changes decreased from young to young-olds and to old-olds, and from 0° to 30° and 60° of scene rotation. Importantly, older adults were less sensitive to object swapping than to object substitution, while young participants did not show any difference. Overall, these results suggest specific age-related difficulties in object-location binding in the context of place recognition.

Aging and route learning: What is the role of sequence knowledge?

Christopher Hilton, Andrew Johnson and Jan Wiener

Bournemouth University

Landmark based route navigation is one of the most common navigation tasks faced in daily life. Typically aged older adults have been shown to have difficulty with learning new routes, even though the neural circuits underlying commonly used strategies (egocentric) are thought to remain relatively intact. However, most route learning paradigms use a training phase in which participants are given a set amount of time or number of exposures to learn a route. We will present data from a series of experiments where participants learn a route until reaching a performance criterion before being assessed on several types of landmark based route knowledge. In the first experiment, we demonstrate age-related differences in the knowledge for the sequence of landmarks encountered along the route, even after the route has been learned successfully. In further experiments, we study the role of sequence knowledge for route navigation.

Assisting navigation in older pedestrians: What suits better?

Valérie Gyselinck[1], Aurélie Dommes[2] and Vanessa Ligonniere[1]

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A whole body of research has been conducted in spatial cognition, but very little of this knowledge, if any, is currently considered to help designing navigational aids. The aim of this presentation is to propose a thorough analysis of the psychological factors that are involved in the construction of spatial representations. These factors contribute to one's spatial expertise and navigational ease. With aging, some of these factors assume greater weight and older pedestrians have been shown to encounter specific difficulties. A series of studies will be presented that explore some of the solutions that could be developed to help navigation in the elderly. The results of two main experiments will be presented and discussed. One relates to the modality of the presentation of spatial information, contrasting visual, auditory and haptic navigation feedbacks. The other experiment relates to the type of spatial knowledge presented, contrasting landmark and turn by turn guiding.

Age effect on topographical memory

Laura Piccardi

Department of Life, Health and Environmental Sciences, University of L'Aquila

When people retrieve a pathway from memory, they use a specific spatial memory system called topographic memory. Topographic memory involves not only visuospatial information, but also vestibular and proprioceptive information relative to the whole-body movements, as well as a continuous change of the person's point of view that implies an active updating of the mental representation and the person's position in the environment. This system was found to be separated by visuo-spatial memory in the reaching space at neural level in normal subjects, as well as in different neuropsychological disorders, such as brain-damaged patients or in patients with Alzheimer's disease at the early stages. Here, we describe the age effect on short and long-term visuo-spatial memory of topographical and reaching spaces in healthy older individuals as well as in patients with subjective memory disorders, mild cognitive impairments and in patients with Alzheimer's diseases at the early stages.

SYMPOSIUM 13: Mental rotation, part 2: Correlates of mental rotation and methodological issues

Convenors: Claudia Quaiser-Pohl[1] and Petra Jansen[2]

[1]University of Koblenz-Landau; [2]University of Regensburg

Almost 50 years ago, Shepard and Metzler (1971) discovered mental rotation as an important paradigm for cognitive psychology. Since then the construct has spread out in many psychological subdisciplines like differential psychology, developmental psychology, neuropsychology and sports psychology, and has produced a large body of research results. However, there are still many open questions, i.e. with regard to its role in the context of other cognitive abilities, its trainability, and the circumstances under which gender differences appear. The symposium tries to shed light on some of these issues.

One issue is the relationship between mental rotation and spatial orientation. In the first paper, van der Ham clarifies the role of mental rotation ability in combination with other cognitive and personal factors with regard to navigation performance. Turgut in the second paper analyzes the implicative relationships between spatial components of mental rotation, spatial visualization and spatial orientation with a complex statistical approach. The role of the solution strategy for mental rotation performance is one topic in the fourth and the fifth paper of the symposium. Pietsch and Jansen present results on the relationship between laterality resp. handedness, solution strategy and mental rotation performance. Meneghetti et al. report findings on short- and long-term gains of different types of mental rotation training with or without strategy enhancement. By focusing on different methods for assessing mental rotation performance Quaiser-Pohl, Rahe, and Ruthsatz et al. in the fifth paper show that the stimulus material (cube figures vs. other stimuli) influences whether gender differences in mental rotation appear.

The papers will be discussed with regard to possible conceptual and methodological improvements to the research on mental rotation.

Individual differences in navigation ability: Impact of demographic factors and mental rotation ability

Ineke van der Ham, Michiel Claessen and Milan van der Kuil

Leiden University

Spatial navigation is an ability we continuously make use of. It shows large variation between healthy individuals and strongly impacts our daily life activities. In search for causes for this large variation, demographic factors like gender and age have been found to affect navigation ability. Also cognitive factors like mental rotation ability have been found to contribute, but conflicting results exist.

We have conducted a large-scale navigation experiment making use of five tasks assessing separate aspects of navigation ability. Participants view a short video of a route on an unknown planet. They are tested on their memory for landmark identity, landmark location, and paths.

Experiment 1 includes a very large and heterogeneous sample of participants aged 8–95 (current N = 4882, data collection ongoing). Preliminary analyses show that performance on all five tasks gradually decreases with age throughout adulthood, males outperform females on two of the location and path tasks, living in an urban area benefits performance, and spatial anxiety has an inverse relation to navigation performance. Further data collection and in depth analyses will be performed to clarify the effects found thus far.

Data on a more elaborate task battery focusing on the cognitive determinants of the same navigation tasks is being gathered in Experiment 2. Pilot data of our task battery (N = 91) have shown that in particular, allocentric location memory (using maps) is linked to mental rotation performance, highlighting its link to mental representations of spatial environments.

Mental rotation and laterality: Do right-handers always gain advantage over left-handers?

Stefanie Pietsch and Petra Jansen

University of Regensburg

For right-handers visual-spatial skills with only few exceptions are controlled by the right hemisphere, while left-handers show no such general preference or even a small left-hemispheric dominance. However, for special visual-spatial skills like mental rotation, both hemispheres are involved in the process of transformation.

Investigation of the relation between laterality and mental rotation revealed a small but significant cognitive advantage of right-handedness on spatial ability, especially on mental rotation performance. But there are highly diverse predictions how low and high hand preference relates to mental rotation performance. In contrast to hand preference measurement there are almost no studies considering the relationship of different forms of hand performance, which is the performance difference between the hands, and visual-spatial abilities.

This study examines the relationship between hand performance and mental rotation capacity. 80 persons (40 left-, 40 right-handers) absolved a chronometric mental rotation test with cube figures, a hand preference and three different forms of hand performance tests (finger tapping, grip strength, peg board). We assume a differentiated relationship between handedness and mental rotation performance depending on the degree of different forms of hand performance. For extreme high as well as for extreme low differences in hand performance we expect lower mental rotation performance. This result contributes to specify the relation between laterality and visual-spatial abilities.

Mental rotation training in young and older adults: The role of practice and strategy

Chiara Meneghetti, Elena Carbone, Enrico Toffalini, Antonino Di Maggio and Erika Borella

University of Padova

The talk aims to present two studies examining the specific short- and long-term gains, and any transfer effects, induced by rotation training in young adults (M = 20.23; Study 1), and in elderly adults (M = 67.25; Study 2). Each study involved three groups: one trained with a rotation task that consisted in comparing pairs of 3D assembled cubes rotated to different degrees—and in the study on older adults with the Tetris game—(the MR group); another trained to use a strategy based on rotation visualization before and while participants practiced with rotation tasks (S + MR group); and a third occupied in alternative non-spatial activities (active control group). There were six training sessions, plus pre-, post-, and follow-up (after 1 month) sessions to measure any transfer and maintenance effects in tasks similar to those used in the training (criterion tasks), or transfer effects in different spatial tasks (mental rotation and perspective taking), and in a fluid intelligence task. The results showed a trend towards an improvement in successive training sessions. The S + MR and MR groups both gained substantially more than the active control group in the short and long term, in the criterion tasks and in most of the transfer tasks. The S + MR group showed greater long-term gains than the MR group in most tasks. The gains made by the young and older adults in the S + MR and MR groups were similar. These findings show the positive effect of rotation training, particularly when associated with strategy use.

Do gender differences in mental rotation disappear when objects other than cube figures are used as stimuli?

Claudia M. Quaiser-Pohl, Martina Rahe and Vera R. Ruthsatz

University of Koblenz-Landau

In psychometric mental-rotation tests with cube figures, males mostly outperform females. The stimulus material has been revealed to be one reason for these gender differences (e.g. Ruthsatz et al. 2017). In two experimental studies, we investigated how important the stimulus material really is. In the first study, male-stereotyped (e.g. tractor; M-MRT) or female-stereotyped objects (e.g. doll, F-MRT) were used as stimuli in a psychometric mental-rotation test. 90 undergraduate college students solved either the M-MRT or the F-MRT and filled out a questionnaire about the self-evaluation of their own test performance and their familiarity with the material. Males were more familiar with the male-stereotyped objects, while females rated the female-stereotyped objects as more familiar. We found a significant

interaction between gender and material, with a higher mental-rotation performance by males resp. females when solving items compatible with their own gender. In the second study cube figures (C-MRT) and structurally similar pellet figures (P-MRT) were used in a psychometric mental-rotation test and we found similar results. 115 participants solved the C-MRT or the P-MRT and filled out a questionnaire comprising a self-evaluation of their test performance and of how gender-stereotyped the material was. For both studies, the mental-rotation performance of females was unaffected by the material while males seemed to benefit from the more familiar or male-stereotyped material used in the tests. A stereotype-lift effect of the male-stereotyped objects could be responsible for these differences, as well as more practical and active experiences of males with objects stereotyped to their own gender.

SYMPOSIUM 14: Beyond the video: Naturalistic approaches to examining social motor behaviour

Convenor: Arran Reader

Karolinska Institutet

Social interaction is a dynamic experience shared between two or more individuals. Yet, as researchers in social cognition, we often use paradigms that assess participants individually, asking them to respond to stereotyped or pre-prepared video or picture stimuli. Whilst this provides a high degree of control over our experiments, it is possible that participant behaviour is different to what we might observe in more realistic, or ecologically valid, scenarios. This is especially true in the study of social motor behaviour, in which we are interested in how individuals assess another person's movements, move in response to them, or move alongside them in shared space. The variety of social motor skills that humans use provide an opportunity to learn not just about social movement, but about the closely related elements of social cognition (e.g., empathy, intention understanding, cooperation) and motor control that support them, suggesting that accurate apprehension of realistic social motor behaviour is a useful endeavour.

How then can we begin to assess social motor behaviour, and responses to social motor behaviour, in ways that allow us to capture the dynamic nature of these phenomena? A growing number of researchers are implementing new and exciting experiments that allow more realistic measurement of movement, or responses to movement, in dynamic social scenarios. These experiments often make use of multi-person experimental paradigms, or implement modern multimedia approaches like virtual reality, to more fully examine how movement allows us to connect with others in the world. The aim of this symposium is to bring together some of the scientists pioneering these experiments, in order to foster discussion regarding the implementation of novel, ecologically valid approaches to the study of social motor behaviour.

The contributing speakers will therefore provide an insight into their respective approaches, all concerned with examining interactions within a more realistic social space, but varying in how they do so. These talks will cover a number of areas closely linked to the conference theme of spatial cognition in a multimedia and intercultural world. Namely, they will address how creating virtual spaces or avatars can help us understand social behaviour, how sensorimotor processes might inform our perspective-taking abilities, and how kinematic analyses can help us to understand how people move together in our shared social space, either in day-to-day cooperative behaviours, or during artistic experiences like music playing.

Multi-level sensorimotor coordination in orchestra playing: A kinematic study

Alessandro D'Ausilio

University of Ferrara

Human interaction plays a central role in shaping cognition and brain organization. To investigate these processes, ensemble instrumentalists are the perfect test-bed. In fact, each player generates information based on his/her body movements that are readable, through the visual, auditory, and somatosensory channels, by the other musicians. In addition, expert musicians may rely on predictive models to cope with the real-time demands of interpersonal coordination. Here, we will report on a series of studies where we recorded body kinematics of ensemble musicians by means of motion capture systems. We use the Granger Causality (GC) method on the kinematic data time series to extract the sensorimotor communication dynamics between musicians (quartets and orchestra) and with conductors (orchestra). In GC, a signal X1 "Granger-causes" a signal X2, if the past values of X1 contains information that predicts X2 future behavior beyond the information contained in past values of X2 alone. We also introduced a series of perturbations to the normal flow of information between musicians, to best characterize its effects on sensorimotor communication. We demonstrate that: (i) communication between conductor and musicians is not unidirectional; (ii) in the presence of perturbations, expert musicians develop internal models of the piece and the group; (iii) sensorimotor communication is layered across multiple time scales, that we described by analyzing ancillary (head position) and instrumental movements (hand position); (iv) adaptation to perturbation differently affect communication mediated by ancillary and instrumental movements.

The use of virtual reality to study the social consequences of behavioral mimicry

Alexandra Georgescu and Antonia Hamilton

Institute of Cognitive Neuroscience, UCL

The positive social consequences of behavioural mimicry have been inconsistently replicated. To date, we still have little understanding about the factors modulating the responses to being mimicked. A closer look at the temporal proximity between the mimicking and the mimicked behaviour could offer more insight. It is often claimed that mimicry naturally happens after a delay of roughly 2–5 s, yet this has not been empirically proven. On the other hand, positive social consequences have been also associated with synchronous actions. In the current study, we investigated whether the timing modulates mimicry effects. To this end we used a paradigm that combines virtual reality (VR) and functional near-infrared spectroscopy (fNIRS) and tested 39 typical adult volunteers, of which we considered 19 for the fNIRS analysis. Participants interacted with two virtual partners in a picture description task while making hand-opening movements which were mimicked by their virtual partners at delays of either 0–1.5 s (fast mimicry) or 2.5–3 s (slow mimicry). Dependent variables involved participants making explicit ratings of perceived

trustworthiness and affiliation of their partners, and the oxy-haemoglobin signal data from the fNIRS measurement. Results show that timing does modulate responses to mimicry: Fast mimicry partners were rated as less trustworthy. On a neural level, for "fast mimicry" compared to "slow mimicry", differential activations in the inferior parietal lobule were found, a region typically associated with agency attribution and differentiating self from other.

Using motion tracking and affordance experiments to examine the emergence of interpersonal synchrony and joint action

Kerry Marsh

Center for the Ecological Study of Perception and Action, University of Connecticut

Background: Perception-action and dynamical systems approaches suggest novel methods of quantifying how two individuals come together as a unified, social perceiving-acting whole or "we". Social synergistic research (Marsh et al. 2006; Riley et al. 2011) uses motion tracking of individuals interacting, or analysis of the "affordances" in a situation (opportunities for the individual or social synergy to act).
Aims: This talk aims to review a variety of studies: (I) One set of studies aims to understand the minimal conditions necessary for unintentional interpersonal synchrony to emerge, for incidental (goal-less) movement. (II) The second set of studies aims to understand whether the emergence of embodied cooperation (joint action) follows nonlinear dynamical principles analogous to what is known from studying solo perception-action.
Method and Results: (I) Pairs of individuals (e.g., adults; adult-child pairs, involving autistic versus typically developing children) engaged in simple rhythmic movements (e.g., rocking in rocking chairs, swinging a wrist-pendulum, or swinging a maraca) under conditions that should manipulate the strength of interpersonal coupling (e.g., varying amount of visual or auditory information).
As predicted, even unintentional synchrony processes followed similar principles established in solo perception-action.

(II) Pairs moved planks of wood of varying lengths, constrained to touching only the planks ends. Pairs' natural shifts between solo and joint action were examined as a function of body/environment fit (pairs' arm length over plank length) and plank sequence (e.g., ascending, descending size).

As predicted, affordance boundaries were precisely predicted by fit, and action modes shifts displayed hysteresis, characteristic of nonlinear dynamical systems.

When the body thinks social: Sensorimotor constraints modulate perspective-taking abilities

François Quesque

Lyon Neuroscience Research Center

Numerous words co-exist to describe the ability to represent others mental states. Among them, the most used terms are probably those of Theory of Mind (ToM) and of Perspective-Taking (PT). These terms are classically defined as the ability to ascribe mental states to others in order to explain and predict their behavior. Behind such definitions, it is suggested that a unique ability (e.g. ToM) supports the inference of others emotions, thoughts, perceptual representations, etc. Contrasting with this classical conceptualization, some clinical studies have reported a possible independence between different types of mental state attribution (e.g. between emotional and cognitive inferences). On the basis of the available literature, we selected the three main domains of perspective-taking: cognitive, emotional and perceptual and we examined their interdependencies or independence. To this aim, we conducted a series of ecological studies based on a motor interference paradigm, kinematic analysis and on the investigation of neurological patients. Our results found independent sensorimotor bases for these different types of perspective-taking. Moreover, individual distributions of scores for the different types of perspective-taking largely differed among participants. Altogether, these results suggest that different independent processes are actually hidden behind the general term of perspective-taking.

Investigating social motor behaviors through virtual reality: From human's to avatar's kinematics

Gaetano Tieri and Vanessa Era

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Background: Understanding the behavioural and neural underpinnings of social motor interactions cannot be based on the exploration of the neural responses of a single person passively observing the behaviour of another. Thus, a main experimental challenge for the field of social neuroscience is to create dynamic contexts to study interpersonal interactions in well-controlled laboratory scenarios. Over the last decades, advances in computer technologies have offered new tools, based on 3D graphic processing and Virtual Reality, opening new possibilities in realizing experimental paradigms and stimuli characterized by high level of control and ecological validity.
Aims: Here, we aim to describe in detail a novel methodological approach for studying social motor interactions. This method, based on the recording of human kinematics and 3D graphic processing, allows us to realize experimental paradigms in which participants can interact in real time with a virtual partner who reacts with naturalistic movements.
Approach: First, we illustrate this novel method by describing its three steps of processing: (1) the recording of a real human actor kinematics (2) the implementation of the kinematics information on virtual avatars and (3) the realization of experimental stimuli for different devices (ranging from standard PC monitors to virtual reality Head Mounted Display or Cave system). Then, we describe the advantages brought by this approach in investigating social motor interactions and highlight its ecological validity by showing comparable interaction features of human-avatar and human-human scenarios. Finally, we provide an overview of recent evidence obtained by using this approach in social neuroscientific investigation.

SYMPOSIUM 15:
From fieldwork to modelling: Explaining the variability of linguistic spatial referencing systems

Convenors: Roberta Rocca[1], Jonas Nölle[2] and Michael Spranger[3]

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Processing and communicating information about object location is a key ability of human cognition and pervasive in social interaction. It lies at the foundation of a wide range of behaviour ranging from concrete everyday activity to more complex types of cognitive tasks, such as navigating varying environments and higher-order social coordination problems.

Crucially, linguistic referencing systems used to encode and express spatial relations of this kind are multifold, extremely flexible, and have been shown to vary cross-culturally. This includes, for instance, preferences for particular Frames of Reference (FoR), coordinate systems used to express distant relations or different types of demonstrative systems that can be found across languages. Different spatial referencing strategies might also prove more or less advantageous according to the demands of specific tasks or communicative situations.

While extensive work has been devoted to exploring the variability of systems for spatial referencing (both across languages and tasks), the general causal factors behind this variability remain unclear. Factors such as environment, socio-cultural variables or contact diffusion have only recently been investigated more systematically. Moreover, different strategies might prove more or less advantageous according to task demands or constraints of communicative situations.

Where does this diversity come from? Despite extensive work that has been devoted to exploring the variability of systems for spatial referencing (both across languages and tasks), no comprehensive review has yet elucidated the exact causal variables contributing to this variability.

The aim of this symposium is to lay the foundation for a cross-disciplinary investigation of the causal factors driving cross-linguistic variability in spatial referencing as well as task-driven preferences in spatial referencing strategies. By bringing together contributions from linguistics, neuroscience and computational modelling, we aim to establish a multimethod platform for a transversal approach to the topic. Indeed, we believe that the complexity of spatial referencing that is embedded in a variety of human activities requires the integration of different methodological angles.

We hope that bringing together researchers from different backgrounds (linguistics, psychology, neuroscience, computer science) will allow us to clarify general mechanisms and causal trajectories that can help explaining the diversity in spatial language and cognition among cultures.

Along this overall goal, the symposium has several purposes. On the one hand, it aims at providing a descriptive account of variability in spatial referencing systems, both relying on insights from comparative linguistic fieldwork and on experimental approaches studying task-dependent variability in spatial referencing strategies. Additionally, it aims at shedding light on causal factors underlying such variability, by discussing the role of undirected drift versus external factors in variability in linguistic in referencing systems from an experimental perspective and based on computational models simulating the emergence of spatial referencing strategies. Finally, we will explore the contribution of different methodologies in shedding light on causal factors driving variability in referencing strategies, as well as in elucidating the functional architecture of the underlying cognitive processes and their neurological substrates.

Combining models and experiments to the study the evolution of competing spatial referencing strategies

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Recently, there has been lively debate about the relation of language and its wider environment. The idea is that language structure does not evolve in a void, but is partly motivated by social and ecological variables leading to diversity (Lupyan and Dale 2016). Whether the striking cross-cultural variation in spatial language and cognition can also be explained by adaptation to specific 'niches' is subject of an ongoing debate (e.g., Majid et al. 2004), where different proposals such as socio-topographic and contact diffusion have been put forward (Bohnemeyer et al. 2015; Palmer et al. 2017). However, exact causal relationships and trajectories have yet to be shown, as there are many contributing and confounding variables and quantification can be become quite complex. We therefore suggest complementing this line of research relying on field-work with an evolutionary approach by modelling the evolution of competing spatial referencing strategies in different environments using both experiments and simulations. We will show a series of referential games, were subject pairs must establish spatial referencing conventions in order to score. The results show that salient affordances in the task environment (e.g., a simulated forest vs. a slope-like environment) can motivate referencing based on different strategies in otherwise identical tasks. In addition, we show how to integrate these findings with a series of computational models using artificial agents (Spranger 2016) to simulate how different strategies stabilize in interaction over large timescales that we could not easily observe in the lab or in field-work.

The biological and cultural evolution of spatial cognition: Evidence from semantic typology

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Department of Linguistics, University at Buffalo

Background: The role of linguistic and nonlinguistic factors in driving preferences for reference frame use across populations has attracted much attention (Bohnemeyer et al. 2015; Li et al. 2011; Pederson et al. 1998; inter alia).
Aims: We develop a methodology for the study of the respective role of environmental, cultural (linguistic and nonlinguistic), and demographic influences on cognition. This design follows loosely 'variationist' approaches to socio-demographic predictors in language use.
Method: Experiment 1: The New Animals recall memory task involves participants memorizing an array of toy animals and rebuilding it after 180° physical rotation. There are six test trials.

Experiment 2: The Talking Animals referential communication task uses four spatial configurations of 3D toy animals to elicit frame use in discourse. Dyads of participants take turns instructing one another to reconstruct the configurations while separated by a screen.
Participants: After exclusions, 105 female and 78 male speakers of English, Japanese, Taiwanese Mandarin, Taiwanese Southern Min, Vietnamese, Yucatec, and Zapotec participated in Experiment 1 and 272 female and 178 male speakers of the same languages participated in Experiment 2.
Results: Exhaustive regression model comparison revealed persistent significant effects: education (E1), literacy (E2), and population density positively correlate with Egocentric (E1)/Relative (E2), and negatively with Geocentric frames; individual language populations similarly predict Egocentric/Relative and Geocentric frame use as expected.
Conclusions: The proposed method permits quantifying the relative influence of linguistic and cultural transmission, demographics, and the environment on human behavior.

Variation in spatial reference between and within languages: Sociotopography and the interplay of language, culture and environment

Bill Palmer[1], Alice Gaby[2], Jonathon Lum[2] and Jonathan Schlossberg[1]

[1]University of Newcastle; [2]Monash University

Diversity in linguistic spatial reference is well known. Most research has focused on cross-linguistic diversity (Levinson 2003; Majid et al 2004). However, recent research shows variation within languages is greater than diversity between them (Bohenmeyer et al 2014; Palmer et al 2017). In addition to environment-based urban versus rural language-internal diversity (Pederson 2006), variation is reported patterning with demographic factors, often correlating with nature of engagement with the environment (Bohnemeyer 2011; Shapero 2017).

We present data from a systematic study of language-internal variation in spatial behaviour in Marshallese and Dhivehi. Data was elicited using identical formal elicitation tasks across diverse communities. Quantitative analyses revealed not coarse-grained Frame of Reference choice, but variation in preferences from among the range of available strategies. Some correlated with differences in environment. However, significant variation correlated with demographic factors including age, gender, occupation, and literacy. Other differences correlated with community-wide cultural practices. Others correlated only with language.

Focusing on overall systems has led to failed attempts to pin everything on language, or landscape, or culture. We argue none of these accounts for everything. Instead, each plays a role in how individual speakers and entire communities use spatial language. Employing the Sociotopographic Model (Palmer et al 2017), we demonstrate that attending only to language-level systems obscures the complex interplay of factors shaping conceptual representations of space: the nature of the environment, engagement with it, cultural associations placed on it, individual and community-wide cultural practices, linguistic resources of the language, and patterns of language use.

Cognitive computational models of reasoning about spatial information

Marco Ragni and Paulina Friemann

University of Freiburg

In the last three decades, several cognitive models for reasoning about spatial information have been proposed. Currently, no comparison between the models exists, and the limitations and potentials of the existing cognitive computational theories remain open. We will present a selection of the 8 existing cognitive models and analyze them with respect to the questions: Is the model able to deal with different reference frames? Which spatial information is covered (topological, directional, etc.)? Which of the many behavioral phenomena of human reasoning are covered by the models on a qualitative level? Do the models cover quantitative predictions as well? What are the core predictions of the model? And on which principles are these models built upon? A comparison in terms of the computational properties and outlined research questions of these models is made demonstrating that few are directly aiming at providing explanations for the phenomena found in the literature. Many of these models focus on: (i) one domain only, e.g., on spatial information about the arrangement of objects, (ii) only on the conceptual level or serve only as a proof of concept, (iii) and only few are implemented. Even less are able to predict the cognitive complexity involved. We propose that the field requires a rigorous comparison to identify the specifics of the underlying cognitive mechanisms of spatial reasoning.

The power of pointing in linking language to the world

David Peeters

Max Planck Institute for Psycholinguistics

In everyday human communication people often refer in speech and/or gesture to entities in their immediate environment, thereby expressing their communicative intentions and shifting their addressee's attention to a specific object, person, or event. Particularly spatial demonstratives and index-finger pointing gestures canonically co-occur in everyday spoken referential communication. The large majority of the world's spoken languages contain more than one type of spatial demonstrative (e.g. English this and that). This has raised the longstanding question which factors determine whether someone uses one demonstrative term and not another while pointing at a referent. In this talk, I will present (i) the results of four recent behavioral experiments in which participants used significantly more proximal demonstratives when sitting opposite their addressee versus when sitting side-by-side, (ii) the results of two recent EEG experiments that indicate that spatial demonstratives are interpreted as a function of the location of a referent inside or outside the physical space that is psychologically shared between speaker and addressee, and (iii) a cognitive model that specifies the various factors influencing a speaker's choice of demonstrative. Together, these findings contribute to a better understanding of the complex interplay between action, attention, language, and space in the production and perception of communicative acts core to human face-to-face interaction.

Linguistic spatial reference systems across everyday domains: How people talk about space in sailing, dancing, and horse riding

Thora Tenbrink

Bangor University

Spatial reference systems have been investigated across many different languages and cultures, partly with the explicit aim of identifying preferred ways of thinking and talking about space in a particular culture. In my talk, I will address variability within a given language (and culture) by looking into everyday specialist domains such as sailing, dancing, and horse riding. Wherever a domain requires people to interact with space in a specific way, conventions for thinking and talking about space arise that may be unknown or at least highly unusual outside those domains. In sailing, it is almost impossible to talk about 'forward movement', due to the various forces acting on the boat; this requires the sailor to calculate a useful course relative to the goal direction. In dancing, creative movement needs to be related to static aspects of the environment, which can be a challenge if dancers are not in a canonical upright position. When riding a horse in a circle, inside and outside become more prominent than concepts of left and right, along with environmental landmarks installed to offer a permanent domain-specific reference system.

Based on a range of examples such as these, I will explore customary ways of talking about space across various domains, and represent specialist concepts in relation to Levinson's intrinsic, relative, and absolute reference systems. This will demonstrate the great extent to which situational domains call for different reference systems, contrary to beliefs that entire cultures can be associated with stable preferences for a specific reference system.

SYMPOSIUM 16: Individual differences in spatial components of search and foraging

Convenors: Alastair D. Smith[1] and Carlo De Lillo[2]

[1]University of Plymouth; [2]University of Leicester

Search—the problem of exploring a space of alternatives in order to identify target goals—is a fundamental spatial behaviour for many species. Although its foundation lies in foraging, most studies of human search behaviour have been directed towards understanding the attentional mechanisms that underlie efficient visual exploration of two-dimensional scenes. In recent years, however, there has been a renewed surge of interest in a more comprehensive characterisation of search that integrates behaviour across a wide range of contexts, environments, spatial scales, and populations. An important result of this breadth is that individual differences in search behaviour have become far more prominent than ever before. Accumulating evidence shows search and foraging to be affected by individual differences in factors such as lifestyle, ecology, species, culture and age, as well as by neuropsychological conditions and neuromodulation. This symposium aims to discuss the sources of individual differences in search and foraging behaviour, and also to suggest how they might impact upon navigation and wayfinding. By presenting data gathered from a variety of contexts, including natural and virtual environments, the session will also explore the generality of findings across different media, and whether the use of different technologies or effectors is liable to modulate behaviour. We have assembled speakers from across relevant disciplines, including psychology, neuroscience, and behavioural ecology, to ensure a representative variety of theoretical and experimental perspectives.

Foraging as a test battery for identifying sources of individual variations in long-term memory, short-term memory and planning

Carlo De Lillo

University of Leicester

Foraging for ephemeral fruit resources in a forest environment has been considered the trigger of brain expansion in primates, including humans. To forage efficiently in such conditions requires a cohort of cognitive skills including long-term-memory for fruiting trees that systematically yield or do not yield fruit (i.e. acquiring botanical knowledge regarding fruiting and non-fruiting plant species), short term-memory for trees visited during a foraging bout and the ability to identify cyclical patterns of ripe fruit availability at given spatial locations. The aim of this talk is to show that a computerised task designed to capture the requirements of foraging in these conditions can provide a battery of tests suitable for assessing patterns of individual and interspecies differences in several related visual-spatial skills. Results obtained with this foraging task suggest that long-term memory is the cognitive function that is the least suitable to detect cognitive change in ageing or detect cross-species differences between humans and monkeys (*Papio papio*). By contrast, the ability to detect cyclical regularities in resource availability deteriorates with ageing and is less developed in monkeys than humans. Individual differences are also detected in relation to Body Mass Index (BMI) in humans. In particular, a facilitation of working memory is observed in people with high BMI, possibly due to the saliency of cues depicting food in such individuals. Overall, these results suggest that the assessment of foraging skills can provide a rich set of information about the variability of cognitive function across individuals, species and age groups.

Inducing difference in search behaviour: Right parietal stimulation modulates efficiency but not learning

Alastair D. Smith[1], Craig Scott[2] and Amy L. Holloway[2]

[1]University of Plymouth; [2]University of Nottingham

Background: Individual differences in visual search performance are usually observed in comparisons between specific populations (e.g. atypical development, dementia, experts). In the present study, we examined the induction of differences between groups of healthy adult participants through cortical stimulation.
Aims: Transcranial direct current stimulation (tDCS) has been shown to affect visuospatial behaviour when current is applied over the right PPC, and we here investigated whether 1 mA of anodal or cathodal tDCS to this region would, respectively, facilitate or inhibit spatial attention in a probability cueing task.
Method: 72 participants were included in a randomised single-blind, sham-controlled study, and were allocated to one of three stimulation groups: anodal, cathodal, or sham. Participants were required to

respond to a visual target, hidden amongst distractors. Spatial properties of the array were manipulated so that the target appeared in one hemifield on 80% of trials.
Results: We observed polarity-specific effects of stimulation on search efficiency: participants receiving anodal stimulation located the target significantly faster than those receiving cathodal stimulation, with performance in the sham group lying between the two. There was, however, no effect of tDCS on probability cueing—all groups reliably biased their search to the cued hemifield, and effects of search efficiency were present for both cued and uncued trials.
Conclusions: Whilst tDCS appears to modulate aspects of visual search performance, the sensitivity to probabilistic cues was unaffected by our intervention. A previous report has implicated a subcortical locus to the probability cueing effect, which may account for the present findings.

The development of executive control in large-scale search

Iain D. Gilchrist, Kate A. Longstaff and Bruce Hood

University of Bristol

We investigated the development of search processes in 140 children (aged 6–12 years) using a large-scale search task. The task for each child was to find a target switch which when pressed turned the surrounding green lights red. The green lit locations were embedded in the floor of a room. The perceptual salience of possible search locations was manipulated by having the green lights at some switch locations flashing and some static. Experiment 1 demonstrated that children were more likely to search at flashing locations, even when explicitly informed that the target was equally likely to be at any location. The magnitude of this effect did not vary with age. However, there was a strong developmental trend in the number of times children revisited previously examined locations. In Experiment 2 we showed that this bias to act on salient locations could be mediated by tasks that reduced or increased memory load. This disassociation between the developmental trajectory of the ability to remember previously visited locations and inhibit salient objects indicated that the development in spatial working memory was at least partially dissociable from perceptual inhibition. We conclude that individual executive sub-processes may play different roles during search and have different developmental trajectories.

Effects of cognitive ageing on finding and selecting reliable landmarks

Ramona Grzeschik[1], Ruth Conroy Dalton[2], Anthea Innes[3] and Jan Wiener[4]

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Not every object is a useful landmark when learning routes, be it due to repetitive occurrence or visual appearance. Salient objects might be easier to memorize than non-salient objects, but if they appear more than once along a route, they cannot be used as reliable landmarks. As cognitive ageing affects executive functions and control of attention, we hypothesized that it could also impact on the process of selecting navigationally relevant objects as landmarks. Here we investigated how cognitive ageing affects people's ability to select unique objects as landmarks when learning novel routes. We created two types of routes through a virtual care home each comprising four intersections each with two objects. On simple routes, the unique landmarks were also salient. On complex routes, in contrast, the salient objects occurred twice, while the non-salient objects were unique. The behavioural data showed that younger participants outperformed the older participants in route learning and the eye-movement data revealed some systematic differences between age groups. Specifically, older adults spent less time attending navigationally relevant information, but both groups effectively directed gaze towards the unique and away from the non-unique objects, even if these were more salient. While the findings highlight differences in control of attention between age groups, we believe that these differences cannot account for the pronounced differences in route learning performance. Instead, we show that individual differences in word list learning and Corsi blocks task performance were predictive for route learning performance in the older, but not the younger, participant group.

Planning of foraging strategies in nonhuman primates: Travel optimization in three semi-free ranging species of primates

Cinzia Trapanese[1], Hélène Meunier[2] and Shelly Masi[3]

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Unpredictable habitats like tropical forests are cognitively demanding for primates foraging activities. A frugivorous diet is hypothesized to trigger a higher need for an accurate mental representation of spatio-temporal availability of food, since fruit is an ephemeral resource. To evaluate the strategy used to visit all feeding sites, we tested semi-free ranging capuchin monkeys (N = 6), Tonkean macaques (N = 5), and Fascicularis macaques (N = 3) in their social group at the Primate Centre of Strasbourg University. We used 42 wooden boxes, fixed on trees of their enclosure and lockable via a remote-control system. Six of them were filled with a preferred fruit. They were strategically chosen according to the relative positions to investigate the spatial foraging decision for an optimal strategy. We recorded subjects' trajectories and the order of visited boxes. Preliminary results showed that while Tonkeans and Fascicularis optimized their route by choosing the shortest path in 21.4% (N = 56 trials with all baited box visited) and 31.6% (N = 19) respectively, capuchins almost never optimized their route (7%, N = 13). They rather follow a "nearest neighbour" strategy, choosing the closest box that had not yet been visited. Travel optimization implies strategic planning but the nearest box strategy also requires an accurate representation of fruit availability. The different strategies used are likely due to the different diet tendency: Tonkeans and Fascicularis being mainly frugivorous while capuchins having a broader dietary breadth. Investigating the spatial foraging strategies helps to shed

light on the origin of cognitive abilities of primates and complex planning capacities in humans.

Eye movements in active search: From scenes to strategy

Tom Foulsham

University of Essex

Searching for something normally involves strategic action. Searchers must move around the world, making decisions about where something is likely to be and coordinating their sensory and motor systems to locate and reach the target. I will discuss experiments using both pictures of natural scenes and active exploration with mobile eyetrackers. In scene viewing, we typically have strong expectations about where real objects will occur, and these are often neglected in models of visual search. In several experiments I have quantified observers' prior knowledge about object location (by asking people to guess where something will be with limited visual information). This prior knowledge is predictive of both search times and visual strategies as measured by eye movements. In active exploration, we have asked participants to navigate within a building (to search for a particular room) and to find a target mailbox. In this context, the way that people explore their environment is influenced both by their prior information (e.g., looking at signs if they are searching for a particular room number) and by the visual characteristics of the target. Such active tasks also contain strategic action sequences, of body, head and eye movement, which provide a very rich set of data for those investigating search. Individual differences in search may be related both to variations in prior knowledge and to idiosyncratic motor strategies.

Intentionality of spatial foraging strategies in wild western gorillas

Silvia Miglietta[1,2], Giulia Bardino[1,2], Terence Fuh[3] and Shelly Masi[2]

[1]Sapienza University of Rome; [2]Muséum National d'Histoire Naturelle & Musée de l'Homme, Paris; [3]WWF CAR

A critical question in primate evolution is: do primates plan for the future? Optimal foraging theory states that animals forage efficiently by optimizing the foraging efforts and nutritional intakes. In unpredictable habitats, random models of foraging should not be the most efficient way to meet nutritional needs. In the tropical forests, primates are nutritionally challenged because of the seasonal fluctuations in food availability. The dispersed locations and unpredictable productivity of tropical fruit trees may promote cognitive complexity in primates. Western gorillas are seasonal frugivores. Fruit availability affects their activity budget, nutritional intake, ranging patterns, health but not their energy budget. To investigate the intentionality of spatial foraging we aim at assessing the presence of goal-directed ranging movements in two groups (N = 7; N = 9; May–November 2016) of habituated wild western gorillas in Central African Republic. Data on gorilla activity and ranging patterns have been collected via focal animal sampling (NTot. hours = 815) and GPS track-log. GPS was used to record the location of the trees visited by the gorillas. 43% of the significant changes in direction (N = 370) of the daily range corresponded to either feeding on patchy resources, resting sites or intergroup interactions. More than half of the change points for feeding on patchy resources were associated with frugivory. Western gorillas show goal-directed movements mainly triggered by frugivory. Investigating the question of foraging strategies helps not only to shed light on the evolutionary role played by the environment in shaping animal cognition, but also on the interconnection between food distribution and different species.

3. Abstracts of Talks

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

Individual differences in navigation style: Effects of home environment structure

Erica Barhorst-Cates[1], Chiara Meneghetti[2] and Sarah Creem-Regehr[1]

[1]University of Utah; [2]University of Padua

Background: Individuals differ on their preference and use of a) distal (far, e.g., mountains) or proximal (close, e.g., traffic signs) cues and b) route-based (egocentric, person-based) versus survey-based (allocentric, world-based) strategies for successful navigation. In a cross-cultural study between Padua (Veneto, Italy) and Salt Lake City (Utah, United States), we tested the effects of environmental structure on navigation strategies. These cities differ vastly in structure, with Utah cities as grid-like and structured by visible surrounding mountains and Italian cities having winding streets through tall buildings which do not easily reveal distal cues.
Aims: The primary aim is to assess how built-in exposure to different cues and layout structures in real-world home environments affects preferences for navigation strategies.
Method: Participants in Padua (n = 56) and Utah (n ongoing = 25 -of 56 total-), completed a battery of visuo-spatial and environment tasks including a real-world pointing task, two virtual navigation tasks (Virtual Water Maze, Dual Solutions Paradigm), mental rotation, and surveys assessing navigation abilities, tendencies, and preferences.
Results: Results from the Italy sample show that participants are more accurate in using proximal compared to distal cues and prefer retracing routes over taking shortcuts. We expect to find that Utah participants will perform relatively better on distal cue tasks and prefer survey-based strategies compared to Italian participants, while Italian participants will perform relatively better on proximal cue tasks and prefer route-based strategies compared to Utah participants.
Conclusions: Results will highlight the contribution of experience in certain environment types to the development of navigation strategies.

Testing depression in awareness space: A proposal to evaluate whether a psychotherapeutic method based on spatial cognition and imagination therapy reduces moderate depression

Christine Beenhakker and Lucas Derks

Society of Mental Space Psychology

Background: The method Depression in Awareness Space (DAS) is a psychotherapeutic intervention technique based on the principles of spatial cognition and imagination therapy with spatial components. The basic assumptions are: mental space is the primary organizing principle in the mind and all psychological issues can be treated by first locating and by next relocating the conceptualizations involved. 20 years of working experience with the Social Panaroma Model led to the conclusion that a mental object (image) gains emotional impact when it is placed more central, closer and higher in the visual field—and vice versa. Changing the locations of mental objects in space thus alters the (socio-) emotional meaning of the relationships.
Aims: The aim of the method Depression in Awareness Space is to reduce the distress of clients with depression in the clinical counseling practice, as a reliable alternative method of psychological therapy for the treatment of depression.
Approach: The method Depression in Awareness Space aims at making dark areas smaller, lighter and more transparent in order to identify the problem or the cause of the depression which lies behind the darkness. It was hypothesized that the darkness is a subjective side-effect of the neurological process of repression.
After the first promising results of a pilot study, The Society of Mental Space Psychology has started up an up scaled experiment of which the first results can be expected in 2018.

Development of a novel test to measure spatial abilities of architecture students: Preliminary findings

Michal Berkowitz[1], Beatrix Emo[1], Andri Gerber[1], Christoph Hoelscher[1], Stefan Kurath[2] and Elsbeth Stern[1]

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Architects are commonly held to have high spatial abilities. We suppose that the long course of study refines the spatial abilities of the students. While spatial abilities in other domains have been studied quite frequently (e.g, engineering, chemistry), the special nature of spatial thinking among architects has not been given as much empirical focus. Moreover, whilst many standard tests of spatial abilities exist, no spatial test is specifically aimed at measuring spatial abilities among architects, without having to rely on prior knowledge in architecture.

We report the preliminary findings of a novel test designed to measure spatial abilities of architecture students. In the first phase of the project, we administered a series of established spatial ability tests (e.g., mental rotations test, paper folding test) to architecture students from several levels of expertise in order to establish a 'baseline' of general spatial abilities.

In the next phase we have developed a novel test, which is composed of three sub-scales: A perspective taking task ('Street view test'), a 3D assembly task ('packing'), and an indoor perspective task. The test is based on architectural design tasks relied to spatial abilities. We report the initial findings from testing sessions of architecture students using the novel test. The idea behind the new test, its validity and relevance for architecture will be discussed.

Topographical disorientation in the young, the elderly, those with subjective memory complaints and patients with mild cognitive impairment: The differential impact of normal and pathological aging on familiar and unfamiliar spatial memory tasks

Alessandro O. Caffò, Antonella Lopez, Giuseppina Spano and Andrea Bosco

Department of Educational Sciences, Psychology, Communication - University of Studies of Bari

Background: Topographical Disorientation (TD) refers to a particular condition which determines the loss of spatial orientation and may be related to the difficulty both in acquiring spatial information in new and unknown environments, and in encompassing familiar environments such as one's neighborhoods. TD and spatial memory impairments occur relatively early as effect of cognitive decline in aging, even in prodromal stages of dementia, namely Mild Cognitive Impairment (MCI).
Aims: (a) to disentangle between different components of TD, namely egocentric and heading disorientation on one hand, and anterograde amnesia on the other, and (b) to show that components linked to familiar spatial knowledge (egocentric and heading disorientation) are relatively spared with respect to unfamiliar ones (anterograde amnesia).
Method: Forty patients with probable MCI, 40 elderly participants with subjective memory complaints (SMC), 40 healthy elderly participants, and 40 healthy young participants were administered with egocentric and allocentric familiar tasks, based on the map of their hometown, and with egocentric and allocentric unfamiliar tasks, based on new material to be learned. A general linear model will be used to analyze data, covariating for age and education.
Results: MCI patients are expected to be selectively impaired in egocentric and allocentric unfamiliar tasks, as well as SMC participants are in allocentric unfamiliar task. No significant differences between groups are expected in performance with familiar tasks.
Conclusion: These results are consistent with the hypothesis of not only quantitative but also a qualitative discontinuity between the process of normal aging and the early stages of dementia.

Emotional responses to facial expressions in peripersonal space determine interpersonal distance in social interactions

Alice Cartaud[1], Gennaro Ruggiero[2], Laurent Ott[1], Tina Iachini[2] and Yann Coello[1]

[1]Scalab; [2]Lab of Cognitive Science & Immersive Virtual Reality

Background: Interpersonal distances are an important determinant of social interactions and are modulated by the representation of the peripersonal-action space, as well as the perception of other's emotional state.
Aim and Method: The aim of the present study was to quantify the physiological response (EDA) triggered by human-like point-light-displays (PLDs) carrying different facial expressions (angry, happy or neutral) when located in the participants' peripersonal or extrapersonal space, and to evaluate the relation between the EDA and the comfortable interpersonal distances with the same PLDs when approaching and crossing the participants fronto-parallel axis on the right or left side.
Results: Results showed an increase of the EDA for PLDs with angry facial expressions presented in the peripersonal space, in comparison to the same PLDs presented in the extrapersonal space. The results also showed an increase of the comfort distance with PLDs approaching the participants with an angry facial expression in comparison to PLDs with happy and neutral ones. Those latter results were related to the increase of the physiological response when stimuli were presented in the peripersonal space.
Conclusion: The findings indicate that emotional reaction triggered by a human-like stimulus located in the peripersonal space can predict comfort social distance with the same stimulus. This suggests that peripersonal-action and interpersonal-social spaces are both sensitive to the emotional valence of other individuals. This could reflect a common mechanism to adapt interactions with both the physical and social environment, but also to ensure body protection from potential threats.

Fashion code, spatial grammar and direction: English and Italian languages in comparison

Maria Catricalà

Roma Tre University

Space is one of the most basic and tangible domains of the clothing experience. This aspect is well-attested by many lexical and morphological elements of the fashion linguistic system that is marked, as every code for special purposes, by a set of specific inter-linguistic features (Catricalà-Guidi 2009): in English "footwear" or "headwear" imply a similar specific motion; in Italian, instead, we distinguish between "copricapo" and "calzatura", and not *copripiede, because the centrifugal force of the leg motion is opposite of the centripetal direction of covering gesture.

It is not for nothing that a crucial relevance in this semantic domain is represented by the concepts of 'Idealized Cognitive Models' (Lakoff-Johnson 1980) and 'Embodiment' (Gibbs 2005; Geerarts-Grondelaers-Bakema 1994). In the Fashion Code, indeed, space is not a physical reference, absolute (as in leggings) and relative (as in overcoat), but it also is a conceptual dimension.

The aim of this presentation is that of describing the dynamic forces active into the verbal compounds V + Clothing_Noun (as Italian "reggicalze" vs. "copricostume") and of comparing them with the English examples as "push up-jeans", linked to two principal schema: Containment and Force.

In addition to the study of the lexicon, I analyse the results of a survey in the light of Embodied Semantics (Gallese-Lakoff 2005) and of the concept of verb-framed and satellite-framed system (Talmy

1991; Slobin 2004). Two groups of Italian and English L2 Learners were asked to choose the more adequate name (on the base of a Likert scale) of a series of fashion products.

Cross-generational changes in linguistic and cognitive spatial frames of reference among Negev Arabic speakers

Letizia Cerqueglini

Tel Aviv University

Spatial Frames of Reference (FoRs) are cognitive and linguistic strategies used to project coordinate systems onto spatial arrays to conceptualize and describe relations between an object to be located (Figure, F) and a reference object (Ground, G) when 'direction' is necessary (Talmy 2000). Coordinate systems can be centered on G's axial asymmetries (Intrinsic FoR), derive from the Observer (Relative FoR) or derive from external bearings (Absolute FoR) (Levinson 2003). I analyze the relationship between FoRs in language and cognition (Levinson 2003; Majid et al. 2004; Dasen and Mishra 2010), comparing two generational Negev Arabic (NA) varieties: Traditional Negev Arabic (TNA: speakers over age 65) and Young Negev Arabic (YNA: speakers under age 45). NA is a variety of Northwestern Nomadic Ḥijāzi Arabic spoken in the Negev. In linguistic tasks, a culture-specific methodology (toys, real objects instead of pictures) was developed based on 'Man and Tree' in Levinson et al. (1992). 12 D(irector)-M(atcher) pairs were combined thus: 4 DM-TNA, 4 DM-YNA, 2 D-TNA + M-YNA, 2 D-YNA + M-TNA. Individual cognitive tasks (recall and recognition memory and transitive inference) follow Levinson (2003: 154–169). Tests proved TNA and YNA spatial languages to be so different as to prevent mutual understanding: TNA applies the 3 FoRs, according to a Gs' culture-specific ontology. YNA lost Absolute FoR and Gs' traditional ontology. Remarkably, in cognitive tasks, both TNA and YNA apply exclusively the Absolute FoR to all Gs. To conclude, FoRs' linguistic innovation triggers cognitive reshaping, yet the duration of the process is unpredictable.

BTT-SCAN: An ecological and technology enhanced tool to assess visual neglect

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Visual neglect (VN) impairs the exploration of one hemispace, usually the left, and patients are not aware of stimuli in that neglected side. Several "paper-and-pencil" tests are used to assess VN, but they are affected by practice: patients can reach a normal performance in these tasks, while showing clinical signs of VN in daily life. Other tests are more ecological, like the Baking Tray Task (BTT), which consists in the disposition of 16 small cubes on a surface, "as if they were buns on a baking tray". BTT is a reliable test for screening purposes and is not influenced by practice, but its scoring can be tricky. One aim of our work has been to develop a technology-enhanced version of BTT, BTT-SCAN, which can assist clinicians during the diagnosis, automatizing the scoring of BTT, once acquired data through an artificial vision module able to detect the cubes' disposition. Moreover, our tool instantaneously produces several indexes of patients' performance. We are now acquiring data from healthy participants and patients and we aim to analyze the different strategies in cubes' composition showed by subjects.

Starting from BTT-SCAN, we aim in future to develop rehabilitative and diagnostic programs in digital environments. Moreover, we plan to collect a large dataset to increase BTT normative data and to set an artificial intelligence module performing an automated analysis of the cubes' pattern. Hence the clinicians could be supported not only for the diagnosis of VN but also informed about the presence of other, nonlateralized visuospatial impairments.

Investigating recognition of emotional pictures with touchscreen interactions: A match between picture valence and its vertical touch location raises recognition confidence

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Background: There is converging evidence that bodily experiences ground mental representations of emotional valence on vertical space (i.e., positive-up/negative-down). Several studies suggest that the retrieval of positive (negative) information is facilitated not only when presented in upper (lower) locations but also when performing upward (downward) arm movements. However, it is still unclear whether similar effects may arise when stimuli are manipulated directly by hand. Interestingly, with the advent of touchscreen devices and their use in experimental paradigms, a direct and more natural hand interaction with the stimuli come to the fore.
Aim: We investigated whether interacting with emotional stimuli across a vertical touchscreen space affects the subsequent subjects' recognition of the stimuli.
Method: Right-handed subjects (N = 60) touched and subsequently moved 20 positive and 20 negative emotional pictures on a vertically mounted touchscreen, either upwards (i.e., from the bottom to the top)

or downwards (i.e., from the top to the bottom). Afterwards, the just moved pictures were mixed with a new set of pictures and were presented individually in the center of the screen. The participants' recognition towards the pictures (i.e. "yes"/"no" response), and the confidence of their recognition (i.e., 1 = low to 9 = high), were measured.

Results: Negative pictures were recognized better than positive ones. Critically, participants' confidence tended to higher ratings for positive pictures moved downwards and negative pictures moved upwards.

Conclusions: The findings suggest that a matching between the pictures' valence and the valence associated with the touch location affects the subjects' confidence related to the pictures' recognition.

Sex differences in attentional object selection triggered by gaze and arrows

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Several studies have shown that gaze and arrow cues trigger reflexive shift of visuospatial attention, although it is not yet clear whether the attentional shifts induced by these cues differ in some important aspects. In a recent study, Marotta, Lupiáñez, Martella, and Casagrande (2012) found a clear dissociation showing that attentional orienting spread to the entire object when arrow cues pointing to one end of the object was used as cue, while attention was selectively directed to the specific location or part of the object looked at, when gaze cues were used. According to the authors, the attribution of mental states (Theory of Mind abilities, ToM) may account for the "specific" attentional orienting triggered by the eye-gaze direction, thus explaining the dissociation observed between gaze and arrow cues. Since it has been reported that women show greater ToM abilities than men, we investigated whether this arrow-gaze dissociation can be extended to the male population. We replicated the pattern of results observed by Marotta et al. (2012), again dissociating between gaze and arrows cues. However, no sex differences regarding attentional selection triggered by gaze versus arrows were observed. Although this finding seems to run counter the intuition that theory of mind abilities can account for the dissociation observed between gaze and arrow, it must be interpreted with caution since no differences in ToM abilities and autistic quotient scores were neither observed between male and female in our sample. Further research is needed to shed light upon this issue.

The Morra game as testbed for automatic and controlled cognitive processing in an ecological setting

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Morra is a 3000-year-old hand game of prediction and numbers. The two players reveal their hand simultaneously, presenting a number of fingers between 1 and 5, while calling out a number between 2 and 10. Any player who successfully guesses the summation of fingers revealed by both players scores a point. The game is extremely fast-paced, making it very difficult for players to achieve a conscious control of their game strategies. In this study, we used Morra as a naturalistic setting to investigate a number of cognitive skills and their interaction. We analyze the abilities of naïve, partially trained, and expert players of Morra to generate seemingly random numeric sequences to predict their opponent's numeric sequences and tested our participants with a battery of neuropsychological tests including measures of working memory, executive functions, processing speed, and attention. Finally, sequence prediction and random number generation performances were compared and modelled against the optimal strategies of a non-deterministic artificial intelligence specifically built to play Morra. Preliminary results indicate that Morra skills (a) do not correlate with the proposed neuropsychological measures; (b) are mostly automatic; (c) are the result of the interaction between perceptual, cognitive and motor components. Results are discussed in the framework of the dual processing theory and its automatic-parallel-fast versus controlled-sequential-slow polarities: in spite of the extreme speed of the game and of the lack of awareness of their strategies, expert players have a better statistical prediction of the opponents' sequences and generate less predictable sequences than naïve players.

Promoting creativity, problem solving and cultural sensitivity through original and multidisciplinary course-based research experiences on technology and multimedia

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Course-based research experience (CRE) makes original research an integral part of a regular course, so all enrolled students are included in original research activities. Historically, CRE has been successfully implemented in Science-Technology-Engineering-Mathematics (STEM) courses, but it has rarely been extended to the humanities and social sciences. Within the HHMI-Inclusive-Excellence program, we are redesigning a large number of courses to include CRE in most disciplines within the College of Arts and Sciences at LTU, including non-STEM disciplines. Several examples of intervention are related

to spatial concepts and spatial cognition. For example, in English Composition class, students experimented with representing essay structure as material structure (made from cardboard, foam, and glue), and analyzed how abstract concepts such as design and form can translate across disciplines. In psychology, students studied responses to affective touch as a measure of implicit bias in Virtual Reality (VR). In a literature and technology course, students explored different models of body-ownership by investigating concepts like avatars, cyborgs, and VR in literature, computer science, and neuropsychology. The comprehensive and interdisciplinary nature of CRE at LTU facilitates the transfer effect of ideas, in which students train their problem-solving skills in different research experiences in STEM and non-STEM contexts. We hypothesize that experiencing CRE in multiple courses fosters an emergent sense of methodological self-reflection with which students can understand how and why methods reflect their discipline and subject matter. Preliminary assessment data suggest that effects of non-STEM CRE can be as positive as the ones previously shown in STEM disciplines.

Conceptual structure and object salience in indoor scene descriptions

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Image captioning of interior spaces is now possible through a combination of computer vision and language processing techniques. However, current methods may not provide enough spatial information detail for these types of automated natural-language scene descriptions to be effective for people without vision to form conceptual maps of indoor spaces. This talk will focus on the types of natural-language patterns used in describing indoor scenes, specifically focusing on the language structures that may best support spatial representations for users of non-visual navigation systems.

Sighted participants (n = 10) were asked to describe two similar scenes for someone who was blind and could not see the scenes themselves. The two interior spaces contained a set of office furniture arranged in a typical room structure (e.g., walls, windows, doors). Verbal descriptions were analyzed using cognitive discourse analysis to identify conceptual and linguistic patterns. Analysis identified three conceptual spatial relations (i.e., contact, disjoint, partOf) within the descriptions and several distinct syntactic structures used to describe the spatial relationships between moveable objects and the room structures. Participants preferred the use of underspecified spatial prepositions over more descriptive spatial terms, despite the explicit instructions to describe the space for a user without vision. Structural elements in the rooms served as primary reference objects that described the position of the other objects in the space. This study provides early guidance on creating standardized specifications for effective automated scene descriptions for blind and low vision users who might benefit from additional spatial detail while navigating within indoor environments.

Walking urban landscape, an eye-tracking study of visual affordances and orientation strategies

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Literature has already comprehensively studied and proven the improvements of adding landmarks within pedestrian itineraries on both navigation performance and user confidence. In this ecological study, we evaluate the impact of landmarks in visual and verbal communicated route instructions to evaluate the efficiency of different information supports in two Parisian train stations and their complex urban surroundings using eye tracking technology.

On a first scenario, half of our 18 participants were provided with a detailed roadmap based on landmarks ("landmark-assisted" group), while the other half could only rely on street signs. On a second scenario, all participants were provided with a digital map. Half group had landmarks information along the path ("landmark-assisted" group); while the other one had only street names.

Eye tracking data was collected, as well as error and task duration as performance indexes. Verbatims, observation grid and mental maps drawn by the participants, supported the analysis.

As expected, first results show significant differences in favor of the "landmark-assisted" group on task achievement for both scenarios. Others relevant results were obtained: significant differences were shown in head orientation between indoor and outdoor environments. There is a trend towards relevant landmarks categorization and ranking.

Visual affordances as well as patterns and strategy for information retrieval were largely induced by the kind of orientation information that was provided. Landmarks proved to be of great help in orientation tasks while eye tracking data was a valuable and complementary addition to declarative data to identify relevant landmarks along the path.

A multi-agent spatial-cognition model to represent infection spread in hospitals

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Understanding the role which the environment plays in human performance early in the design process phase poses a major difficulty for architects, particularly due to the unforeseen impact that a physical setting produces on human decisions. Human spatial behaviour shows mixed mechanisms that give rise to emergent phenomena: from the natural tendency to stay at a distance to imitation effect, from competition for shared space and between different activities to co-operation.

We present a multi-agent system to investigate the impact of the spatial cognition of the built environment on the hand hygiene practice in hospital wards, simulate the Hospital Acquired Infection (HAI) transmission in a 3D virtual environment and visualize the contamination propagation dynamics, modelling the profile and behaviour of individuals, the characteristics of pathogens and the role of inanimate objects and spaces.

The model adopts an Event-Based approach, whereby spaces, actors and activities are grouped into computational entities, which direct agents' behaviour in space. The application of a Certainty Factor method measures the confidence that hand hygiene would be performed when contextual conditions are verified. We take into consideration human factors relating HAI to human spatial behaviour and the use of built space, i.e. local conditions, perceived barriers, risk awareness. Through such a framework we assess the role of the perception-of-risk conditions and the spatial cognition of built environments on agents' choices. The working proof of a "what-if" scenario demonstrated how the pathogen circulation vary depending on initial causes and conditions, the heterogeneity of agents' features and spatial configurations.

Using VR for immersive spatial exploration and user experience in the field of large-scale landscape architecture and urban design

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The main goal of the abstract is to present an exploration of combining application fields of human interaction with large-scale environmental data flow in the realm of Virtual Reality (VR) and Augmented Reality (AR).

Complex decision-making, involving sometimes hundreds of parameters and key players, is inherent in landscape architecture and urban design. In this context, the integration of Mixed Reality can provide a link between the virtual environment and the physical world to utilize interactive and intuitive spatial interfaces like augmented urban and landscape models. Changes done on these models through human interaction or machine actuation can be fed back into the digital environment through 3D scanners and enable real-time integration in the design process.

Purpose: The multidisciplinary research project, aims at developing an innovative platform in VR/AR to enable the designer and the future users of landscape architecture and urban design and planning projects to actively understand and interact with the hidden layers (datasets) of the site. Perception, imagination and engagement with abstract data (noise, sound, wind, temperature, visibility) aims to open up new possibilities for revealing the relevance of datasets in relation to design.

The following questions will be discussed in the paper: How can the symbiosis of the themes of Big Data, VR/AR and robotics, capture new possibilities for the profession of landscape architecture and urban design? What kind of experiences do we create through the engagement of data in virtual spaces? How does this method enables us in dealing with complexity for achieving sustainable designs?

Modality matters: Space–time mappings differ in vision and audition

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Background: What is the relationship between space and time in the human mind? Many experiments show a space–time asymmetry: People use space to think about time more than vice versa. By hypothesis, this asymmetry arises because spatial aspects of events are more available to perceive, imagine, or reproduce than temporal aspects. Yet, this difference may be specific to vision: In audition, temporal information may often be more available than spatial information. If so, the space–time asymmetry should differ across sensory modalities, accordingly.
Aim: To determine whether the relationship between space and time in the mind depends on the modality in which spatial and temporal information is perceived.
Method: Participants were presented with a focal source of sound (auditory condition) or light (visual condition) that traveled across a speaker array or projector screen. 5 distances and 5 durations were crossed to produce 25 unique stimuli in each modality. Distances and durations were matched across modalities in their subjective magnitudes (Subjectively Matched) or their physical magnitudes (Physically Matched). Participants reproduced either the spatial or temporal magnitude of each stimulus.
Results: In vision, we found the standard space–time asymmetry: task-irrelevant spatial information influenced temporal reproduction more than vice versa. In audition, however, this relationship between space and time changed. For Subjectively Matched stimuli, time influenced space as much as vice versa; for Physically Matched stimuli, time influenced space more than vice versa.
Conclusions: The relationship between space and time in the mind varies by modality and is shaped by their relative perceptual availability.

Good images are remembered better

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Background: Some images are intrinsically more memorable than others (e.g., Isola et al. 2014) but the features making them memorable are not yet well understood. We hypothesized that the memorability of images depends on how well they are organized perceptually.
Aims: We wanted to test the notion of "good Gestalt" in three different ways, to account for the efficiency of the organization process as well as the distinctiveness of its resulting organization.
Methods: We used meaningful real-life scene photographs from a previous memorability study (Bylinskii et al. 2015). In the rapid categorization study, participants had to indicate whether a briefly presented image (32 ms, followed by a mask of 83 ms) belonged to a particular category (indicated by a subsequent label). In the shrinking study, a regularly-sized image was surrounded by nine thumbnails on each trial and participants had to locate the shrunken version of the

middle image as fast as possible. In the distinctiveness study (conducted on-line), participants rated the distinctiveness of all 44 images within a category on a 7-point scale.
Results: Our measures for categorizability, shrinkability, and distinctiveness showed high consistencies across observers (mean split-half Spearman's rho up to .90). As expected, distinctiveness was highly correlated with memorability (.48). The predicted correlations of the two measures of processing efficiency (categorizability and shrinkability) with memorability were lower but significant when distinctiveness was statistically controlled for (.10 and .18, respectively).
Conclusion: Images are more memorable when they can be organized more quickly and the resulting organization is more distinct.

Route planning on a map: Challenging the existence and interpretation of a southern preference

Elise Grison and Valérie Gyselinck

Ifsttar

Background: For decades, the study of route planning on map has highlighted several biases. For instance, Brunyé et al. (2010) have shown that the southern routes are mainly preferred over northern ones. An implicit association (IA) between north and physical effort was advanced to account for the results. However, when changing some characteristics of the map, replication fails, bringing the existence and interpretation of the bias to be questioned.
Aims: We aim at a better understanding of this bias through three experiments by questioning north and effort association, potential perceptual bias, and confronting perceptual with cognitive explanations.
Method: In two studies participants were asked to choose one route amongst two presented on a map, for two dilemmas (south/north, west/east). Either a compass pointing to the north or a legend signaling starting point, routes, parks, was displayed (4 north orientations: towards top, left, etc.; and legend positions: at the top, right, etc. An IA Test between south and down was administered. In a third running experiment, participants had to plan the route either from a map or from memory.
Results/Conclusion: Results showed a preference for the northern route ($ps < 0.01$), and no compass or legend effects. These results contradict the existence and the explanation of the bias. An IA between the north and up was found, that may explain our results, with going up be perceived as more positive. If the bias is cognitive and not perceptual, the third experiment should show a greater bias in the memory condition.

Individual differences in the improvement of spatial thinking following a high school geoscience course

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Despite evidence that spatial thinking skills are critical for students' success in a range of STEM fields, spatial reasoning is rarely taught in K-12 classrooms (NRC 2006). The present study investigates whether a year-long high school course that teaches spatial reasoning through geospatial technologies (i.e., the Geospatial Semester) affects students' spatial thinking. Further, we examine whether improvements in spatial thinking are related to individual differences in student characteristics (e.g., spatial anxiety, beliefs about ability, gender). Students who took a year-long geoscience course (N = 84) were compared to students enrolled in alternative science-elective courses (N = 125). Pretest and posttest measures included spatial ability (e.g., mental rotation, embedded figures), spatial language use and gestures during spatial problem solving, spatial habits of mind, and beliefs about spatial ability (e.g., spatial anxiety). A subset of students completed tasks in an fMRI scanner. Compared to students in other elective courses, students who completed the Geospatial Semester tended to think about problems in a more spatial way, as demonstrated by increased spatial habits of mind, increased recruitment of brain regions implicated in spatial thinking, and use of more spatial language during problem solving. Results will be analyzed to investigate whether these improvements are moderated by individual differences. Preliminary results indicate that gender and spatial beliefs moderate some of these improvements. Overall, findings provide evidence that teaching spatial thinking embedded within a high school classroom can produce changes in problem solving processes at the cognitive and neural level, but that improvements are greater for certain students.

New entanglements between instrumental and mental maps in the exploration of urban space: Preliminary results

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Background: After many years of interactive artistic experiences between participants in distant cities, the goal of the present research is a better understanding of the links between mental, instrumental and shared maps. The question is whether connected and dynamic applications renew our shared mental representations of urban spaces.
Aims: We will approach the notion of mental maps (introduced by Tolman) in its individual and collective dimension with regard to the new uses created by connecting devices. The hypothesis is that new access to cartographic tools is likely to produce new kinds of individual mental representations.
Method: The objective is to compare the mental maps evidenced by maps drawn after the exploration of a single urban district between 2 groups of participants: (1) group of individuals equipped simply with a passive GPS tracking tool, (2) group of individuals equipped with an urban navigation application. Measures will include: (1) style of representation (pictures of landmarks, vectorial or sectorial spatial configurations); (2) accuracy of distances between landmarks; (3) individual variance in represented distances between landmarks. We will compare the two groups relative to these measures.
Expected Results: We will address the following question: Is there a difference between individual spatial cognition and individual augmented spatial cognition?

An ethnomusicological case study: Steelpans topologies

Aurélie Helmlinger

CNRS

What is the preferred spatial organization of steelpans, steelband's melodic idiophones made of sunk recycled oil drums? These percussions are a whole family of instruments, rich and original data for spatial cognition. The pan topologies or « styles » (note placements) are very abundant: freed from the common linear low to high setting (proportionality of the distance between the notes to the musical scale) because of acoustical constraints, the variety of steelpans topologies is stimulated by the factorial possibilities of the drum placement around the musician (1–12 according to the tessitura), and the sequence of the notes set in concentric rings on the top of the drum (up to 15 notes). The placement of musical intervals creates geometrical figures in three dimensions, with a variable degree of regularity.

This paper is based on a corpus of about 370 steelpan layouts collected in Trinidad and Tobago in 2011, out of a corpus of about 500 items. An on-line database is gathering the collected topologies, all being drawn in vectorial format in order to extract the note position information. It becomes therefore possible to analyze the popularity styles in terms of the motor or cognitive advantages, one of them being the regularity of the intervals. On a category of steelpans, we'll show that the interval consistency (stability of the distance between semi-tones/tones/thirds…) is a major factor of success: instruments with consistent interval setting have been preferred over the years.

The contribution of children's spatial skills to their scientific recall and reasoning about sound propagation

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Background: Recent research from our group was the first to demonstrate a relationship between spatial skills and science achievement in children (aged 7–11 years) (Hodgkiss, Gilligan, Tolmie, Thomas and Farran 2018). Whilst this was a vital starting point, science was assessed across a range of conceptual topics and skills, making it difficult to draw specific conclusions.
Aims: This study investigated the relationship between a range of spatial skills and specific science skills, in the context of a single science topic: sound.
Method: Participants (N = 102; mean age: 9.2 years) completed five spatial tasks, based on a model of spatial thinking whereby skills vary along two dimensions: intrinsic-extrinsic; static-dynamic. Intrinsic skills relate to single objects and extrinsic skills involve the relationship between objects. Dynamic skills involve movement, whereas static skills do not. IQ was estimated using matrix reasoning and expressive vocabulary tasks. Within whole-class groups, children were taught a 1-h lesson on the topic of sound and then completed factual-recall questions and transfer problems.
Results: Even after controlling for verbal and non-verbal IQ, a positive relationship was found relationship between spatial skills and near and far transfer scores, but not factual scores. Mental folding (a dynamic spatial skill) was the only unique spatial predictor of overall transfer scores, accounting for 7% additional variance in scores.
Conclusions: Dynamic spatial skills, which involve movement, may play a role in the development of a mental model of the science of sound propagation, a dynamic process. These findings have implications for interventions and training.

Golden gait: A spatio-temporal bridge from biomechanical to cultural constraints

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Background: Human walking is a standardized, repeatable and rhythmic locomotor act, with biomechanical patterns reported as common to all healthy individuals.
Aims: This review aims at investigating the changes in gait parameters due to personal, social and cultural factors.
Method: Studies investigating top-down related differences in healthy walking patterns were reviewed.
Results: Socio-economic factors were found at the basis of differences in pedestrian speed. A variability of about 10% was found related to the pace of life of different countries, faster in industrialized countries than in developing ones. During walking, differences in gait speed did not affect cortical resources needed for spatial cognition. However, children develop head anticipatory movements related to spatial cognition later than upright gait stability. In women, these head movements are smoother than in men, probably for ancient cultural reasons related to women's poise. Step cadence tends to be synchronized among walking companions. The most reliable parameter resulted to be the ratio between stance and swing duration. That was found close to the so-called golden ratio and related to an energy optimization.
Conclusions: Despite the high reliability of physiological walking, humans may adapt their gait patterns to sexual, cultural, and even socio-economic factors. High reliability was associated to "golden gait", i.e. walking in a harmonic proportion based on the golden ratio. It is an irrational number considered by ancient Greeks as a formula of harmony and beauty. Further studies should investigate if harmony plays a role in both motor control and cognitive processes.

Justifying the elicitation versus corpus distinction in psycholinguistics

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Background: In the study of language, there has traditionally been a division of labor such that corpus research is the prerogative of linguists whereas experimentation is the prerogative of psychologists. Hence it is not at all usual that one and the same phenomenon should be investigated by one and the same person by means of these two dissimilar methods. But when this is the case, interesting differences are likely to emerge.
Aims and Methods: To show in concrete detail that dissimilar methods produce dissimilar results, fictive motion ('The bridge goes

over the ravine') was studied by means of both corpus and elicitation. The first part of the study was based on a written corpus of 24 million words. In the second part, written descriptions were elicited from 50 subjects in response to 36 pictures.

Results: (1) Corpus data reveals limitations inherent to eliciting: (a) The number of possible Figures and motion verbs is greater than elicitation may lead us to believe. (b) When recurrent features of the larger morpho-syntactic context are taken into account, fictive motion turns out to be less similar to genuine (dynamic) motion and more similar to (static) non-motion than is generally assumed. (2) Elicitation reveals the amount of both intra- and inter-individual variation, whose existence is much more difficult to infer from corpus data (and whose causes remain to be determined more precisely).

Conclusions: Our study suggests that the role played by corpus research should be just as important in psycholinguistics as it is in linguistics.

Social density and building layout: The experience of crowding in wayfinding

Kristina Jazuk, Panagiotis Mavros, Tyler Thrash, Victor Schinazi and Christoph Hölscher

ETH FCL

The physical environment we navigate in has spatial and social components. Spatial aspects, such as distance, direction, visibility, or connectivity, are one part of the experience and information processed, determining wayfinding decisions. And yet, there is little research on the other part, namely the social environment in relation to spatial navigation. Pedestrians may perceive the co-presence of other people, in small groups or larger crowds, as obstacles to efficient locomotion, but equally as social cues to reaching a destination ('following the crowd').

The goal of this research is threefold. We investigate (1) the impact of the spatial layout/characteristics and (2) the effects of social density, i.e., varying numbers of people present in the environment, on wayfinding behavior, as well as individual emotional and stress responses, and finally (3) disentangle the dynamic interaction between these two factors, i.e., spatial configuration and social density.

A wayfinding experiment was conducted in a shopping mall in Singapore, under varying levels of social density. The preliminary results support the assumption of the dynamic interaction between the factors, as participants (n = 40) in the low and high density conditions showed systematic preferences for different routes. Similarly, emotional appraisal, measured with a standardized questionnaire, (Self-Assessment Manikin SAM, Bradley and Lang 1981), varied significantly on the dimension of dominance (situational control), but not valence or arousal. Participants in the high density condition tended to choose the route with higher footfall, and indicated that they feel more in control of the situation. We discuss the implications of the multi-cultural environment.

A feeling of physical proximity: The role of relative fluency in distance judgments

Romàn Josa, Philippe Servajean and Denis Brouillet

Paul Valéry University, Montpellier III

Empirical evidence shows that when the energetic cost of an action increases, the distance judgment associated to this action increases also (Witt et al. 2016).

We were interested in a metacognitive signal—the relative fluency –, which is known as the deviation from the expected easiness or difficulty with which people process information (Wänke 2015). We hypothesize that relative fluency influences distance judgments as the mediator of non-visual influences on perception.

First, participants read a sentence with the last word missing. The sentence was projected on a table in front of them. To reveal the last word, participants pushed a central button. The word appeared in their sagittal axis at different distances beyond the peripersonal space. The word was either expected or unexpected (fluent or non-fluent), and either bleu or purple. Second, participants used a fluent or non-fluent motor response (an ipsi- or a contra-lateral gesture) to categorize the color of the word. Third, participants were told to perform a spatial comparison task with their forefinger on a tactile scaled potentiometer to estimate the position of the word. Results revealed an interaction effect between the words fluency and the motor fluency ($p < .01$, $\eta p2 = 0.37$), with the fluent words being judged closer after a non-fluent motor response than after a fluent motor response.

Our interpretation of these results is that the feeling of cognitive proximity toward the words caused by relative fluency could have transformed into a physical proximity and led participants to make shorter distance judgements.

Blind persons taking photos

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This study shows how blind persons perceive space with their advanced sense of hearing, touch and smell and which environmental cues they use during their walking tour in a complex urban environment, namely Kemeralti, İzmir/Turkey. The initial visit to the area was made by the researcher alone to determine the route and turning points for the walking tour. The participants were asked to mark those important reference points along the route by taking photographs and by verbally describing the features of the environment. 7 blind participants were chosen who had a photography course for 1 month. The participants' verbal reports were recorded during the photo campaign. The result of the study shows, the photos are the documents of the environmental references that move together along the route. In fact, each photo shows us the frozen sense at that moment. Such as, a sudden voice, a sudden smell or a sudden wind that touches the face. The study shows us, sighted and blind individuals "see" the same things in the city but they focus on different environmental cues. The main finding of this study is, blind participants give priority to sense of hearing and echo of the city during their walking tour therefore most of the photos mention the buildings which create a feeling of enclosure. Furthermore, the rest of photos that were taken in turning points show references of touch and smell information

which are not as reliable as constant buildings or slope in the route for the participants.

The effect of tracking training on visual attention

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Classical attention theories presumed a single focus of selection but many everyday dynamic environments, such as crossing busy intersections, or watching over children from danger, require multifocal regions of interest. In laboratory, the ability of tracking four or more targets simultaneously can be examined by multiple object tracking tasks. In addition, several researches showed the fact that both accuracy and reaction times declined as number of tracking targets increase. Although it can be assumed that the typical trackable performance could be differed by individual experience, the researches investigating the association between multiple object tracking performance and individual experience is still sparse. The present study examined the role of attention and expertise in multiple object tracking. The experiment compared the ability of juggling experts and novices to acquire and track subsets of randomly moving targets amongst distractors and respond accurately. Forty participants including twenty juggling experts and twenty novices participated in this experiment. Numbers of tracking objects were 2, 3, 4, 5, and 6. Results showed that juggling experts are better in tracking multiple targets than novices. The results have new implications for theories of multiple object tracking and the great importance of the tracking training.

Decision points in architectural space: How they affect users' visuo-locomotive experience during wayfinding

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Decision points in a wayfinding path are considered not only the intersections but also changes in geometry and in directions, merging of paths, or transitions. Carpman and Simmon (1986) pinpoint the need for environmental cues in these points where users' confusion arises. In this study, we investigate the morphology and the manifest cues of the decision points in relation to the visuo-locomotive behaviour of users recorded during a wayfinding case-study conducted in two healthcare buildings at the Parkland Hospital (Dallas).

We collect and analyse the embodied visuo-locomotive experience of 25 participants, using eye-tracking, external cameras, behavioural mapping, questionnaires, interviews, and orientations tasks. In our multi-modal qualitative analysis, founded in Spatial Reasoning, Cognitive Vision, and Environmental Psychology, we focus on the aspects of visual perception, decision making, orientation, and spatial knowledge acquisition. The comparison between users' transition in eight decision points involves correlations between occurrences of confusion-related events, detection and categorisation of manifest cues, navigation performance, as well as visual attention analysis in relation to the available spatial features.

Primary results suggest that (1) stop and looking-around behaviour mostly emerge in the decision points; (2) behaviour that indicates confusion is mostly encoded in narrow and enclosed decision points; (3) transitional spaces intensify visual search; (4) visibility ahead of time, and visual disruptions affect the visuo-locomotive behaviour; and (5) detection of manifest cues is affected by the morphology of decision points. The correlations between behavioural and morphological data encoded to conceptual language can be useful as a baseline for computationally-driven behavioural analysis.

The handle orientation effect: Critical bottom-up attentional factors that have received little to no attention

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In 1998 Tucker and Ellis found that keypress responses are faster when the task-irrelevant orientation of a graspable object's handle corresponds to response hand location. Over the past 15 years, researchers have disagreed over the extent to which grasping affordance or spatial compatibility contributes to the effect. However, this ongoing debate has been taking place in the absence of a thorough discussion on the low-level perceptual characteristics of stimuli, which may be the cause behind conflicting findings and interpretations.

The present study evaluated the role of visual salience and bottom-up attention in the occurrence of the effect. Exp. 1 involved a vertical orientation task (bimanual keypresses) using photographs of graspable objects, centered based on width or pixel area. The same procedure was performed using a color discrimination task on solid-colored silhouettes, large (Exp. 2) and small-sized (Exp. 3), as well as silhouette outlines (Exp. 4). Similar result patterns across all experiments revealed that the compatibility effects arise as a function of asymmetric changes in luminance between both hemifields, coupled with object-center eccentricity relative to fixation. These low-level factors were critical in modulating the direction of compatibility effects (toward handles or bodies), irrespective of grasping affordance, task, object detail, or stimulus size.

The present findings demonstrated that the Tucker and Ellis paradigm for studying variable affordances is extremely vulnerable to exogenous deployments of attention. This problem is only exacerbated in the relevant literature, whereby visually-complex stimuli are primarily discussed in terms of their graspable nature and relation to task, rather than their low-level, attention-capturing features.

Role of script in tribal group of Odisha

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The study examined the hemispheric advantage as a function of Script ('Orthography' and 'Roman') with two bilingual groups (Santali first language, Odia second language and Odia first language, Santali second language. The method used to measure visual-field superiority was Split Visual-Field Technique. Existing literatures on orthography reflects right visual-field is dominant for processing of language but left visual-field is also partially responsible with function of language. Multivariate ANOVA technique was used to analyses the data. Dependent variables were Recognition Accuracy and Response

Latency and independent variables were Visual-Field, Stimulus Content, Word Type and Presentation Mode. Two experiments were conducted to test the effect of script among bilinguals. In first experimental design the role of 'Script' on both bilingual groups was analyzed. In second design 'Script' was between subject factor and within subject factors were Visual-Field, Word Type, Presentation Mode and Stimulus Content. The result showed that Visual-Field, Stimulus Content, Presentation Mode and Word Type were significant. Emotional words had more recognition accuracy in left visual-field than that of right visual-field in case of 'Orthography' script, whereas in 'Roman' script emotional words were recognized better in right visual-field than left visual-field. Recognition Accuracy of Odia words was significantly higher in left visual-field than Santali words when the words were presented orthographically. Overall, this paper indicates dominance of orthography and its relation to hemispheric involvement in various linguistic tasks of bilinguals.

User judgments of perceived and traversed distances in a real shopping mall and a corresponding virtual model

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The goal of this study is twofold. First, to investigate whether underestimation of perceived and traversed distances in virtual environments (VEs) could be ameliorated with an HTC Vive, one of the most popular head-mounted displays (HMDs). Perceived distance refers to estimates of the egocentric distance between the observer and an object immediately perceivable. Traversed distance refers to estimates of a route's length learned during movement through the environment. Second, to examine the effects of three control interfaces in VEs (a treadmill, teleportation, and a touchpad) on judgement of traversed distance. The treadmill has a dish-shaped platform with a slippery surface. Participants "shuffle slide" on the treadmill in order to walk in VEs. This mode provides proprioceptive feedback. In contrast, no such feedback is available during teleportation, as virtual agents are transferred from one location to another without traversing the VEs in between. In the present experiment, participants were guided to learn nine different routes in a shopping mall (virtual or real). They were asked to estimate perceived distance to a red cylinder at the start of each route and estimate traversed distance after "walking" this route, both measured by verbal reports. These measures were converted into estimated-to-actual distance ratios prior to the analysis of variance. The results demonstrated that perceived distances in the HTC Vive were still slightly underestimated, but this underestimation was lower than previous research using old HMDs. We also found that traversed distance estimates after teleportation were overestimated compared to the treadmill and touchpad conditions.

The effect of different scene information types on path integration efficiency

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Background: Path integration refers to the process that people integrate distance and angle information depending on their current position and the starting point. The influence of landmarks on path integration is of great importance for spatial navigation. There have been some studies on landmark in path integration (e.g., Foo et al. 2005; Zhang et al. 2013), but few about the comparison between the effect of landmark and other cues on integrating efficiency, including the distance and angle estimation.
Aims: The main purpose is to investigate the effect of different scene environment information conditions on path integration in a dynamic virtual reality environment.
Method: Thirty (15 male and 15 female) participants attended this one-factor within-subject design experiment. They were requested to learn four 5-segments outbound paths separately under four environment conditions (pure, texture, landmark, and texture and landmark) in a dynamic virtual reality scene firstly, and then finish the path completion task with their response time, distance error, angle error and position error recorded.
Results: The results suggested that the response time, distance error, and position error in path completion task were affected by environment conditions significantly (ps $< .001$), while there was no significant difference found for the angle error ($p > .05$). The performance order was texture and landmark > landmark > texture > pure.
Conclusions: The landmark is an effective spatial cue in path integration, while it will be more useful combined with the texture condition. However, it will not contribute to the angle judgment in the course.

Selective filtering of task-irrelevant information in visual working memory

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Theoretical work has assumed that visual working memory (VWM) is able to flexibly manipulate stored information, and thus supports a wide range of complex cognitive activities such as problem solving and creative thinking. Flexible manipulation of VWM contents is especially crucial in the real world because visual information constantly gains or losses relevance as the environments we interact with are rapidly changing. The present study investigated flexible manipulation of stored information during VWM maintenance. Specifically, two questions were addressed: (1) Can observers exclude a particular feature dimension from VWM? (2) Does suppression of irrelevant dimensions differ between spatial and non-spatial dimensions? These questions were addressed by presenting participants with an array of stimuli varied along three dimensions (i.e., color, shape and location). Participants memorized the stimulus array, and decided whether a feature swap occurred between two stimuli after a retention interval. During the retention interval, a retro-cue which informed participants of the irrelevant dimension was presented (in the ignore-dimension condition: "Ignore shape" or "Ignore location"; in the baseline

condition: "Ignore none"). The results show that participants' performance was significantly better when they were retrospectively cued to ignore objects' shapes compared to the baseline condition in which all feature dimensions were relevant. However, cueing participants to ignore the locations of the objects profoundly impaired performance. These findings suggest that non-spatial features can be flexibly suppressed during VWM maintenance while spatial information is difficult to suppress.

Categorical and coordinate spatial information: Can they be disentangled in country sketch maps?

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Background: When individuals have prolonged experience with an environment, they attempt to build a relatively accurate spatial representation. They use this to make spatial judgments and describe spatial relations between objects and between objects and the observer. They can either use metric coordinate properties ("A is near to/far from B") or use a more abstract way, making reference to the categorical position of the objects (e.g. "A is right/left of B").
Aims: The present study is a first attempt to employ the categorical/coordinate paradigm in the sketching of country maps, in order to see whether it is possible to disentangle these two different sources of mental representations. Starting with a series of very simple sketches of country maps, we try to measure separately the two kinds of information. Moreover, the study also investigates the role of familiarity on sketch map performance.
Results: The results will be discussed in the light of literature about categorical and coordinate spatial relations. Participants can represent geographical information with different degrees of accuracy according the two encoding systems. We will also examine whether familiarity has special effects on the two spatial coding mechanisms.
Conclusion: This study will add further insights into the encoding of spatial relations and extend findings on categorical/coordinate systems to sketch maps.

Attentional networks and intellectual performance in children: Preliminary evidence from ERPs

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Background: High intellectual performance (HIP) of children is characterized by a rapid and greater capability of information processing, requiring less repetition for understanding compared to their peers of average intellectual performance (AIP). This could be associated with a better cognitive executive control (attentional focus and preconscious selective inhibition), exhibiting cognitive flexibility in task change demands. Physiologically, attention involvement is related to higher amplitudes in some event-related potentials (ERPs). To date, little work exists on the specific correlates between intelligence performance and the attentional networks functioning in children.
Aims: To test the hypothesis that the HIP group shows differences compared to the AIP group for peak amplitudes related to each attentional network in the following ERPs: Contingent Negative Variation (CNV), N1, for cue-target interval (alerting and orienting); N2 and P300 (P3a, P3b), for target-response interval (executive control).
Method: In this study, participants' brain activity was recorded through EEG during their performance on the Attention Network Test to measure the amplitude and latency of N1, N2, and P300 (P3a, P3b) components. Also, reaction times and accuracy were measured. Their intellectual performance was assessed through the Wechsler Intelligence Scale for children.
Hypotheses: (a) HIP group shows greater CNV and N1 peaks amplitudes compared to the AIP group (better on Alerting and Orienting), and (b) HIP group shows reduced latencies for N2 and P300 reduced amplitudes for incongruent targets (better conflict monitoring and executive performance).
Results: Here we show preliminary results corresponding to 10 participants for each group (N = 20).

Geo-spatial literacy: An underrated capability in our technology driven world?

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Background: Geospatial literacy is often overlooked as a social and intellectual capability. Emerging generations appear adept in their usage of various forms of geo-media (smartphones/watches, satellite navigation, geo-tagging). However, this appearance may be misleading. Superficial technological knowledge of geo-media may mask genuine understanding and therefore become an issue for young people when entering industry or tertiary institutions. Currently, no benchmark measure for geospatial literacy exists.
Aim: The aim of this study is to develop and test a simplified ontology of geospatial literacy on final year 'Geography' and 'Earth and Environmental Science' secondary school students. Through diagnostic evaluation of final year Australian students, comparable to industry and tertiary expectations, we can determine the extent of targeted intervention or extension required.
Methods: An adapted 'ontology of geospatial literacy' that has informed a diagnostic tool is explained. Participants complete the online diagnostic assessment, consisting of a series of questions designed to assess foundational geospatial literacy. Interviews are used to gather industry and tertiary expectations, and establish desirable geospatial literacy benchmarks for school leavers. Diagnostic assessment results are compared with the expectations of tertiary institutions and industry.
Expected Results: Data are still being collected. However, early indications are positive, showing that the resulting geospatial literacy levels sit comfortably within desirable benchmarks, particularly because the study's focus is on students in the geo-sciences. More extensive data collection, currently in progress, will highlight any discrepancies between the students' geospatial literacy levels and set benchmarks. Analysis of this more extensive data will be reported in the presentation.

Think of the future in the right way: Processing time activates the motor system

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In previous studies, the association between the left space and past time, as well as right space and future time, was established for left-to-right writing cultures (Mental Time Line, Aguirre and Santiago 2017; Ding et al. 2015; Eikmeier et al. 2013; Fuhrman and Boroditsky 2010; Ouellet et al. 2010; Santiago et al. 2007; Santiago et al. 2010; Ulrich and Maienborn 2010). However, several researchers failed to find this association when the task was time-unrelated (Aguirre and Santiago 2017; Ulrich and Maienborn 2010) which calls into question the automaticity of these associations and their functional role in time understanding. We used highly sensitive grip force measurement (Aravena et al. 2012; Nazir et al. 2015) while presenting participants with past- versus future-related auditory words and expressions (yesterday, in 1 week). The task was time-unrelated (to detect color names) and all stimuli of interest were no-go trials, i.e., only passive understanding was required. We found increase of grip force in the right hand for future-related stimuli and increase of grip force in the left hand for past-relate stimuli [$F(2,60) = 3.39$, $p = .02$, within the first 200 ms after stimulus offset]; no difference between neutral materials and past-related stimuli was revealed. This result suggests automatic and task-independent activation of motor-spatial associations when processing time. The absence of this result in previous studies suggests that reaction time-based methods are not sensitive enough to detect obligatory spatial representations of abstract concepts. Possible mechanisms for this link between time concepts and the motor system will be discussed.

Diana and Actaeon: An eye tracking study on old mythology

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The measurement of gaze movements applied to representational artworks became a central topic in Art Psychology. This study specifically focuses on the presentation of juxtaposed images in art. We hereby describe an experiment of Eye Tracking on two same size paintings, oil on canvas from the XVII century regarding the myth of Diana and Actaeon, presented both as real paintings, and as a digitalized version of them. The experiment was realized on 22 subjects. In the first part of the experiment the digitalized versions of the two paintings were presented, the two images being juxtaposed on the screen. In this occasion we performed an eyetracking analysis of all subjects. In the second part, the two paintings were shown in their original location in the museum site, to the same group of subjects. The subjects were then asked to write a short spontaneous report on their reflections and emotional processes during such an experience. Finally, the gaze paths and the verbal reports were compared and analyzed. An emotional and cognitive discrepancy effect was found in most of the subjects while moving from the digitalised to the real version. Such an effect was based on perceptive, spatial and emotional components. Further, the emerging of a significant Kuleshov Effect has been verified.

Action-specific effects on distance perception: A multilevel Bayesian meta-analysis

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According to action constraint theories (e.g., Witt 2011; Morgado and Palluel-Germain 2015), people perceive distances to the surrounding objects according to the variables defining their action abilities (i.e., action constraints). For instance, the easier people can reach an object, the closer they would perceive it to them. Although many studies supported these theories, the question of the existence and magnitude of such action constraint effect on perceived distance is still highly debated. Additionally, some authors argued that action constraint effects reflect experimental demand bias on judgement rather than genuine perceptual effects. To fill the gap in the literature, we investigated this issues by conducting a systematic review based on a multi-level Bayesian meta-analysis of the available literature (37 experiments; N participants = 770). Our purpose was to compute a proper estimation of the size of the physical action constraint effect on distance perception and to evaluate the moderator role of two variables expected to play a role in these effects if they come from experimental demand (i.e., measure of distance perception and experimental design). Our meta-analysis indicated that people estimate that a target is farther away of 0.44 standard deviation unit when they are in high constraint condition than in low constraint condition, Hedge's $g = 0.44$, 95% CrI [0.24, 0.67]. However, even if our estimation seems to be inflated by publication bias, our moderator analysis does not support the experimental demands hypothesis. To conclude, our meta-analysis supports the action constraint theories according to which action constraints influence perceived distance.

Gender differences in spatial navigation: An approach to characterizing how we wayfind

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Background: Navigation and wayfinding are daily parts of the human experience, from going to the grocery store, hiking up a mountain on vacation to exploring a virtual world in a favorite video game. Navigational ability is measured with self-report, but the direct link between self-reports of wayfinding skills and performance on real-world navigation has not been established. Gender differences are frequently found in performance on self-report measures of navigational ability, large-scale wayfinding tasks, and spatial tasks. Men consistently navigate better than women, potentially due to differences in their pattern of environment exploration.

Aims: The current study characterized how people move through space during goal-oriented navigation, and how this related to navigational success.
Method: West Point cadets were given coordinates of target locations, maps and compasses and a one way GPS tracker. Participants were sent into a natural environment. We assessed their ability to find the target locations, as well as their GPS track patterns as they related to navigational success.
Results: Results showed that males performed better than females. Further, traveling longer distances without changing course, pausing, and revisiting behavior were significantly related to navigational success. Consistent with a full mediation model, the relationship between gender and navigational success was mediated by these exploration variables.
Conclusions: The results of this study suggest that gender leads to differences in exploration patterns, which results in differences in navigational success. This study is a step towards showing the relationship between gender, navigational success, and the patterns of exploration in a real-world navigation task.

"Let's do it more bigger": Relationships between spatial language and constructive play

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Background: Recent research in spatial cognition has demonstrated that spatial thinking skill is essential in student success (Ness et al. 2017) and overall success in the workforce (Kell and Lubinski 2013). Moreover, the role of spatial language and its influence on the development of spatial thinking has gained traction (Ferrara et al. 2011).
Aim: The purpose of this study was to examine young children's emergent spatial skills through their language and actions. While research in space and language is replete with findings based on specified tasks provided by the investigator, few, if any, studies have examined the extent to which language and physical actions with constructive play objects influence the development of spatial thinking in naturalistic settings.
Method: The investigators used naturalistic observation through case study to identify 4- and 5-year-old children's spatial language and actions in their everyday constructive play. The case offered in the present study offers what Geertz (1973) refers to as a type of "thick description", which permits an in-depth interpretation, and takes into account the child's history, motives, intentions, personal meanings, social discourse and interactions, cultural forms and artifacts, and the like.
Results/Conclusions: Spatial words having to do with size ("bigger") and location ("up there") demonstrate planned behaviors as two children engage in block building in uniquely different ways—Fernando builds his structure vertically and symmetrically while Gabe builds his asymmetrically. Spatial language coincides with spatial actions in such a way whereby comparison of structure plays a major role.

Interface: A region of reversibility. Phenomenological-topological approach to new media

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Background: Interface is a key spatial phenomenon of new media (i.e. digital and social media). For phenomenology (i.e. the philosophical school founded by Husserl), interface means not only a technological double-sided surface of mediation, but also a specifically articulated layer of our life-world.
Aims: I aim to analyze how to approach interface from the phenomenological point of view. My goal is also to emphasize the benefits of phenomenological analysis of interface for understanding new media.
Methodology: I will employ phenomenological accounts of tactility; primarily Merleau-Ponty's research into the transitivity of touch. I will also utilize the notion of the phenomenological field to prove if it may help to understand interface as the "autonomous zones of activity" (Galloway 2012: vii).
Results: The transitivity of touch (chiasm) articulates interface as a region of our life-world. It enables to understand interface not only as a double-sided surface, but transitively, as a region of actions. These actions include not only direct relations to technical interfaces (tangible media) such as screens, touch-displays, etc. but also our access to digital worlds of social media. Tactile experience seems to be what establishes, phenomenologically, the sphere of interface.
Conclusion: Merleau-Pontyian conception of tactile reversibility is applicable for explaining interface as an autonomous region of activity (and thus also of life-world). The phenomenological approach also offers a novel understanding of the spatiality of interface (not only double-sided surface, but also a region of reversible spatiality).

Visuospatial response formats in tablet-based verbal working memory tasks: Insights from developmental psychology

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To allow for administration in group settings, current tablet-based verbal span tasks employ a visuospatial response format (RF). Participants are asked to reproduce an auditively presented series of items by tapping corresponding pictures in a picture matrix. Hence, verbal span tasks with a visuospatial RF include cognitive processes such as recoding and visual search that go beyond those required for traditional tasks (verbal recall). As these cognitive processes undergo decisive developmental changes across the life span (e.g. Palmer 2000; Trick and Enns 1998), age-dependent effects on the measurement of working memory (WM) performance cannot be excluded. So far, a systematic evaluation of different kinds of RFs in verbal span tasks has been lacking. To close this gap, we compared performance on tablet-based digit and word span tasks with a visuospatial RF to corresponding tasks with a verbal RF in 105 first and second graders, third and fourth graders, and adults (Mage = 22.5 years, SDage = 3.2). While children's WM performance was lower under visuospatial RF, adults' performance remained unaffected. A second experiment ruled out the possibility that the mere arrangement of stimuli (variable vs. static) within the visuospatial RF influenced WM

performance in 383 first and second graders, third and fourth graders, secondary school students, and adults (Mage = 21.8 years, SDage = 2.0). The results are interpreted against the background of well-established WM models. Underlying mechanisms for age-dependent effects of a visuospatial RF and the potential of tablet-based tasks for resource-saving collection of developmental data are discussed.

Limits in visual working memory manipulation

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To adapt to our changing environments, we must keep track of multiple sources of information and adjust our expectations as circumstances change. To this end, we rely on Visual Working Memory to store and manipulate mental representations of objects in the face of new information.

Computational models (Bays et al. 2009) have identified three sources of error underlying storage limits: reduced precision, forgetting, and object-location misbindings. Here, we investigated the extent to which these errors similarly underlie failures in manipulation, to characterize limits placed on this ability.

Across three experiments, participants were presented with empty placeholders that were subsequently filled with colors (sampled from continuous color-space). Colors then disappeared (requiring them to be stored in memory), and pairs of placeholders remained stationary or swapped positions (requiring manipulation of color-location bindings). Memory for a cued item was reported by clicking on a color-wheel, and responses were categorized into the abovementioned error types using the Swap Model. We found that increasing manipulation load (manipulating 1 vs. 2 colors simultaneously) led to an increase in misbindings errors—with no effect on precision or forgetting (Exp 1). These misbindings errors could not be attributed to interference from lingering sensory representations, as similar rates were observed when a previously-colored placeholder moved to an empty location versus a previously color-occupied location (Exp 2). Lastly, we found that increasing the number of manipulated items increased rates of misbindings, with no effect on precision or forgetting (Exp 3). These findings indicate that constraints on manipulation stem from binding failures.

Gender differences in route-navigation in a virtual environment

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Navigation promotes the adaption to the environment. It requires to mentally transform 2-D images into 3-D images when a map to reach a goal is used, or to inspect and recognize familiar places showed from different perspectives. Men outperform women in navigational tasks, especially when the task requires allocentric (i.e., a map-like representation: survey navigation) rather than egocentric strategies (i.e., a first-person perspective: route navigation). Gender differences emerge when mental rotation ability is specifically required. Here, gender differences in a route learning task in a virtual environment (Boxes Room) were explored. The virtual environment consisted of a square room with 16 boxes placed on the floor and various marks for disambiguating spatial locations (e.g., door, drawings on the walls). Fifty-five college students (21 men and 34 women) assumed a first-person perspective and used a joystick to move around the room. The task was to find 3, 5 or 7 rewarded boxes across 10 trials. Results showed that women performed worse than men only in the 3-boxes condition. No gender difference was found in the 5-boxes and 7-boxes conditions. These results showed that men are better than women when the navigational environment is not familiar; when the environment becomes familiar gender differences disappear even though the task difficulty increases. Basically, women needed more trials than men to reach their asymptotic level, especially in the condition with 3 boxes. Thus, gender differences in navigation might depend not only on strategies used but also on familiarity with the environment.

Geometric features that describe reference frames in forming intuitive landmarks during spatial navigation

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Like language processing, humans use geometrical language to encode visuospatial sequences. This raises question of how intuitive processing of geometric features in environments influence the way humans navigate. It is of interest in Psychology, to understand how geometric features bias while integrating information from an egocentric viewpoint to build allocentric representations. The goal in built environment is easier navigation. Here we study how specific geometric features guide humans build and use allocentric and egocentric reference frames affecting proximal and distal navigation. In previous human navigation experiment, we found geometric features like edge, node, centroid and fractals contribute in intuitive geometric constructs (which are combination of determined and derived geometric constructs based on dominant and dormant geometric feature respectively) as references during navigation.

A cohort of 60 subjects (43F, 17 M; mean age: 19.2 years) participated in the experiment. We found an increased response time was required for distal than proximal by subjects to comprehend space during which allocentric and or egocentric reference frames were utilized. Average time taken for proximal and distal ambulation is 301 and 436 s, respectively (SD 95 s) with predominant use of centroids in proximal and edge, node and fractals in distal at respective geometric shapes they encounter. Results shed light on the timing and which geometric features may bias humans to change reference frame during navigation. In future eye-tracking version of the task studies the fixations, saccades and events that take place sequentially during

navigation would better characterize when and how interplay of allocentric and egocentric representations switches.

Spatializing time and numbers: How culture shapes cognitive universals

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Background: People conceptualize both time and numbers as unfolding along a horizontal line, either leftward or rightward. The direction of both the mental timeline (MTL) and the mental number line (MNL) are widely assumed to depend on the direction of reading and writing within a culture.
Aims: Here we argue that this assumption is false and show how different aspects of cultural experience selectively shape spatial mappings of time and number.
Method: We measured how the MTL and MNL were changed by three training experiences that spatialize time and number differently. Reading training (Experiment 1) spatialized time but not numbers. Unlike reading, counting up on the fingers (Experiment 2) spatialized numbers. Counting down on the fingers (Experiment 3) spatialized time and numbers in opposite directions.
Results: In Experiment 1, after reading normally (left-to-right), participants, showed the space–time and space–number associations typical of Westerners. After reading mirror-reversed text (right-to-left), participants' space–time associations were significantly reduced but their space–number associations were unchanged. In Experiment 2, participants showed normal space–number associations after rightward finger counting but after leftward counting, their space–number associations were significantly reduced. In Experiment 3, the MTL changed according to the way time was spatialized in training, despite the way numbers were spatialized. Likewise, the MNL changed according to the way numbers were spatialized during training, despite the way time was spatialized.
Conclusions: The MTL and MNL have distinct experiential bases. Whereas the MTL is shaped by experiences that spatialize time, the MNL is shaped experiences that spatialize numbers.

Visual motion cues from a held tool contribute to the perception of one's arm movements

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Incorporation of a tool into the body schema is a well-established phenomenon. We assessed whether visual signals originating from the incorporated tool provide relevant cues for the perception of arm movements as would signals originating from the arm holding it. Kinaesthetic illusions were investigated by passively moving one arm and therefore the tool (a rake), using the mirror paradigm with the reflected part being limited to the tool, the arm, or both. Sensations of illusory movements concerned the other arm, holding a tool, identical to the one held in the left hand, but hidden behind the mirror and remaining static. Results revealed that the reflection of the moving tool in the mirror was sufficient to induce kinaesthetic illusions in the arm hidden behind the mirror, similarly to the reflection of the moving arm itself. The originality of the present study was to show that visual signals originating from the tool, not only participate in updating morphological or positional aspects of the body schema, as already known, but can also be integrated with proprioception and visual cues from the arm in order to sense arm movement. Any lack of visual signals originating from the arm, known to be of particular relevance for the sense of movement, can therefore be compensated al least partly by those originating from the tool.

Time for space: Studies of spatial and temporal order memory

Albert Postma and Neeltje Kant

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Objectives: Remembering when and where something happened involves memory for important contextual features of past events. Spatial location memory and temporal order memory may be naturally connected. Events close in space are also close in time. In contrast, there are also indications for separate processing mechanisms. In this presentation we will review previous neuropsychological studies on these two memory domains (cf Kant et al. JINS 2017) and discuss in how far selective disorders in spatial location and temporal order do occur.
Participants: Thirty-six stroke patients (mean age = 57.1 years) and 44 healthy controls (mean age = 55.4 years) participated.
Methods: Six objects were shown in a square frame on a computer screen, either serially (3 s per object) or simultaneously (18 s in total). Next participants had to reconstruct either the temporal order of the presented objects or their spatial locations or do both.
Results: Stroke patients performed overall worse than controls. In particular left hemisphere patients did worse on temporal order memory. Three patients had selective spatial location impairments and two patients selective temporal order deficits.
Conclusions: Functional dissociations between spatial and temporal order memory can occur as revealed by lateralization effects in patients. Selective impairments in single patients further confirm these dissociation patterns. We will further address in how far separate as well as connected mechanisms exist for the processing of time and space.

Practice effect in spatial updating: A longitudinal study using virtual reality navigation

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University of Manitoba

Spatial updating is the ability to derive and update directional information about the position of external objects or ourselves after a series of active whole-body rotations and transitions. Studies suggest that impairment in spatial updating is one of the early symptoms of dementia in older adults. Thus, performing longitudinal spatial updating assessments is necessary to detect the onset of dementia. However, detecting meaningful changes over time requires investigating the practice effect of any spatial test over the repeated sessions. Using a novel landmark-less Virtual Reality Navigation (VRN) test

designed in our lab, we investigated the practice effect in spatial updating ability of older adults. Following an initial assessment of 104 older adults (30 males, age: 66.3 ± 5.7 years and Montreal Cognitive Assessment (MoCA) scores: 27.6 ± 2.0), a subgroup of them (52 individuals, 17 males, age: 65.3 ± 5.6 years and MoCA scores: 27.9 ± 1.7) performed the same experiment approximately 6 and 12 months apart. Participants' performance was assessed by Error-Score, which is based on a weighted summation of various plausible error types when a participant is attempting to find a target in the VR environment. Repeated-measure ANOVA revealed significant reductions in Error-Score from the first to the second assessment (31.7 ± 22.1 to 21.0 ± 15.4) and from the second to the third assessment (20.4 ± 13.1 to 15.3 ± 13.3). Our results show that there is a practice effect in spatial updating tests. Therefore, if such a test is used as a diagnostic aid for dementia detection, the practice effect must be considered and teased out by repetitive testing.

Role of bodily postural muscle tensions in perception of space during imagery

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We examined spatial transformations of mental images in 34 male and female undergraduate psychology students who were asked to lengthen the spine while looking at mental images. Participants were undergone training to produce column vertebral elongation. An experimenter measured in cm the obtained elongation. Current literature considers space perception as a form of trans-modal perception connecting visual input with perception of body dimensions and activity. We hypothesize that postural muscular tensions play a relevant role in this perceptual process. In our hypothesis, muscular tensions are interconnected with each other forming a unified weave that wraps around the body like a single mesh. We think that integration of postural tensions of different bodily districts constitutes the basis of the perception of space. Furthermore, we believe that this process acts both in perception of outer space and spatial imagery. In fact results of this study suggest that spatial modifications appeared by modifying relationships between bodily districts (increasing distances between vertebrae that increases some muscular tensions). Participants were asked to imagine an apple placed on a table both in their standard posture and during column elongation: about 88% of the participants observed transformation in the dimensions of the image and in some spatial relationship. We find interesting that 23% of participants noticed a spatial separation between apple and table: the apple raised evidently from the table. Results suggest also relationships between participants' responses and features of their vertebral column lengthening (classified as mono-directional, bidirectional or without lengthening). Further research is necessary in future.

Moving non-affective pictures in the horizontal space on a touchscreen: Valence ratings depend on movement direction

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Could body interactions that are performed in multi-touch environments influence user's emotional experiences? A recent study has considered this question in light of the emerging interest of embodied cognition approaches to interactive technologies, particularly in affective experiences with touchscreen interfaces. In this study, right-handed participants evaluated the valence of positive and negative emotional pictures after interacting with them by moving the pictures with the dominant right or the non-dominant left hand from left-to-right or from right-to-left on a touchscreen monitor. The results indicated that positive (negative) pictures moved with the right (left) hand from right-to-left (left-to-right) were evaluated more positively (negatively). In the present study, it was examined whether moving neutral emotional pictures with the dominant right hand from middle-to-right or from middle-to-left on a touchscreen monitor could influence the emotional evaluation of the pictures. The results suggest that pictures moved from middle-to-left (middle-to-right) were evaluated more positively (negatively). The finding supports and extends former results by showing that moving pictures on a touchscreen monitor to the left influenced the evaluation of the pictures positively whereas moving them to the right influenced the evaluation of the pictures negatively. Importantly, this is true independently of the starting point of the movement and also for neutral emotional pictures.

Emotional landmarks in a virtual route: The role of arousal and valence

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Background: Some studies have shown that the presence of emotionally laden landmarks along a route influences the way people perceive and represent spatial information of the route itself. However, no study has investigated if this influence is determined by the valence (i.e. positive or negative affectivity) and/or arousal levels (i.e. how calming or exciting an information is) of the landmarks.

Aim: This work investigates the role of valence and arousal on the way people represent spatial properties of landmarks and of the path connecting them.
Method: Participants watched a movie of one of four virtual routes with emotional landmarks, crossing high and low arousal with positive and negative valence, or a route with neutral landmarks (control condition). Afterwards, participants were asked to: (a) imagine walking distances between landmarks; (b) indicate the absolute position of the landmarks; (c) judge the metric length of the route; (d) draw the route.
Results: Participants in the emotional conditions were more accurate in drawing the route with respect to the control condition. However, participants in both negative conditions were less accurate in mentally reproducing distances between landmarks and in indicating their absolute position. Finally, participants in the negative low arousal condition judged the route as metrically longer than participants in the positive high arousal and neutral conditions.
Conclusions: These results support the idea that both valence and arousal influence the way spatial information is represented, but the weight of one or another depends on the spatial task at hand.

Is artificial stereoscopy really helpful for a correct distance perception in virtual environments?

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Background: A correct spatial representation of both real and artificial environments requires an appropriate perceptual spatial information processing. In Virtual Environments (VEs), depth and other spatial cues are rendered with stereoscopy by doubling the display and adjusting the angular distance to the viewer's eyes to simulate binocular disparity. Although this "trick" sounds reasonable and many studies report great advantages of using stereoscopy in VEs, such as higher transfer of skills in Virtual Trainings (VTs) and a stronger sense of "Presence", results disagree when performing basic perceptual tasks such as evaluation of distances, showing poor performances in verbal metric reports in VEs in general.
Aims: To evaluate if stereoscopy improves VE's distances perception and mental spatial representation and in which cases.
Hypotheses: When stereoscopy is available, evaluation of distances would be more precise, still anyway less than in the RE control condition. Men would perform slightly better than women in this spatial task.
Method: Verbal metric and nonmetric evaluation of egocentric and allocentric distances task were collected in 2 computerized environments (indoor and outdoor) both available with and without stereoscopy. We correlated subjects' performances with their Mental Rotation (MR) ability and their metric estimates performance in a Real Environment (RE).
Results: Considering only verbal metric estimates of distances, (a) in the stereoscopy condition more errors were done in both ego and allocentric distances; (b) women underestimate more than males and (c) only female good mental rotators had an improved performance. Stereoscopy resulted to improve performances only in nonmetric distance estimates.

Tactile interpretation of spatial relations in a live soccer game for non-visual soccer spectatorship

Felipe Sarmiento and Peter Coppin

OCAD University

Soccer spectatorship traditionally includes the visual perception of spatial relations among a ball and players in combination with aurally perceived spoken commentary. When visual cues are not available, spoken and written commentary are utilized exclusively: This is the case for audio-descriptive commentary (Carey 2005). In prior work, we described how the translation process from visuals to text (or speech) is a poor proxy for the visually communicated spatial properties of gameplay because many possible spatial relations can fall under a given spoken or written category (Coppin 2015). Building on this prior work, we turned to fieldwork in Colombia to observe a unique tactile sign language system that is co-designed by actual soccer spectators, a sign language interpreter, and a Blind-Deaf spectator. Two portable cameras (GoPro Hero3) were used to capture the live interpretation inside the stadium. Video analysis and field notes revealed how the loss of spatial and topological relations among the ball and players is counteracted by employing a combination of props and gestures.

In this presentation, we focus on how this spatial language system is employed during interactions supported by customized spatial-language material objects—a wooden model of a soccer field—to communicate spatial relations among players and the ball. The parts of the system devoted to conveying spatial relations among players and the ball are rapidly evolving towards iconicity whereas aspects of gameplay like player faults or the whistle of the referee are evolving away from iconicity and toward symbolicity (Sarmiento and Coppin 2018).

Perceived immersion and preferences between binaural and stereo mixes of music

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Binaural technology can create a virtual auditory space, which, when presented over earphones, produces sound that appears to originate from different positions in space. Among other applications, this technology can be used to create three-dimensional (3D) music, with instruments virtually located all around the listener, not only on a stereo left/right axis.

Adding a new dimension has the potential to offer a novel, more immersive experience for listeners.

The present study investigates perceptual differences between binaural music listening experience and stereo music listening experiences. The aims are to determine whether a 3D mix can increase the immersion into the musical content, and if it is preferred compared to a stereo mix.

Musical excerpts are presented to participants in three mixing conditions: stereo, generic binaural mix (based on KEMAR Head Related Transfer Functions (HRTF)), and individualised binaural mix (based on HRTF pre-selected to fit each participant).

Immersion and preference between the mixes are directly rated by participants during listening.

The hypothesis is that 3D music, especially when individualised, will induce more immersion, compared to the stereo. For the preference stereo might be overall preferred, because listener are familiar with it. Preliminary results suggest that binaural music is preferred over stereo, especially when individualized. For immersion, binaural music seems to be also more immersive.

Results are expected to increase our understanding of how 3D musical content is perceived, and, in a more general sense, of the impact of spatialized audio on the listening experience.

Towards an ontology-based framework to store and recover memories for creative architectural projects

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Background: Memories have a fundamental role in the creation of architectural projects. Remembrances of childhood, travel, and working experiences filtered by reflections and training paths—e.g., the following of rules typical of a discipline or of a style (with its language protocols), embraced by an architectural school—all contribute to the development of new ideas as described in cognitive studies, interviews with architects, critical writings on architecture, etc. (Rossi 1990; Zumthor 2003).
Aims: We aim to help the architect to re-contextualize her memories when captured via external supports like photos, sketches etc., by mimicking the way image schemas are used for the resolution of metaphors in cognitive science (Lakoff 1990). Note that the approach applies also to sound, taste, smell, texture etc.
Method: We use techniques of applied ontology to analyse the formal notions required to encode suitable schemas as well as their application to specific kinds of object features. Focusing on spatial/temporal patterns, we associate and transfer aspects of recorded scenes (e.g., topological or geometrical structures that identify spatial distributions of features of objects) to imagined project solutions. For instance, the alternation of empty and full spaces perceived while looking at the rows of a vineyard on a hill may be creatively transferred to a pattern of colors, textures, or materials for a façade.
Conclusions: Our framework supports architects in annotating (recorded) memories with spatial patterns and helps them to retrieve and reinterpret these patterns for the development of creative project solutions.

How do Chinese speakers conceptualize time? Beyond the horizontal and vertical dimensions

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Spatial metaphors are universally used to conceptualize time (Boroditsky 2001; Li and Cao 2017; Moore 2017). But the use of both vertical and horizontal spatial metaphors in Chinese has provoked debate. Boroditsky (2001) claimed that Chinese speakers think about time vertically because they use also vertical metaphors, whereas other scholars have argued that Chinese speakers think about time both horizontally and vertically (Gu et al. 2013; Hong et al. 2017).

Having studied the etymology of spatial metaphors, we found that beyond the vertical and horizontal dimensions, there might be a cyclical concept of time in Chinese. Researchers use shàng 'up'/xià 'down' to demonstrate the vertical temporal conception, completely ignoring that this use originated in people's observation of the Sun's cyclical movement.

In this study, we hypothesized that the front/back metaphors are used in Chinese to underline temporal order, while the use of up/down metaphors might be explained by the cyclical character of entities. For example, to express last month, Chinese speakers use shàngyuè 'up month' instead of qiányuè 'front month', probably due to the cyclical phases of the Moon, whereas to express the day before yesterday, they use qiántiān 'front day' instead of shàngtiān 'up day', perhaps in order to underline linear transformation of perceived time, as illustrated in (1) and (2).

(1) shàngyuè (up month), zhāng qùshì le.
*qiányuè (front month), zhāng qùshì le.
'Last month, Zhang died.'
(2) qiántiān (front day), zhāng qùshì le.
*shàngtiān (up day), zhāng qùshì le.
'The day before yesterday, Zhang died.'

Does ethnicity influence interpersonal distance?

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Background: During social interactions, we maintain a personal space boundary; we have an invisible "buffer zone" that others cannot enter, without triggering discomfort. This boundary influences how much physical space we keep from other people, creating interpersonal distance. However, personal space boundaries differ as a result of how we identify with others, experience social situations, and perceive our body size.
Aims: Therefore, we investigated the effects of ethnicity, social anxiety, and body dissatisfaction on interpersonal distance.
Method: Full-body photographs of Asian and Caucasian individuals, facing one another, were projected. Apertures, which varied in width, were formed between the images. Caucasian and Asian Australians saw either two photographs or silhouettes and imagined walking between them. They then judged whether they could pass through apertures, without rotating their shoulders. Interpersonal distance was the spatial requirement deemed necessary for collision-free passage.
Results: Caucasian participants' interpersonal distance was significantly smaller for Caucasian, compared to Asian, stimuli. Our preliminary data for Asian participants suggest they required similar distances for Asian and Caucasian stimuli. As both samples yielded small effect sizes, we are currently collecting additional data from both participant groups. We also found that social anxiety and body dissatisfaction were unrelated to interpersonal distance.
Conclusions: Thus, ingroup favouritism was observed amongst the ethnic majority (Caucasians), but not the ethnic minority (Asians). These findings suggest majority members are motivated to differentiate themselves from outgroups. Conversely, minorities showed no differential bias, likely assisting their development of cross-race friendships, and their integration into multicultural societies.

Cognitive rehabilitation of spatial navigation impairment: A feasibility study

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Acquired brain injuries can lead to navigation impairments, which have a profound impact on the quality of life, as patients experience spatial anxiety, limited mobility and reduced autonomy. Impairments often affect spatial abilities in either the egocentric (route knowledge) or allocentric (survey knowledge) domain. A navigation rehabilitation training in the form of a serious game has been developed to train patients to use compensatory navigation strategies. A study with healthy participants (n = 86) was conducted to test the feasibility of the rehabilitation application and to determine the effect of the training on navigation strategies and abilities. Navigation strategies and abilities were assessed in pre and post-training sessions. Based on their pre-training strategy, participants played either the egocentric training (n = 21) or the allocentric training (n = 22) version of the game. Participants engaged in 4 training sessions over a period of 2–3 weeks. Participants in the control conditions (n = 43) did not play the game.

Results show that 42.86% of participants in the egocentric training condition adapted an egocentric strategy after the training. The percentage of participants that changed strategy after using the allocentric training (13.63%), was comparable to that of the control groups (16.23%).

Egocentric training successfully induced strategy change in healthy participants, while the allocentric training did not. We conclude that using serious games to train navigation strategies is feasible. Future research is required to determine the rehabilitative efficacy of the training in a patient population.

Piecemeal and holistic perception as alternating processing modes

Cees van Leeuwen

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Perceptual experience tells us that we see objects as wholes. But perceptual processing studies by Hochberg, Peterson, and others, tell a different story. They suggest that even within an object, perceptual information is available mainly in a piecemeal fashion. Integrated information is something we possess only for that part of the figure our attention is momentarily focused on; for the remaining stimulus the integration is loose at best. This claim, we suggest may be true some of the time, but certainly not always. We propose that perceptual organization dynamically alternates between global, integrated modes, and piecemeal perception. We presented stimuli with ambiguous orientations, flanked by disambiguated stimuli. During a 60 s interval, perception switched, not only between the different orientations of the figure, but also between a piecemeal and a holistically integrated representation. In the latter state, the surrounding context served as a cue to bias the perceived orientation of the figure. These switches were associated with fluctuations in the width of spatial attention, as well as on individual factors, and their correlates in EEG.

Spontaneous representation of vista spaces: Similarities and differences between sighted and blind people

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Vista space (VS) is a psychological space whose scale is "larger than the body but can be visually apprehended from a single place without appreciable locomotion" (Montello 1993). Moreover, VS can combine to represent larger spaces (Meilinger 2008). VS are considered as unit elements of mental representations of space and have only been assessed in sighted subjects (not in visually impaired people).

In this study, we compared VS of sighted and blind people.

We designed a cardboard model of a famous square in Toulouse and the surrounding buildings. 30 subjects (21 blindfolded sighted, 9 blind) who had previous knowledge of the square were asked to spontaneously imagine it (dominant viewpoint). Then they positioned and oriented a figurine in the model, at the location of this dominant viewpoint. We used vector based hierarchical clustering to extract meaningful groups of subjects.

52.4% of the sighted subjects had their viewpoint oriented towards the city hall side, i.e. their mental representation was based on the square geometry. The others had representations attached to the way they usually enter the place, i.e. autobiographical strategies. Two main clusters were identified, one containing 57.1% of the sighted subjects and no blind subjects, another containing 55.6% of the blind subjects and only 4.8% of sighted subjects.

The clustering analysis suggests that VS strongly differ between sighted and blind people. VS of sighted subjects rely on the geometry of the place and strong visual landmarks, whereas blind subjects' VS are mainly based on autobiographical memories linked to navigation.

Children's utilization of response, landmark, and metric strategies in spatial memory

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Spatial information can be encoded using either egocentric or allocentric processing perspectives. The current study examined age related differences in utlizing egocentric response focused, allocentric landmark focused, and allocentric geometric focused information in 69 children aged 6–10 years old and 53 adults. Participants completed a series of experiments in a modified radial arm maze. The maze was composed of six arms which were of three different lengths. Each arm was facing directly to a unique landmark. Participants needed to find a target arm. Unknown to the participant, the arm was defined as a unique combination of its length and neighboring arms' lengths, hence metric information. By systematically changing the starting locations and the consistency of landmark arrangements, we gradually manipulated the reliability and availability of response and landmark information while maintaining valid metric information. Results suggested a rather competent use of allocentric landmark strategy in children as young as 6–8 years old. Their landmark strategy is also

flexible and children were able to discard a previous useful landmark when it was no longer indicative of the target arm. However, relative to adults, both 6–8 and 9–10 year olds performed relatively poorly when only allocentric metric information was available. Adults outperformed two children groups in all quantitative measures, ps $< .05$. Finally, there were also individual differences in how well adults could acquire metric information.

Beat gestures encode spatial semantics

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Background: People gesture when they talk, and often gestures carry information about their words and thoughts. Beat gestures, however, which are simple flicks of the hand, are widely believed to carry no semantic information.
Aims: We show that beats carry hidden meaning, in a large-scale quantitative analysis of more than 5000 spontaneous co-speech gestures.
Method: Pairs of participants (N = 80) told scripted stories suggesting literal or metaphorical motion in one of four directions: up, down, left, or right. The directions of speech and gesture were coded separately. Each gesture was classified as a beat or another type of gesture according to its form. Finally, we used bootstrapping tests to determine whether beats followed the direction of the accompanying speech more often than chance.
Results: Beats constituted the majority (76%) of storytellers' gestures, and their directions matched the directions implied by the accompanying speech much more often than would be expected by chance ($p < .0001$). Beats followed the story directions not only during literal spatial language (my rocket went higher), but also when participants used spatial metaphors for abstract motion (my grades went higher), and when they expressed the same abstract ideas without using any spatial language (my grades got better). Beats were congruent with the directions implied by speech across multiple communicative contexts, even when the listener could not see the gesturer.
Conclusions: Beat gestures are pervasive and meaningful. Unbeknownst to gesturers (and to gesture researchers), beats' directions reveal automatic activation of the spatial schemas that scaffold even highly abstract thoughts.

An inquiry into active spatial language using virtual reality

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Background: Spatial perception is an essential aspect of human intelligence, which among other things, enables us to describe, learn and remember the world around ourselves. Thus, understanding the formation of spatial concepts and their use in active spatial experiences is an important challenge for the study of spatial perception. However, there has not been a comprehensive study for characterizing the use of active spatial language in observational tasks in real world conditions.
Aims: In this research we aim to understand the interactions between spatial perception and language in various environmental conditions. In particular, we investigate spatial concepts in language that are used during active explorations, and characterize them in relation to corresponding visuospatial context.
Methods: We develop an immersive virtual reality system that allows conducting spatial exploration tasks and recording perceptual and language data. Using this system we conduct a an experiment with 16 subjects, and generate a novel dataset, which includes audio recordings and time coded transcriptions; visual modalities such as RGB and depth, and camera extrinsic for a 10-min exploration per subject.
Results: We present a benchmark quantitative analysis of observational statements regarding their referential manner, explicit use of spatial descriptions, temporal continuity, as well as the degree of correspondence between the verbal statements and available perceptual data.
Conclusions: Our research contributes to development of immersive data collection and experimentation methods for the study of spatial perception. Our initial study enables characterization of active spatial language in relation to available spatio-temporal context and opens up possibilities for further inquiries.

Impact of object shape on the interpretation of spatial relations

Liga Zarina, Jurgis Skilters and Signe Balina

University of Latvia

Different descriptions of spatial relations induce different corresponding interpretations of these relations in the visual field (Logan and Sadler 1996). In our study, we explore the differences between the linguistic descriptions of spatial relations and the induced visual areas involving geometric (e.g., squares, triangles) and functional (e.g., mushroom, tree) objects. We conducted an in-group quasi-experimental online study with students (n = 113) of Science, Technology, Engineering, and Mathematics (STEM) and humanities/social sciences as it was also our intention to test possible differences in interpretation of spatial relations according to well-documented links between spatial skills and study fields. Our expectation was that STEM students' interpretations of spatial relations would be more precise and focused (with narrower and more predictable scopes). Subjects' task was to indicate onscreen the location of the particular spatial relation with respect to an object—12 spatial relations with respect to 20 geometric or functional objects with different experimentally varied symmetry properties (e.g., rotational, reflection symmetry). According to our results, the interpretation of different spatial relations depends on the sequence of stimuli sets (geometric stimuli followed by functional, or the other way around). This result is discussed in our paper in the context of perceptual learning of simple spatial relations depending on the shape of the object. The results allow us to conclude that the symmetry axis and center are reliable indicators impacting the interpretation of spatial areas involving geometric and functional objects.

Reading 'sky' and listening to high pitch: Cross-modal mapping between pitch and word meaning

Alexander Zdorovets and Oksana Tsaregorodtseva

Tomsk State University

It has been shown that auditory features such as high and low pitch could be mapped into visual stimuli such as dots presented in upper and lower parts of the screen (Evans and Treisman 2010). Such findings demonstrated the ability of the brain to combine information from different perceptual sources and to employ modality combination for performance enhancement. The purpose of the current study was to test whether perceptual features such as high and low pitch would be linked with words that convey spatial meaning directly ('up' and 'down') and non-directly, i.e. words that have referents with typical space localization (e.g. 'moon', 'grass'). We conducted four experiments asking participants to judge the pitch (high or low) whilst observing visual stimulus on the screen. The results revealed incorporation of word meaning and pitch: when participants saw the directional word 'up', they were faster in judging of the high pitch than the low pitch (vice versa with the word 'down'). The interaction between pitch and non-directional words, however, is not a clear case as the cross-modal effect was not found when non-directional words were placed in the center of the screen. The effect appeared only after we manipulated the position of the words (upper/lower part of the screen) or the task itself (Stroop-like instead of pitch evaluation). The results suggest a linkage between 'real' auditory modality and visual modality, simulated by word meaning, or, in other words, simulated and actual perceptual experience. Automaticity of such linkage, however, should be proposed with caution.

Acknowledgments: Authors express the deepest gratitude to Armina Janyan (New Bulgarian University) for her idea of the work, invaluable assistance in the first stages, and her inspiration during all the time that makes the current research possible.

Walking and learning in a large-scale mediated space: Impacts of viewpoint transition and proprioceptive feedback on spatial learning in virtual reality

Jiayan Zhao[1], Alexander Klippel[1], Meredith Minear[2], Nora Newcombe[3], Bobby Bodenheimer[4], Timothy McNamara[4], Alina Nazareth[3] and Tesalee Sensibaugh[2]

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In room-scale VR applications, most virtual environments are larger than the physical space they occupy. This makes it necessary to creatively think about locomotion approaches in virtual environments to compensate physical constraints. While there is substantial research on this topic, few studies exist that related locomotion to spatial learning. This research investigated the effects of viewpoint transition and proprioceptive feedback on spatial learning in a large-scale virtual environment (VE). In the experiment, participants were divided into three conditions and were directed to travel four routes and learn eight landmarks along paths using teleportation or continuous walking on the desktop display, or using teleportation on the HTC Vive. Two spatial tasks, on-site pointing task and model-building task, were conducted to evaluate the spatial learning outcome. After controlling for the sense of direction and the virtual experience preference, participants' performance of pointing task in the Vive condition was significantly worse than that using continuous walking on the desktop display. In the model-building task, participants using continuous walking on the desktop display had the best performance. Participants using teleportation on the desktop display processed significantly higher modeling accuracy than that using teleportation on the HTC Vive. Findings from this research show that continuous visual flow may enhance spatial learning in large-scale VEs while the spatial advantages of proprioceptive feedback were suspicious. One follow-up is implementing continuous locomotion on the HTC Vive, in which the combination of viewpoint transition and proprioceptive feedback is expected to benefit spatial learning in large-scale VEs.

4. Abstracts of Posters

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

Investigating the role of imagistic imagery in aesthetic experience

Elif Aktas Yanas

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Mental imagery plays a significant role in human reasoning process. Mental imagery is mainly considered as visual. However, like perception, mental imagery is accompanied by multiple perceptual modalities. In mental imagery theory, representation of a mental image is depictive and consists of several types such as imagistic imagery. Imagistic imagery can be described as a mental simulation of an event on the basis of a physical intuition including visual and spatial aspects of situation. Therefore, imagistic imagery is highly associated with motor actions. This relation between motor activities and imagery is merely investigated in terms of imagistic imagery. This study aims to investigate the contribution of visual and spatial physical experience to imagistic imagery. In this regard, two protocol studies will be conducted in order to examine if related visual and spatial experience have an effect on the mental imagery process when interpreting a visual art. Protocol studies will be held among the students who have practical painting experience and those who do not. In the first protocol, students will be asked to interpret an impressionist painting in think-aloud protocols. Protocols will be captured by audio-video records. Transcript of the activity will be reported based on the descriptive hand motions and narratives. In the second protocol, same experiment will be repeated with another impressionist painting. Prior to experiments students will be told to imagine and consider the experience of the artist to see if the instruction affects their imagery process. The results will be discussed based on the acquired data.

Modulation of attentional asymmetries by thin and plus-size models

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Background: As part of our daily life, particularly when we are online, we are constantly confronted with advertisements, which results in the frequent viewing of idealised, and unrealistically thin bodies, as few plus-size models are present within mainstream media. Additionally, prior research supports different attentional patterns when viewing thin versus plus-size bodies.
Aims: We were interested to determine if models of different body weights impact attentional asymmetries (i.e., pseudoneglect). Pseudoneglect is an attentional phenomenon wherein neurologically normal individuals overattend to the left side of space.
Method: Participants (N = 36 females) completed an initial landmark task, to determine their baseline attentional asymmetry. Following this, participants completed a second task wherein a pair of images was presented (one in the left visual field, one in the right) prior to the pre-bisected lines. Image pairs consisted of a combination of thin female underwear models, plus-size female underwear models, and colour-matched handbags (neutral image).
Results: When the thin models appeared on the left, leftward biases were stronger than baseline. In contrast, when the plus-size models were presented on the left, pseudoneglect was nullified, as no significant asymmetries emerged. Importantly, these differences only occurred when the pair consisted of one thin and one plus-size model. Therefore, it appears that participants' attention was attracted to the thin models, but also directed away from the images of the plus-size models.
Conclusions: Our findings suggest that thin and plus-size bodies differentially modulate pseudoneglect, with the socially desirable thin body catching the eye of young women.

Mental manipulation and goal-directed behavior

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Mental manipulation (MM) involves mental evaluations and transformations of various aspects of entities, where some of these processes involve operating on a perceived object, while others reflect integration and manipulation of non-objects, such as ideas. MM is presumed to be domain-general in that it involves a wide variety of mental activities and can be assessed by different measures varying in their content.

The goal of the current study was to examine the relationship between MM and cognitive control. Cognitive control refers to several mental processes within the context of goal-directed actions. As conceptualized in the current study, MM is an essential factor within the context of goal-directed behavior.

The current study was designed to explore the relationship between MM and various aspects of cognitive control, using the methodology of Structural Equation Modeling (SEM). This analysis approach captures the common variance among multiple measures that were selected to reflect the same underlying construct, while attending to differences arising from other cognitive abilities, and correlations of these abilities with MM measures.

In order to examine the relationship between MM and measures of cognitive control, 230 participants completed a variety of tasks of MM and cognitive control (working memory and inhibition). The analyses produced favorable evidence supporting MM as a differentiated construct, yet indicated some degree of shared, underlying cognitive processes.

The pattern of correlations among MM and cognitive control factors seems to be in line with our suggestion that cognitive control and MM share some cognitive processes but also involve distinct operations. Mental manipulation (MM) involves mental evaluations and transformations of various aspects of entities, where some of these processes involve operating on a perceived object, while others reflect integration and manipulation of non-objects, such as ideas. MM is presumed to be domain-general in that it involves a wide variety of mental activities and can be assessed by different measures varying in their content.

Using immersive virtual environments to explore the blocking of geometric information during spatial learning

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Background: When individuals have prolonged experience with an environment, they attempt to build a relatively accurate spatial representation. They use this to make spatial judgments and describe spatial relations between objects and between objects and the observer. They can either use metric coordinate properties ("A is near to/far from B") or use a more abstract way, making reference to the categorical position of the objects (e.g. "A is right/left of B").
Aims: The present study is a first attempt to employ the categorical/coordinate paradigm in the sketching of country maps, in order to see whether it is possible to disentangle these two different sources of mental representations. Starting with a series of very simple sketches of country maps, we try to measure separately the two kinds of information. Moreover, the study also investigates the role of familiarity on sketch map performance.
Results: The results will be discussed in the light of literature about categorical and coordinate spatial relations. Participants can represent geographical information with different degrees of accuracy according the two encoding systems. We will also examine whether familiarity has special effects on the two spatial coding mechanisms.
Conclusion: This study will add further insights into the encoding of spatial relations and extend findings on categorical/coordinate systems to sketch maps.

Whose pointing is beneficial for visuo-spatial working memory: Mine, yours or an animated hand's?

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Many studies have documented that movements performed during the encoding phase interfere with visuo-spatial working memory. However, recent results show that moving one's own hand (i.e., pointing) towards to-be-remembered locations can, under specific conditions, facilitate the recognition of spatial arrays. The present study was aimed at determining, first, whether pointing movements performed by others might also facilitate VSWM performance and, second, whether the positive effect of pointing is limited to biological co-actors. Participants performed a task in which each trial required the maintenance of two consecutive spatial arrays of squares and circles. For one array participants passively observed the items without making movements, whereas for the other array a hand was moved towards the location of each item until touching it. Over three experiments, pointing movements could be performed by the participant (Exp. 1), by the participant alternating with the experimenter (Exp. 2), or by the participant alternating with an animated hand (Exp. 3). We always replicated the beneficial effect of pointing on recognition performance. Importantly, in Exp. 2 and 3, we found that movements performed by the experimenter or by the inanimate hand enhanced array recognition to the same extent as self-performed movements. Results suggest that the facilitatory effect of pointing is not limited to human co-actors and support the hypothesis that the production of movements enhances item distinctiveness at encoding. Future studies should further test this idea by including an attention control condition (e.g., by replacing the pointing movements with flashing lights or other salient events).

Attentional bias toward threatening stimuli in Italian anxious individuals: Evidences from an Emotional Spatial Cueing using three types of emotional stimuli

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Some theories have suggested a higher orienting of attention toward threatening stimuli in anxious individuals. This attentional bias (AB) has been investigated by using different stimuli and paradigms, obtaining inconsistent results that could depend on the different stimuli used and the cultural background. No study so far has examined the impact of three different types of stimuli by using an Emotional Spatial Cueing Paradigm (ESCP).

Aims of the present study were to evaluate the AB in Italian high trait anxiety individuals (HA) by using these three different types of emotional stimuli with an ESCP. 36 HA and 31 low trait anxiety individuals (LA) completed three experiments, each using the ESCP with one of the three cue types (pictures, faces, words) with threatening vs. neutral content. Attentional indexes of engagement and disengagement were calculated in each experiment according to Koster et al. (2006).

A Group (HA, LA) × Experiment (pictures, faces, words) × Validity (valid, invalid) × Emotionality (threatening, neutral) ANOVA showed the main effects of Experiment, Validity, Emotionality and the Group × Experiment × Validity × Emotionality interaction. A Group (HA, LA) ANOVA on Engagement and Disengagement scores for each Experiment showed that HA presented lower attentional engagement than the LA in the Face Experiment.

This is the first study assessing AB using three different types of stimuli. The results highlight only a slower engagement toward threatening faces in HA. To investigate cultural differences in the AB toward various types of emotional stimuli, future studies could replicate this experiment in other countries.

The eccentricity effect of inhibition of return is dominated by the nasal retina

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Inhibition of return (IOR) typically refers to the slowed response time to targets appearing at the previously cued relative to the uncued locations. In recent years, it has been shown that the magnitude of IOR is much stronger in the periphery relative to the perifoveal region of the visual field. In the present study we further investigated whether this effect shows an asymmetry between nasal and temporal retinae under monocular viewing condition. Using a spatial cueing paradigm, IOR magnitudes at two stimulus eccentricities (7° and 21°) were measured in a simple detection task with either the subject's left

or right eye. The results revealed that IOR magnitude was significantly larger for more peripheral stimuli, showing an eccentricity effect of IOR. However, this eccentricity effect was only observed in the temporal visual field and not in the nasal visual field. This asymmetry was observed independent of which eye was used. Our results match the neuroanatomical observations that the nasal retina has a stronger geniculocortical projection with a higher degree of divergence, which presumably also applies to the collicular projection.

Navigating towards a more human-focused space syntax

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Although already much research has been devoted on indoor navigation, the need for more user friendly indoor route guidance systems is still actual. The architectural characteristics of an environment have an influence on the users' wayfinding performance and the construction of their cognitive map. A user friendly route guidance system should be able to take these elements into account. In several researches space syntax theories have been used to establish this link, but rarely were they compared to actual user experiences.

This research will therefore first of all compare space syntax measures with user perception on complexity. The link between theory and practice will make it possible to calculate the perceived complexity for every decision point in a building. To decrease cognitive load during a wayfinding task, route communication can be adapted to the complexity of a decision node. This way, the correct amount of information is provided in the most suitable manner. The aim of this research is therefore the development of an adaptive indoor route guidance system where route communication (amount and type of information) is adapted to the perceived level of complexity.

The link between space syntax, cognitive load and route communication will be established through online surveys, eye tracking and thinking aloud experiments. By applying this user centred design the usability of the final product will improve. This poster will report on the first steps of the research and its results, namely the space syntax calculations and the online survey outline, which are currently being executed.

Crowding across depth

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In two studies, we investigated how defocus blur and binocular disparity affect crowding effects across the third spatial dimension, depth. Crowding is the phenomenon of reduced recognition of peripheral targets, which are flanked. Its extent in 2D depends on the spatial configuration of stimuli, e.g. target eccentricity and target-to-flanker spacing. To present stimuli in real depth, displays of two adjustable screens were superimposed by a semi-transparent mirror. That way, in two experiments flankers (Experiment 1) and targets (Experiment 2) were defocused within the depth of field, while the other (target or flanking) stimuli were kept on the fixation depth.

In Experiment 1, we expected less crowding with increasing depth separation of flankers. However, results indicated more crowding for larger depth separation. Double images due to retinal disparity might account for this effect. Additionally, we found an asymmetry between presenting stimuli in front compared to behind: When flankers were in front, there was less crowding than when flankers were behind. Thus, in front of fixation depth sensitivity to blur and retinal disparity might be increased.

In Experiment 2, when target stimuli were defocused, we replicated the asymmetrical distribution of crowding effects in depth: Crowding for targets in front of the fixation depth was increased compared to the two-dimensional condition on fixation depth; whereas crowding was decreased when targets were defocused behind. Again, effects of blur and retinal disparity might account for an increased sensitivity for stimuli in front of the fixation depth. Thus, defocusing the to-be-identified target in front increases crowding.

Seeing or hearing? The influence of music and spatial surrounding on perceived atmosphere

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Previous research has shown that music affects the emotional experience of environments. In the present study we aimed at determining how exactly music and room ambience interact in creating emotional atmosphere. By conducting two pretests we identified two rooms which strongly contrast in the valence of their perceived atmosphere. We also identified a musical piece matching each of the room with regard to perceived valence, respectively.

In the experiment, 32 participants were exposed to the four combinations of spatial surrounding and music for 10 min each, on two different days. Immediately after exposal they rated their experienced overall atmosphere. Room valence and musical valence both significantly affected the experienced overall valence. In line with our pretests, the pleasant room was rated more positive than the unpleasant room and the pleasant music was also rated more pleasant than the unpleasant music. However, a significant interaction showed that the valence of music had a stronger effect on overall atmosphere in the pleasant room than in the unpleasant room. Accordingly, the valence of the spatial surrounding influenced the overall atmosphere stronger in the pleasant music condition than in the unpleasant music condition. These findings suggest that positive spatial surroundings amplify the atmospheric impact of highly valent music. This indicates that pleasant surroundings might be easier influenced in their perceived atmosphere by unpleasant stimuli than unpleasant surroundings.

How social orienting affects attentional bias toward food stimuli

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Many intercultural studies have investigated the attentional bias (AB) for food-stimuli and the influences of body-shape on eating behavior; however, no study has assessed whether males and females present a different AB for food-stimuli when their attention is triggered by social-stimuli.

The aim of this study was to investigate, in male and female, how social-stimuli affect the orienting toward food-stimuli.

Sixty-five Females (Age: 24, 51; DS: 2, 97) and forty-five Males (Age: 24, 87; DS: 3, 62) completed an Eye Gaze Cueing Task using as central cue a face (the same woman's face changed to Under-Weight, Normal-Weight, and Obese). The targets were hypercaloric-food IAPS-images that were presented right or left respect the cue. The trials were Valid (the stimulus was presented to the same side where the woman's gaze was directed) and Invalid (the stimulus was presented on the opposite side to the woman's gaze direction).

An ANOVA GenderxCuexValidity on mean Reaction Times (RT) revealed significant main effects and interactions; these were analyzed by a CuexValidity ANOVA on males and females separately. Results showed slower RT in Under-Weight-Face then in Normal-Weight or Obese-Face only in Invalid trials, in females ($F_{2,128} = 5{,}66$; $p < 0.005$; $p\eta^2 = 0.08$).

The results showed an attentional avoidance towards food-stimuli when the face was thin, only in females. This gender difference could suggest a higher females' sensibility to social-stimuli, and it could depend on the fact that the cue was represented by a woman's face. These findings could be an interesting starting point to investigate the relationship between the ideal physical beauty and the social attention to food-stimuli also in different cultures.

When does it emerge the trainability of mental rotation in preschool education?

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Background: In the last decades, the trainability of spatial skills has been acquiring a remarkable relevance. Given the malleability of spatial skills in adults and scarce studies in Preschool Education, a key question arises about when emerge and can be training the mental rotation capacity. The previous research has not showed clear evidence about the benefits of a mental rotation training in preschoolers under 5 years old.
Aims: It will be analyzed the effectiveness of a mental rotation program.
Method: 58 preschoolers (27 girls and 31 boys; M = 3.21 years) of 1st year, and 61 (32 girls and 29 boys; M = 3.9 years) of 2nd year participated in the study. The training consisted of three sessions of increasing difficulty applied on consecutive days. In the training phase, while the training group was trained, the control group performed their normal class.
Results: It was found a significant improvement in mental rotation in training group compared with control group, only in 2nd course. With respect to young children, the training was not effective, although it could be established a tendency towards significance.
Conclusions: This study showed that a mental rotation training was effective in young children from very early stages. Nonetheless, for children between 3 and 4 years old, this training seems to be not enough to promote their mental rotation improvement. The results underline the importance to provide adaptative spatial resources as a tool that could benefit the spatial development, especially in 4 and 5 years old children.

Sensorimotor integration of allocentric spatial information for reaching

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Previous studies investigating the role of allocentric cues for reaching typically employed landmarks lacking ecological relevance. To overcome this limitation, we use naturalistic visual scenes containing multiple visual landmarks. This allows us to identify the contextual factors influencing the use of allocentric cues for reaching. In a series of experiments we asked participants to encode object arrangements in naturalistic visual scenes presented either on a computer screen or in virtual reality. After a delay, a test scene briefly reappeared with one object missing and other objects shifted horizontally. Participants then reached toward the remembered location of the missing target on a grey screen. On the basis of reaching errors, we measured how object shifts influenced reaching behavior. We found that reaching errors systematically varied in the direction of object displacements. Importantly, these errors only occurred when the shifted objects were task-relevant, i.e. they were potential reach targets. Environmental objects irrelevant for the task were largely neglected as indicated by eye movement behavior. Reaching errors in the direction of object displacement increased with the number of task-relevant objects shifted and were more pronounced when the shifts were spatially coherent. The influence of object shifts on reaching behavior was similar for objects presented on a screen (2D) and in a virtual scene (3D). Our results demonstrate that humans use environmental information for reaching in 3D space. However, task relevance and image coherence are important factors determining to which degree this information is integrated into the reach plan.

Visual spatial attention in elderly: Analysis of the orienting effect

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Aging is characterized by a decline in the spatial orienting that negatively affects daily life activities, making the elderly poorly able to select quickly and correctly the areas and/or the objects of interest for

the activities they are doing. Aims of this study were to analyse the age-related effects on attentional orienting, costs and benefits.

Twenty-seven Young (Age: 23, 33; SD: 1, 30) and twenty-seven Elderly (Age: 61, 74; SD: 6, 44) completed the ANTI-Fruit, which use strawberries and pears as target and flankers stimuli. Participants were required to respond, by clicking the right or left button on the mouse, to the fruit on the center of one semicircle consisting of four fruits (flankers). Before the presentation of the stimuli, an asterisk appeared in the same position of the upcoming target (valid condition); in the opposite position than the one signalled by the cue (invalid condition); in no-cue condition no cue was presented. Reaction times (RTs) were used to estimate: orienting effect (Invalid-Valid), attentional-benefits (no-cue-valid) and attentional-costs (invalid-no-cue).

The ANOVAs (Elderly, Young) revealed that orienting-effect ($F1,52 = 8, 47$; $p < 0.01$; $p\eta^2 = 0.14$) and costs were higher in elderly than in young ($F1,52 = 7,02$; $p = 0.01$; $p\eta^2 = 0.11$).

Findings of the present study suggested that the impairment of the orienting in the elderly could be due to a greater difficulty in reorienting the attention from an invalid to a valid position. The attentional costs in the elderly people could be due to an impairment in voluntary processes of spatial attention.

Anticipation of body-scaled action is related by socio-affective resources

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When interacting with their environment, people automatically consider the spatial representation of their body and generate sensorimotor representations that are involved in guiding action (De Vignemont 2006). Recent findings have suggested that physical and socio-affective resources affect space perception and action (Stefanucci and Geuss 2009; Osiurak et al. 2012). For instance, Morgado, Muller, Gentaz, and Palluel-Germain (2011) provided insights on the relationships between socio-affective resources and spatial perception. They demonstrated the more participants feel affectively close to two acquaintances, the more they judge they can pass between them and the less space they require. These results suggest perception of aperture between two acquaintances relates to socio-affective resources such as affective closeness. An intriguing issue is whether this effect generalizes to other socio-affective resources such as self-esteem, social anxiety, or appearance evaluation. To address this issue, we requested 55 women to complete a questionnaire about socio-affective resources. Then, they imagined passing through an aperture and judged whether they could pass. To examine whether the effect of socio-affective resources on spatial perception depends on social context, participants judged their ability to pass at varying width between two silhouettes or between two walls. We found that they felt more able to pass between two walls than two silhouettes. Whatever the social context, the more they are satisfied of their appearance, the more they felt able to pass. This provides first evidence of the relationship between appearance evaluation and the perception of aperture, confirming that socio-affective variables constrain space perception.

Street angle sensitivity in map reading

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TU Darmstadt

Why are people getting lost even if map information is available? One factor might be that the simplified and detail-reduced top-down view of a map has to be compared to the environment perceived in walking perspective. Using the example of x-intersections, we aimed to quantify to which extent humans are able to perceive a mismatch between map and environment. Data was collected from 52 participants facing a VR-intersection in walking perspective and a map view on a computer screen. Map and intersection corresponded completely or differed in one street angle. Participants were asked to decide whether the given map view showed the intersection or not. For every participant, we identified the individual angle deviation necessary to perceive a mismatch between map and VR-environment. This data was correlated to performance in the Spatial Orientation Test (Hegarty and Waller 2004) and self-reported spatial orientation abilities (FRS, Münzer and Hölscher 2011). While street angle sensitivity did not differ between males and females, only for male participants did a higher street angle sensitivity correlate with a higher score in the FRS scale "cardinal directions". The average angle deviation to detect a mismatch was 17.7 degree (SD = 7.79) for women (n = 29), and 18.1 degree (SD = 10.62) for men (n = 21). Further research should address how these values change with intersections' geometry (e.g., T-intersections) and complexity of the environment or map.

Climbing as a couple: How sighted coaches and visually impaired athletes coordinate their perception and action in indoor guided climbing training

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Background: Although providing evidence that coaching practices affect the athletes' participation and performances (Ford et al. 2010; Horn 2008; Jowett and Cockerill 2003), also in the case of athletes with disability (Banack et al. 2011; Tawse et al. 2012), most psychological research in the sport domain underestimate that coaching, as a situated and coordinated activity, is achieved by means of interactional and discursive practices (Miller and Cronin 2012).
Aims: During paraclimbing training and competitions, visually impaired athletes are verbally guided by their coaches. Sensory resources for accessing the climbing space are distributed between the coach (visual access) and the climber (haptic access). The study aims at showing that coach and climber act as a couple and that the climbing performance is realized through interactional and discursive practices working as ad hoc devices for dealing with the climber's visual impairment.
Method: The study is based on a corpus of 12 h of video recorded indoor climbing training sessions involving 3 elite climbers with visual impairment and 2 sighted coaches. We adopt Conversation Analysis to analyse the sequential relationship between verbal instructions and body movements during guided climbing sessions.
Results: Verbal instructions display the coach's close monitoring of the climber's actions. The climber's responses to instructions embody locally shared understandings about the projections of the unfolding instructional activity. Among the resources mobilized by the coach,

frames of reference used for locating foot/handholds are sensitive to the climber's disability and deictic expressions (i.e., locatives, demonstratives) work as means for attuning the coach's visual and the climber's haptic experience.

Perceiving and acting in a common and shared space: A systematic exploration of the social dimension of peri-personal space

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Peri-personal space (PPS) is a multisensory area surrounding our body, where we can easily interact with objects and people. PPS refers to a dynamic representation, which adapts to changes of body properties as well as to characteristics of objects in the environment. Several studies have also pointed out the social value of PPS, showing that the multisensory processing of stimuli is altered by the simple presence of a confederate. In this context, we conducted several experiments in order to explore the social dimension of PPS, focusing on both how people perceive and actively explore their action space when they perform a cooperative task with a confederate in cooperative and competitive conditions. We also investigated the effect of sharing the action space in a cooperative task performed either concurrently (active confederate) or successively (passive confederate). In three experiments, participants estimated the reachability of 31 visual targets presented at different distances along the sagittal body-midline axis, before and after realizing with a confederate a game-like target selection task on a tactile table. Results showed that exploration patterns of action space were dependent on social context and task constraints. PPS representation was found to expand following the game-like target selection task, but not differently in the competitive and cooperative conditions. Moreover, PPS representation did not change after sharing the space with a passive confederate. Overall, these experiments highlighted the plasticity of the representation of PPS which depends on body characteristics, objects value, but also on the dynamic aspects of social interactions with confederates.

Virtual reality in landscape architecture

Evan Granito and Mark Lindquist

University of Michigan

This poster explores ways in which virtual reality is being used by landscape architects and urban planners at the University of Michigan. It displays 3D exterior environments in the traditional 1080p video format, a monoscopic 360° video format, and a stereoscopic 360° (VR) video format. It also explores current applications of these immersive visualization formats for urban planners, children's hospitals, and community outreach/participatory design initiatives around Ann Arbor, Michigan. The QR codes found throughout the poster allow viewers to use their own handheld mobile device to view 3D/VR video content.

The poster also contains a link to an Android mobile App (in the .apk file format) that can be installed on any Android mobile device. This application contains a simple User Interface allowing users to view the same videos linked in the poster (eliminating the need for a QR code reader), while also allowing the user to scan the poster itself and view augmented reality (AR) 3D models of exterior environments. This demonstrates one method of easily integrating AR/VR content into poster displays or client presentations—a method which could facilitate the integration of these technologies into existing industry workflows.

The mobile application was created using the Unity3D video game engine by graduate students at the University of Michigan. It can be easily downloaded and installed free of charge by following the link on the poster. As with any other mobile application, it may be easily deleted and removed from the device after use.

Latent factors of mental rotation accuracy and speed: An item response theory analysis

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Successful performance on spatial tasks is marked by both speed and accuracy, although these indicators are frequently correlated (i.e., speed-accuracy tradeoff). Understanding the relation between speed and accuracy is critical given that response times can provide an indication of spatial strategies, and gender differences tend to be exacerbated on timed spatial tasks. The present study investigated the relation between the speed and accuracy of spatial task performance using newly developed Response Time Item Response Theory (IRT) modeling. Adolescents (N = 206) completed a 3D Mental Rotation Task (Shepard and Metzler 1971) while accuracy and response time (RT) were recorded. Four latent factor response time IRT models were fit and compared: (Model A) a single factor predicting both accuracy and RT; (Model B) two uncorrelated factors separately predicting accuracy and RT; (Model C) two correlated factors predicting accuracy and RT; and (Model D) separate, uncorrelated factors for accuracy and RT in addition to a general factor predicting both accuracy and RT. Model D was the best fitting model, and indicates that a general mental rotation ability factor contributes to both speed and accuracy of performance, above and beyond unique latent factors of speed and accuracy. There were gender differences favoring males on all three latent factors (p's $< .001$). Understanding the latent factor structure of mental rotation ability has implications for deepening our understanding the multi-faceted construct of spatial ability and improving interventions.

Comparison of learning with vibro-audio maps versus traditional tactile maps background

Benjamin Guenther, Nicholas Jensen, Brad Butler, Kaitlyn Haase, Toni Kaplan and Nicholas Giudice

University of Maine

Current technology supporting indoor spatial learning by blind and/or visually impaired (BVI) individuals generally relies on static, hard-copy maps produced on expensive equipment. This study investigates

an alternative solution, designed to increase accessibility by using vibration and audio cues via a touchscreen-based smartphone interface, called a vibro-audio map (VAM).
Aims: Promising results have been found with sighted populations using the VAM and the present research aims to test its efficacy for supporting learning/wayfinding by BVI individuals.
Method: Five BVI participants studied (via free exploration) two maps (containing four target locations) rendered either with the VAM or an information-matched hardcopy tactile map (HTM). Target locations were at structural landmarks (intersections) or midway along corridors. After learning, participants performed an environmental transfer test in the corresponding physical building, where they navigated between target locations without access to the map. As specific routes were not provided during environmental learning, wayfinding performance at test required accessing an accurate cognitive map.
Results: While learning with the HTM was quicker (201 s) than learning with the VAM (359 s), overall target localization accuracy was consistent between conditions, HTM (70%) versus VAM (70%).
Conclusions: As expected, learning took longer using the VAM. Importantly, equivalent wayfinding performance was observed in both conditions, demonstrating the potential of the VAM for supporting learning and cognitive map development. These findings suggest the VAM warrants further exploration as an accessible and robust new navigation solution for blind and visually impaired people.

Authentic places: Does knowing about the history of a place influence the emotional impact of associated pictures?

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Against the background that context information about a place can influence people's judgments this experiment aimed to investigate whether negative context information about a building results in more negative ratings of associated pictures. Therefore we manipulated participants' prior knowledge by telling them about Nazi crimes that happened in the building in that they currently are (group A), about the same Nazi crimes without reference to the building (group B), or giving them no prior information (group C). Afterwards participants were shown pictures portraying situations related to the Nazi history and had to rate the valence and arousal provoked by each picture. We also let participants rate the valence and arousal associated with the room they were currently in and measured how long they took to leave it. Additionally, participants' personal mood and arousal was measured before (t1) and after (t2) providing the context information as well as directly after rating the pictures (t3). Both groups A and B rated the pictures' valence significantly more negative than group C. This effect was mediated by participants' personal mood (t2). Furthermore, group A perceived the pictures significantly more arousing than group B, whereas group C did not differ from groups A and B. Analogously this effect was mediated by participants' personal arousal (t2). Group A perceived the room more negative and with higher arousal than group B. Regarding the time required to leave the room no differences were found. Overall, the results suggest that context information has an impact on judgements about associated pictures and places.

Immersive 3D haptics for navigating virtual space background

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Immersive virtual environments (VEs) are almost exclusively rendered and perceived visually. This research presents an innovative new approach for unconstrained bimanual exploration of 3D VEs rendered completely through touch.
Aims: To assess the efficacy of our immersive haptic interface by demonstrating that blindfolded individuals can use the system to learn and navigate unfamiliar virtual routes.
Methods: Ten blindfolded participants used two HTC Vive controllers to navigate three-leg routes built with Unity3D. The controllers provided independent haptic feedback to each hand when contacting the virtual walls. Hand/head tracking (using optical sensing) allowed for real-time updating of user position in 3D space during navigation. In one condition, a constant vibration was used to indicate the walls and in a second condition, a pulsing vibration was added to indicate the presence of junctions. After navigating one route in each condition (counterbalanced), participants performed a point-to-origin task from the route's terminus to assess cognitive map development. Navigation time, number of wall-collision errors, and pointing errors were logged and analyzed.
Results: Data collection is ongoing but pilot results support our hypothesis that blindfolded users can complete simple virtual routes using our vibrotactile interface. Navigation times were shorter with pulsing vibrotactile signals indicating junctions (51 s) than with constant vibration (74 s). Data trends also indicate fewer collision errors and higher pointing accuracy with cues than without.
Conclusions: Findings support the efficacy of our haptic rendering technique and have broad-based applications to nonvisual navigation research and the use of immersive haptic VEs as a learning tool.

The experience virtual reality: Are individual differences in mental imagery associated with sense of presence?

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The concept of 'presence' describes the quality of subjective experience in Immersive Virtual Reality (IVR). Presence is a specific state of consciousness: we behave and feel as if we actually were in the virtual world although we know there is nothing there. In their handbook of Virtual Reality, Burdea and Coiffet (2003) suggested that the experience of presence would emerge from the combination of three I: Immersion (capacity to isolate from the external world), Interaction (capacity to naturally exploring the virtual environment), Imagination (individual differences in mental imagery). Several studies have investigated the technological and psychological factors affecting the degree of immersion and interaction. However, no study

has explored the relationship between perceived presence and mental imagery. Here we aim at filling this gap through a correlational study comparing self-reports about sense of presence and mental imagery. After experiencing two IVR scenarios (art gallery and sitting room), 142 male and female users were administered with questionnaires assessing the degree of presence (Igroup Presence Questionnaire, IPQ), and the degree of vividness (Vividness of Visual Imagery Questionnaire, VVIQ) and control (Test of Visual Imagery Control, TVIQ) of mental images. Results showed a clear positive correlation between presence and vividness: the higher the rated vividness of mental images the stronger the sense of presence felt in IVR scenarios. Instead, the capacity of imagery control showed a weaker association with presence. We may conclude that individual differences in perceived presence and mental imagery abilities are associated.

Endogenous attentional shift modulates inhibition of return: Look down, detect faster

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Inhibition of return (IOR) in detection tasks is observed when participants respond slower to targets that were peripherally cued with a cue-target onset asynchrony larger than 300 ms. Although much research has been done, little is still known about the role of spatial endogenous attention in the IOR effect. We examined whether different endogenous cues would interact with the peripheral exogenous cue and modulate the IOR effect. Two types of endogenous cues were introduced: symbolic (arrows pointing up or down) and semantic (words with direct spatial meaning: up vs. down). The cues were presented centrally, simultaneously with the exogenous cue.

Our first experiment replicated IOR with vertically presented cue-target stimuli (squares). Experiment 2 (semantic cue) showed that words did not interact with the IOR effect, however, they influenced target detection in one condition: target in the lower part of the screen was detected faster when it was preceded with a word "down". Experiment 3 (symbolic cue) suggested IOR modulation by the down-arrow: IOR magnitude was increased in cases of a conflict between exogenous cue (upper part of the screen), target location (upper or lower part of the screen), and the arrow pointing down. More precisely, down-arrow facilitated target detection in the lower part of the screen and inhibited the detection in the upper part of the screen, in a way, breaking the IOR profile. The results showed a specific role of endogenous attentional shift in target detection connected, probably, with a lower visual field advantage in object detection.

The effects of digital drawing on social-emotional skills: A pilot study

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Background: The ability to correctly identify the others' emotions represents an important socio-emotional skill. Visual arts education (e.g., portrait drawing) may foster this skill since it includes both receptive and productive processes that may lead to a deeper elaboration of relevant facial features that are diagnostic for emotion recognition.
Aim: Connect the field of visual arts education with a psychological perspective in order to optimize socio-emotional skills, especially emotion recognition. We expected that participants who focused on emotional facial features (emotion drawing task) perform better in an emotion recognition task than participants whose attention was directed to non-facial features, e.g. workwear (job drawing task). In addition, we were interested in studying the effects of self-reference on emotion recognition.
Method: 145 participants categorized emotional expressions as quickly and accurately as possible before and after the drawing task using an animated emotion recognition task. A mixed design with the within-factor emotion (angry, happy, fearful, sad) and the between-factors drawing task (emotion, job) and self-reference (picture of me/another person) was employed. We investigated the impact of self-reference when participants had to draw facial or non-facial features of their own picture (with self-reference) or of a picture of another person (without self-reference).
Results: The results indicated that participants in the emotion drawing task improved in their anger and sadness recognition, irrespective of self-reference, compared with participants in the job drawing task.
Conclusions: The results suggest that drawing can be a potential method to improve participants' emotion recognition skills.

Ambiguity of landmark pictograms enhances salience and recognition performance

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Landmarks, salient objects in the environment used for orientation, navigation and the generation of cognitive maps are often represented in maps as pictograms. In order to support these tasks effectively and efficiently, the landmark pictograms also need to be salient, as the map user needs to identify and process them quickly and easily. Two additional characteristics relevant for the usability of landmark pictograms are their interpretability and memorability. Interpretability is required to understand which objects the pictograms are representing. Memorability prevents the necessity to consult a map repetitively and may support the generation of a cognitive map of the environment. In the presented study, we investigated the relation between salience,

interpretability and memorability of OpenStreetMap (OSM) pictograms and potential effects of visual complexity of pictograms on these usability characteristics. Salience was measured via eye fixations on specific pictograms, interpretability with an explicit continuous scale and memorability with a recognition task. Statistical analyses showed that pictograms draw more visual attention if they are visually complex or if their meaning is inapprehensible or ambiguous. Interestingly, such ambiguous pictograms lead also to worse recognition performance. Long fixations on a pictogram increase the likelihood of false recognition in subsequent situations when the pictogram is no longer valid or relevant. Based on the findings, we suggest balancing the interpretability and visual complexity of contiguous pictograms to enhance their recognition and to provide an optimal level of salience of single objects.

Navigation strategy with a virtual-reality hallway environment

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A successful navigation requires humans to encode cues in an environment to move towards a destination. Reorientation paradigm has addressed the use of geometrical and featural cues in a rectangle or a trapezoid room by adding perturbation. This study addresses a similar topic but in a larger environment with an immersive virtual reality setup. We recruited 40 university students (20 males) who learned a route to a target door in a hallway model with 3 distinct landmarks placed along the route. Once they learned the route, they went through 4 testing trials, in which perturbations were added to the environment, i.e. removing all the landmarks, adding extra hallways, displacing the landmarks, and changing the starting location. Then, they had a control trial identical to the learning trials. In each trial, the participants were asked to find the target door, and their navigation path in conjunction with the choice of the door was recorded to investigate navigation strategy, i.e. whether they used the learned route or the landmarks to find the target. The results showed 13 participants could use the learned route during the trials without the landmarks. Most participants preferred using landmarks to find the target during the other testing trials. Thirty-five participants found the target, while five other participants chose one of the incorrect doors during the control trial. Chi square test did not reveal a significant difference in the navigation strategy between males and females. Overall Conclusion: the majority of young adult relied on landmarks to find the target.

Effects of stereotype activation on gender differences in performance and metacognition during a first-person virtual maze learning task

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Background: In addition to the persistent gender difference in spatial navigation performance, there is preliminary evidence to suggest the genders differ in their metacognition of spatial tasks. It is also unclear whether stereotype activation would have an effect on the gender difference in navigation performance, and whether this effect would influence metacognition.
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 via changes in metacognition.
Methods: Participants ran through a first-person navigation task consisting of a series of video tours paired with 30 maze performances. 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 (Pro Male condition), or (2) Women are better at this navigation task than men (Pro Female condition), or (3) That the genders do equally well (Neutral condition).
Results: Stereotype activation had an effect on all navigation performance measures, where the gender difference was greatest for the Pro Male condition and smallest for the Pro Female condition. However, stereotype activation had no effect on metacognitive measures. Discussions on the gender differences in metacognition, in spatial anxiety and general spatial metacognitive knowledge reveal the need for further research.
Conclusions: This research supports the idea that gender differences in navigation performance can, at least partially, be explained by sociocognitive differences.

Oculocentric reference frame of inhibition of return in the far peripheral visual field

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Inhibition of return (IOR) provides a well-established paradigm to investigate attentional control in the visual field. Recent studies have shown that IOR is characterized by a functional dissociation in the visual field with a stronger inhibitory magnitude in the periphery compared to the perifoveal visual field. The present study further investigates whether IOR in the two regions of the visual field is controlled by the same or different spatial reference systems. Using a spatial cueing paradigm, both the perifoveal and the peripheral IOR were measured in twenty four university students at the originally cued position of the visual field and the corresponding retinotopic location following a gaze shift. The results showed a clear difference between the perifoveal and peripheral IOR (indexed by the RT difference between the mirror symmetric cued and uncued locations). In the perifoveal region, an environmental coordinated IOR was observed, but in the periphery both the environmental and the retinotopic coordinated IOR were demonstrated. This observation supports the functional dissociation of attentional control in the visual field with different spatial reference systems in the perifoveal and peripheral visual field. As has been suggested previously (Singer et al. 1977, EBR 29, 173–190), attentional fields are much larger in the periphery which presumably explains the observed dissociation.

Tactile mislocalisations on the fingers and toes

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Localising where on the body one has been touched is a fundamental perceptual problem. Recent research has shown highly systematic patterns of mislocalisations and confusions between digits. These distortions appear highly stereotyped and consistent across individuals. The present study addressed whether such mislocalisations arise from early somatosensory maps or higher-level body representations. Given that the glabrous and hairy skin of the hands and feet have distinct representations in somatosensory cortex, an effect arising from early somatotopic maps may show distinct patterns on each skin surface. In contrast, if the effect arises from higher-level body representations which represent the digits as complete, volumetric units, similar patterns should be apparent on both sides of the digit. We applied tactile stimulation to the hairy and glabrous skin of the fingers and toes, and asked participants to identify the stimulated digit. From this, we obtained patterns of mislocalisations across both skin surfaces of the fingers and toes. Our results clearly replicated the characteristic pattern of mislocalisations on the glabrous skin of the toes reported in previous studies, as well as the distinct pattern of mislocalisations across the fingers. Critically, these effects were highly similar on the hairy skin of the hands and feet. These results suggest that mislocalisations occur at the level of complete toes, rather than individual skin surfaces, consistent with their resulting from higher-level body representations. Despite the pattern of mislocalisations being highly stereotyped across participants, there were consistent individual differences in task performance across the two skin surfaces for each individual.

The evaluation of attentional orienting in Italians and Chileans children with ADHD: Effects of two different school integration strategies

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The Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common psychiatric disorders in childhood. Different formal education systems seem to be more or less effective in improving the attentional performance of the ADHD children.

The aim of this study was to assess whether two different school integration strategies, Italian special education teacher and Chilean School Integration Program (PIE), can differently affect the attentional performance of children with ADHD.

Forty Italian children (20 ADHD, 20 control) and 40 Chilean children (20 ADHD, 20 control) aged between 8 and 13 completed the ANTI-V, which allows to simultaneously evaluate the three attentional components (alerting, orienting, executive) and directly measure the vigilance.

A Group (ADHD, Control) × Nationality (Italy, Chile) × Cue (Valid, Invalid, No-Cue) × Warning (Warning, No-Warning) × Congruency (Congruent, Incongruent) ANOVA on accuracy showed a significant Group × Nationality × Cue interaction.

Results have shown a significant difference within the Italian group between ADHD and control group children in the invalid trials. In the Italian ADHD group, there was also a difference between valid and invalid trials.

These findings could suggest a higher difficulty for Italian children in reorienting their attention; specifically, this difficulty would be more accentuated in children with ADHD. To verify the effectiveness of these results, other analyses are needed. If these findings will be confirmed, the adoption of a similar program in Italy could allow proving the effectiveness of the PIE educational support in the ADHD treatment.

Dancing: A spatial activity that enhances visuospatial skills?

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Dancing has proved to be an interesting activity for training spatial skills, especially those related to egocentric rotation (Cortese and Rossi-Arnaud 2010). Dancing may also enhance visuospatial abilities in a broader sense, as an environmental skill, compared to other sports which require less spatial rotation. The aim of the present study was to examine spatial and navigation abilities, and self-perception of movement imagery in dancing. The sample was composed of two groups: 14 modern group dancers aged 16–21 (M = 18.47; SD = 2.03) and 15 volleyball players aged 17–21 (M = 19.73; SD = 1.79) with 10–14 years of experience. A series of tasks testing visuospatial working memory (VSWM) and mental rotation, and questionnaires on spatial preferences (De Beni et al. 2014) and movement self-perception (Roberts et al. 2008) were administered. Participants also learnt a route in a virtual environment, reproduced it and then found a shortcut. The results showed that, by comparison with volleyball players, dancers had more movement self-perception, and performed better in the VSWM task, while the two groups showed a similar rotation task accuracy. After learning the route, the two groups also had a similar route reproduction accuracy, while dancers were better at finding shortcuts. Overall, although our findings need to be confirmed in a group uninvolved in any sporting activities, these results suggest that experiencing egocentric rotation in certain spatial activities, such as dancing, is associated with better visuospatial resources, and the formation of better environment representations.

On the plausible nature of the effect of Ebbinghaus illusion on throwing performance

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The Ebbinghaus illusion refers to the fact that people perceive targets as bigger when they are surrounded by small circles than by big ones. Recent studies showed that people are also more accurate at throwing a projectile at targets surrounded by small circles than by big ones. Some researchers concluded that displaying small circles around targets would increase throwing accuracy through increasing their perceived size. Although this conclusion paved the way for using the Ebbinghaus illusions to improve motor learning and performance in sport, it is not consistent with previous studies on this illusion. Indeed, these studies showed that the mere presence of surrounding circles decreases the perceived target size but that the small ones decrease it to a lesser extent than the big ones. In our study, participants estimated the size of targets projected on the floor before throwing a projectile at them. We manipulated not only the size of the surrounding circles but also their presence. Our results indicated that the presence of small circles did not affect estimated target size, whereas the presence of big circles decreased it. In contrast, the presence of small circles increased throwing accuracy, whereas the presence of big circles did not affect it. These results are inconsistent with the perceptual explanation of the positive effect of small circles on throwing accuracy. This underlines the need for considering how visual illusions work to prevent overconfident conclusions about their practical interest in sport.

The effect of observed tool-use on distance perception

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Reaching for an object with a tool seems to influence distance perception. People estimate targets to be closer to them when they have a reach-extending tool available than when they have no tool. This effect also seems to arise when observing someone else using a reach-extending tool. Witt and Proffitt (2008) proposed that motor simulation, usually defined as the activation of the same neural pathways when performing or observing an action, plays a central role in such effects. As motor simulation is supposed to rely on the perceiver's motor knowledge, observing an action that is not physically plausible should not elicit motor activation. To evaluate the role of motor simulation in tool-use effects on distance perception, participants watched point-light videos of an actor reaching a target with a tool or with his hand. We manipulated the kinematics of the actor's movements, assuming that observing modified movements should interfere with participants' motor simulation. We predicted that if motor simulation plays a key role in tool-use effects, this effect should vanished when the actor's movement does not follow human biomechanical constraints. However, in our experiments we were not able to replicate the main effect of tool-use. Participants estimated targets to be further away from the actor when he used a reach-extending tool, which is the opposite of the underestimation of reachable distance reported in the literature.

Mental rotation of ears: Which type of transformation is elicited by left/right judgments of unmovable body parts?

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Background: Mental rotation involves three types of transformation: object-based (rotating an object), effector-based (moving one's own effector such as hands or feet), and perspective transformations (rotating one's own perspective). The selection of transformation is modulated by task demands. While object-based transformations are predominantly adopted for same/different judgments of two stimuli, any type of transformation is possibly adopted for left/right judgments of a single stimulus, depending on stimulus type. Specifically, effector-based and perspective transformations are adopted for left/right judgments of effectors and whole bodies, respectively. However, it is unclear which transformation is employed for left/right judgments of unmovable body parts (e.g., ears).
Aims: The present experiment examined whether unmovable body parts elicit object-based, effector-based, or perspective transformations, using pictures of human ears as stimuli.
Method: Participants performed same/different judgments of a pair of ears and left/right judgments of a single ear. Stimuli appeared in different orientations in the picture plane across trials. After each task, participants reported, using visual-analogue scales of 0% to 100%, on how often they adopted each of three transformations during each task.
Results: While participants reported mostly using object-based transformations (94.8%) for the same/different judgments, both object-based (69.3%) and effector-based (27.3%) transformations were used for the left/right judgments. Furthermore, the two transformations led to different response time functions across stimulus orientations: response time increased monotonically with orientation for object-based transformations, but not for effector-based transformations.
Conclusions: People could perform effector-based transformations in the form of simulated head movement for left/right judgments of ears, which are unmovable body parts.

Tracing a route and finding a shortcut: What are the cognitive, motivational, and personality factors involved?

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The present study aims to investigate the role of spatial ability, visuospatial working memory, spatial anxiety, pleasure in exploring,

self-efficacy, and personality treats in affecting two different navigation tasks: route retracing and shortcut finding. A total of 116 (87 F.) participated. University students was conducted through a route of a virtual environment and were successively requested, first, to retrace the same route as that learned and, second, to find the shortcut from the start to the end point. A series of instruments assessing sense of direction, self-efficacy, spatial anxiety, positive attitude in exploring, personality traits, spatial ability and visuospatial working memory were administered. The results showed that spatial ability and visuospatial working memory predict route retracing, whereas self-report measures of anxiety, efficacy, and pleasure in exploring, along with some personality traits are more likely to predict shortcut performance. We concluded that personality and ability individual variables can influence wayfinding performance, but with specific relationships depending on task requests.

Web search navigation strategies: The effect of age and intelligence

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In the last years, the number of elderly people using internet is increased. However, it emerges that older adults find fewer correct answers than younger adults during Web searching tasks (Chevalier et al. 2015). These differences could be explained by the age-related decline of some cognitive abilities such as memory and reasoning (Park 1999) or problem solving (Crabb and Hanson 2014). The aim of the present study was to understand the relationship between the Web Search Navigation Strategy and individual characteristics, such as users' age and Intelligence Quotient (IQ). The intent was to identify differences due to age and not to other variables (i.e., cognitive decline, or computer expertise). For such purpose we involved only participants with the same experience in the Web use.
Method: 20 students (18–30 years) and 20 adults (60–75 years) performed the experiment. Inclusion criteria were the frequent use of computers and the Web searching activity; older adults performed MMSE (Folstein et al. 1975) to exclude cognitive impairment. Participants were requested to solve the K-BIT-2 (Bonifacci and Nori 2016) for IQ level and nine Web Search Tasks (Chevalier et al. 2015). Results showed that elderly take more time to solve problems ($F1,38 = 6.91$, $p < .05$) but with the same accuracy than young people ($F1,38 = 1.12$, $p = .29$). Furthermore, as expected IQ was a mediator of this relationship ($F2,39 = 4.41$, $r^2 = .15$, $p < .05$). These results may reflect that older people need more time to solve the task as a consequence of the need to pay attention and to monitor their thoughts, as found in other previous studies on elderly.

Influence of stereoscopic depth information on visual search

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Stereoscopic depth information is important in everyday life. It enables us to interact with objects in a three-dimensional environment. Recent findings indicate that (unexpected) depth information might possess the ability to automatically attract attention. Yet it is still under debate whether attention can be focused onto specific depth planes. This question was investigated in a series of experiments. Participants searched for a singleton (target) which was defined by (stereoscopic) depth (i.e. presented in a "near" or "far" depth plane) and accompanied by an additional but irrelevant singleton (distractor). Distractor type (color or depth) as well as target and distractor depth plane ("near", "far") were varied in order to test whether these features modulate visual search behavior. The pattern of results indicates that depth information can be used to facilitate search performance. However, it was also apparent that irrelevant information captures attention. Although stronger interference was related to distractors presented in the target depth plane, it was apparent that information from unattended depth planes causes attentional capture as well. This was independent of distractor type (color or depth). Finally, there are inconsistent results regarding the role of the target depth plane: Targets presented in the "near" depth plane are detected faster in some experimental conditions. However, it was also observed that targets displayed in the "far" depth plane can be detected faster, especially when attentional shifts across depth planes are required. Overall, these findings indicate that attention in space is a non-uniform process and can be modulated by task-specific requirements.

Parent–child talk about spatial relational comparisons within an informal learning setting

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Research highlights the value of spatial relational comparisons, in which children compare sets of spatial properties or relations, attending to similarities and differences, for engineering learning in makerspaces (Ramey and Uttal 2017). Evidence suggests that comparisons facilitate abstraction of relational structures, and subsequent transfer of knowledge to novel contexts (Alfieri et al. 2013), ultimately promoting children's acquisition of engineering principles (Gentner et al. 2016). However, little research has investigated the variability of spatial relational comparison usage within makerspaces. Therefore, the current study explores families' use of spatial relational comparisons within a makerspace exhibit at a children's museum. 25, 6- to 8-year-olds and their parents were video recorded while addressing an engineering design challenge: building playground equipment on which a finger-monster can move. The conversations were coded for spatial relational comparisons. Results revealed that 72% of families compared materials and tools (e.g., "If we get a bigger bit we get a bigger hole, it would be good if the hole was big enough to stick this in."), 24% compared others' creations (e.g., "We

might need more support for this. See how that girl put a support on top and drilled it in? Maybe that's what we should do."), and 52% drew comparisons to prior knowledge (e.g., "Think about how a monkey bar looks. It's usually pretty thin, right?"). Further, 24% of families made 1 type of comparison, whereas 48% made 2 types and 28% made 3. Additional analyses will examine the role of spatial relational comparisons within the engineering design process.

Is the mental-rotation performance influenced by gender and orientation abilities?

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In spatial cognition tests, males often outperform females with the greatest effect in mental-rotation tests. The aim of the study was to clarify whether gender differences in orientation skills could be one possible reason for gender differences in mental-rotation performance.

We administered a chronometric mental-rotation test with cube figures (47 items) to 65 participants (16 males, 49 females, age: M = 21.85; SD = 2.35) and measured error rate and reaction time. Afterwards, they filled out a questionnaire about their abilities to get along with certain means of orientation such as navigation systems or compass direction as well as their overall orientation skills.

Males outperformed females in error rate but not in reaction time and had higher scores in orientation skills and compass direction (controlled for imbalanced sample). A better use of navigation systems is correlated with fewer errors in the mental-rotation test. Only for males, a faster reaction time is correlated with a higher score of navigation systems and compass direction.

The correlation of the use of navigation systems and mental-rotation performance could be mediated by interest for technology of participants who are using navigation systems. Another possible explanation could be that navigation systems are often pointing to the north and the display must be mentally rotated to match the representation of the real world while a map can be rotated manually. The higher scores in orientation and compass direction in males could be related to a more successful strategy in mental-rotation and therefore lead to better performances.

Emotional facial expressions implicitly affect on the regulation of interpersonal distances

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The distances between persons are defined 'Interpersonal space' (IPS). People react by extending this space when feeling in hostile/uncomfortable situations or reducing it when feeling in friendly/comfortable situations. Recent research has shown a close link between these interpersonal mechanisms and 'Peripersonal space' (PPS), i.e. the area in which we can interact with objects and people. Explicit distance judgments typically assess these spaces: comfort-distance for IPS (distance at which people still feel comfortable with the other's proximity); reaching-distance for PPS (distance at which people think they can touch the other). Recent evidence has suggested that the size of IPS and PPS are similarly affected by emotional facial expressions that would elicit approach/avoidance behaviors. Critically, this finding could reflect a tacit compliance with the explicit instructions rather than spatial-emotional mechanisms. To assess the robustness of the impact of emotions on spatial regulation, a perceptual discrimination task implicitly requiring the regulation of interpersonal distances was devised. Since threatening cues can produce an "interference effect" on behavior, we expected that angry (neither positive nor neutral) facial expressions should disturb the perceptual task and, consequently, reduce interpersonal distance. In Virtual Reality, participants were approached by avatars showing happy, angry and neutral facial expressions. Participants had to stop them as soon as they could discriminate a target-stimulus on their t-shirts. The results showed a difficulty in perceptual discrimination, and consequently shorter interpersonal distance, when facial expressions were negative than positive and neutral. This confirms that threatening emotions implicitly influence the regulation of interpersonal distances.

Trust, personality factors, attachment styles, and modulation of the interpersonal space: A correlational study

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Research has shown that attachment styles and personality factors can affect complex social behaviors, such as the interpersonal-comfort space, i.e. the distance people maintain between themselves and others. Typically, people expand the distance from intruders in uncomfortable situations and shrink the distance in comfortable situations. Another key component in the regulation of the social space is the trust people establish with the others. Trust refers to the assumption that people are honest and will not deliberately do anything to harm us. To our knowledge, no study has directly investigated the relationship between these factors. This study aimed at investigating whether the trust, personality dimensions and attachment styles are associated with the regulation of the interpersonal-comfort distances. Two-hundred six participants (100 women; Mean age = 32.74 y.o.a., SD = 11.08; range = 18–60 y.o.a.) were administered the Big Five Questionnaire, the Attachment Style Questionnaire's (ASQ), the Interpersonal Trust Survey (ITS), and the Interpersonal Visual Analogue Scale (IVAS). The IVAS was used as a proxemics projective measure about comfort distance. The main results should reveal that a short interpersonal-comfort distance is positively related to the trust (to own and others' behavior), to Dynamism and Openness, and negatively with the need of approval and discomfort with closeness. The ASQ subscale trust should result associated with the reduction of the comfort distances (IVAS). Age-effects will be also analyzed. The findings should reveal that the complexity of our behaviours is modulated by our socioemotional life along with the need of controlling the social context in terms of protective near body space.

Differences in spatial skills among STEM and humanities and social sciences' students: Evidence from SBSOD test

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According to several studies [3, 4], spatial skills can be a predictor of success in different areas of studies. In our study (an online experiment with students from STEM areas (n = 59) and humanities/social sciences (n = 52)), we explored whether the Santa Barbara Sense of Direction (SBSOD) test [2] shows differences across fields of studies and what the impacts of demographic factors are present. Although our results show no significant differences ($\alpha = 0.05$) between students with respect to the field of study, there are (a) differences between male and female participants from STEM areas, (b) impacts of hobbies on the results for some parts of the SBSOD test—e.g. active use/experience of space seems to support spatial skills. We also discuss the impacts of our sample structure and agree with Hegarty [1] that different STEM fields exhibit various strengths of connection to spatial skills. We conclude by arguing that a more complex structure of impacts among demographic profiles and different STEM fields is necessary.

[1] Hegarty et al. (2010). Do all science disciplines rely on spatial abilities? Preliminary evidence from self-report questionnaires. In International Conference on Spatial Cognition, Springer, pp 85–94.

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[3] Uttal et al. (2013). The malleability of spatial skills: A meta-analysis of training studies. Psychol Bull, 139(2), 352.

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Perceivers change their perspective when an agent is introduced in a static situational context

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Background: The relative frame of references includes three strategies: translation, reflection and rotation. We are interested in changes of strategies in situations with different complexity.
Aim: The study investigated which strategy German native speakers chose in simple spatial relations and in relations supplemented by an artificial agent. It explores, whether the participants shift their perspective to the agent.
Method: In a mouse tracking study with German native speakers, we examined the interpretation of 248 sentences and illustrations of static spatial relations. In the simple condition, participants interpreted the location of a bottle in a room with different furniture, answering the question "Where does the bottle stand?" In the complex condition, an agent was additionally introduced and participants completed sentences like "Hans says the bottle stands…"
Results: For simple static extrinsic relations, participants mostly use the reflection strategy. Spatial relations with a round object caused less doubts to the participants than with rectangular one, particularly with locatum to the right of the relatum regarding the reflection strategy (from participants' point of view). Participants chose the expected reflection strategy more frequently in the simple condition than in the complex one. In the complex condition, most participants shift the origo to Hans' point of view. However, they deviated from the interpretation more frequently in relations with the bottle 'to the right/left of' than 'in front of/behind' the table from Hans' point of view.
Conclusion: These data suggest that an increase in the situational complexity has an impact on the interpretation of spatial relations.

Can postural control interfere with episodic memory?

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Background: Episodic memory allows someone to mentally travel in the past and relive an event in the same contextual features (e.g., spatial) than during encoding. Thus, a spatial task should interfere with recall if spatial processes are engaged; even though the source recall doesn't explicitly require remembering spatial features.
Aim: This experiment aims to study the relationship between postural control demand and memory performance.
Method: Participants learned three lists of 17 words in three different conditions (i.e., reading, copying and one-by-one presentation on a computer screen). They performed a semantic task of similarity judgment (i.e., what feature do these two objects have in common?) with three possible answers (i.e., proportion, flexibility or weight) and an episodic task of source recall. These two tasks were realized while the participant was supine or upright (Experiment 1); standing on a static or a moving platform (Experiment 2). The center of pressure under the feet was registered during the tasks.
Preliminary results: In Experiment 1, postural control demand didn't impair memory performances. However, different postural sway profiles have been observed during episodic and semantic task.
Discussion: The first results showed that stance can be modulated by the memory task's properties. It can be suggested that the postural and episodic tasks would interfere more with each other than the postural and semantic tasks when balance condition become more challenging. In line with situated cognition, this should suggest that an episodic task requests an online reconstruction recruiting processes used in current postural control.

The eccentricity effect of inhibition of return along the vertical meridian of the visual field

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Studies with a spatial cueing paradigm have indicated an eccentricity effect of inhibition of return (IOR), namely, the peripheral visual field beyond approximately 15° eccentricity is associated with a stronger IOR relative to the perifoveal one. This effect is found to be independent of cortical magnification and resistant to subjects' practice. Since all previous observations supporting this phenomenon come

from a spatial cueing paradigm that manipulates stimulus eccentricity only along the horizontal meridian, the present study aims to further find out whether there exists a vertical border, and if so, where. By measuring the IOR effects (indexed by the RT difference between the cued and uncued locations) at different stimulus eccentricities along the vertical meridian in a series of studies using typical spatial double-cueing procedure, we found that the IOR magnitudes were significantly stronger at the more peripheral locations, confirming the eccentricity effect of IOR. The border between the two functional regions along the vertical meridian was found at an eccentricity of approximately 6°–8°. These results complement previous observations and suggest a functional dissociation of attentional control in the visual field with a narrower vertical border than the horizontal one.

Men in black and green: Testing a link between perceptual and conceptual knowledge

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Previous studies showed that perceptual knowledge is able to shape abstract concepts such as "good" and "bad" due to activation of conceptual information during color perception (Meier et al. 2004). It was suggested that conceptual knowledge about particular color is activated and affected processing of words (positive/negative words in black and white color). In the set of the research in this field, the issue about automaticity of the perceptual/conceptual link is still unresolved. Meier et al. (2004) showed the aforementioned link only in the semantic categorization task, while Sherman and Clore (2009) demonstrated it in a simple Stroop task. Four experiments were conducted to examine whether color (associated with positive/negative emotion) would affect the processing of emotion-laden words (adjectives, describing positive/negative man's characteristics) in various types of tasks. In the pretest, green was evaluated as 'good' color and black as 'bad'. No effect was found in experiment 1 (Stroop-like task), experiment 2 (lexical decision task) and even in experiment 3 with semantic categorization task, where participants had to judge whether word means color or not. Only in experiment 4, where participants were asked to discern positive and negative word semantics, a significant interaction between color and meaning was obtained. Green positive words were evaluated faster than black positive words. The reversed pattern was found for negative words. Thus, claim about automaticity in such perceptual/conceptual link is limited, since a strong interaction between color and word was found only when task drew participants' attention to particular features of semantics.

Acknowledgment: Authors express the deepest gratitude to Dr. Armina Janyan (New Bulgarian University) for discussions during the research and her assistance in the first stages of the work.

Spatial categories around bodies and objects

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Recalling object locations from memory in impoverishment conditions requires the combination of two types of information, metric and categorical. The latter helps to increase the accuracy in performing the task when the former is noisy but it elicits spatial biases because responses are systematically directed towards the central value (or prototype) of the surrounding region (the category). This phenomenon has been observed for various geometrical shapes (Huttenlocher et al. 1991; Wedell et al. 2007) and natural objects (Holden et al. 2013) and it can be used to map the internal representational structure of objects. However, to our knowledge, no studies investigated if the same phenomenon can be observed when people have to remember a location in the space around an object or a body, meaning when there is no surround that can help to segment the space. Here we report a series of experiments that show that spatial prototypes also emerge around objects and bodies. Participants had to locate a dot that was previously presented in the vicinity of one object (or a body). We observed that responses were biased towards specific sub-regions around the object suggesting that people divided the surrounding space into four sub-quadrants. A new method for analysing the spatial prototype effect is also discussed.

Is good always right? The level of on-line stability of space-valence body-specific associations

Violeta Valkova and Armina Janyan

New Bulgarian University

According to the body-specificity hypothesis (Casasanto 2009) people who interact with the environment differently (e.g., right- and left-handers), should also construct different mental representations even of abstract concepts such as "good" and "bad" depending on their handedness. Casasanto (2009) showed that people associate positive concepts with the space around their dominant hand and negative concepts with the space around their subordinate hand. First, we have replicated and extended previous findings, establishing a relationship between handedness and mental representation of abstract concepts. In a task required categorization of positive and negative nouns participants showed the expected RT-profiles: right-handers categorized positive concepts faster with their right hand than with the left one, and negative concepts faster with their left hand than with the right one. Left-handers showed the opposite pattern. Our third examined group, ambidexters, showed no significant interaction. Second, we asked whether short-term changes in motor fluency could re-shape the association between the space and abstract concepts to the extent visible in the online valence categorization task. We reduced the hand motor fluency of our right-handed participants applying a "glove-and-domino-task" (Casasanto and Chrysikou 2011). Then the same participants were run through the RT valence categorization task. The results showed a non-significant interaction with the same pattern obtained with left-handers discussed above. To conclude, the experiments showed fast re-shape of mental representations of abstract concepts manifested in an online categorization task. Thus, the results suggest high level of instability of our mental representations and their dependency on currently experienced motor fluency.

Off the beaten track: Intuitive indoor navigation support

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Indoor navigation systems are not well adapted to their users. More specifically, the algorithmic route planning support is usually limited

to the shortest path algorithm or derivatives although people not always prefer these paths. Adjusting these algorithms to guide people along more intuitive paths could be a substantial improvement of these systems. To identify the aspects that differentiate an intuitive path from the shortest path, first, an exploratory study was conducted to provide an overall view on the problem. One of the findings of that study was that complexity of a route should be considered on different levels: the global level (e.g. the structure of the route) and the local level (e.g. specific environmental characteristics inducing complexity). In a subsequent analysis, we conducted an online survey focusing on this local complexity. Video recorded segments of an indoor route from the navigator's perspective were shown to the participants. They were asked to score their comfort level towards the situations in the videos on a Likert scale. This survey was published on Amazon Mechanical Turk to reach an international public. The preliminary results of the online survey did not reveal any patterns so far. A real-life experiment is planned to validate these findings. The outcome will provide answers to which path characteristics are determinative for people in their indoor route planning and how people interpret these path characteristics. Translating these findings into a cognitive route planning algorithm will facilitate people's navigation indoors.

5. Author Index

For each first author reference is made to type of contribution (KEYNOTE, SYMPOSIUM, TALK, or POSTER), and for every co-author reference is made to the first author.

Holloway, A.L.
→ Smith, A.D. (SYMPOSIUM 16)
Hölscher, C. → KEYNOTE; Jazuk, K. (TALK); Li, H. (TALK)
Hood, B. → Gilchrist, I.D. (SYMPOSIUM 16)
Huckauf, A. → Eberhardt, L. (POSTER)
Iachini, T. → SYMPOSIUM 9; POSTER; Cartaud, A. (TALK); Rapuano, M. (POSTER); Ruggiero, G. (SYMPOSIUM 12); Serino, S. (POSTER)
Innes, A. → Grzeschik, R. (SYMPOSIUM 16)
Iosa, M. → TALK
→ TALK
Itkonen, E.
Ivanov, T. → POSTER
Janmaat, K. → Dolins, S. F. (SYMPOSIUM 3)
Jansen, P. → Lehmann, J. (SYMPOSIUM 10); Pietsch, S. (SYMPOSIUM 13)
Janyan, A. → Ivanov, T. (POSTER); Valkova, V. (POSTER)
Jaussen, P. → Delogu, F. (TALK)
Jazuk, K. → TALK
Jensen, N. → Guenther, B. (POSTER)
Johnson, A. → Hilton, C. (SYMPOSIUM 12)
Jones, P.M. → Baxter, R. (POSTER)
Josa, R. → TALK
Jouffrais, C. → Vergnieux, V. (TALK)
Jusyte, A. → Kastner, L. (POSTER)
Kalay, Y.E. → Esposito, D. (TALK)
Kan-Kilic, D. → TALK
Kant, N. → Postma, A. (TALK)
Kao, V. → Delogu, F. (TALK)
Kaplan, T. → Guenther, B. (POSTER)
Kastner, L. → POSTER
Kavounoudias, A. → Polidoro, L. (TALK)
Keil, J. → POSTER
Khamassi, M. → Pasala, S.K. (TALK)
Kikuno, Y. → TALK
Kilteni, K. → SYMPOSIUM 7
Kimura, K. → POSTER
Klippel, A. → Zhao, J. (TALK)
Kolvoord, B. → Grossnickle Peterson, E. (POSTER); Grossnickle Peterson, E. (TALK)
Kondyli, V. → SYMPOSIUM 1; TALK
Kostov, K. → TALK
Kuchinke, L. → Keil, J. (POSTER)
Kumari, B. R. → TALK
Kurath, S. → Berkowitz, M. (TALK)
Lachmair, M. → Cervera Torres, S. (TALK); Ruiz Fernandez, S. (TALK)
Latham, X. → Delogu, F. (TALK)
Lehmann, J. → SYMPOSIUM 10
Lemieux, C. → POSTER
Levin, D. → SYMPOSIUM 2
Levine, S. → SYMPOSIUM 6
Li, H. → TALK
Li, J. → TALK
Li, Q. → TALK
Li, X. → Tong, Y. (POSTER)
Ligonniere, V. → Gyselinck, V. (SYMPOSIUM 12)
Lin, Y.T. → Bohnemeyer, J. (SYMPOSIUM 15)
Lindemann, O. → Miklashevsky, A. (TALK)
Lindquist, M. → SYMPOSIUM 3; Granito, E. (POSTER)
Lini, S. → Durupt, C. (TALK)
Liu, Y. → POSTER
Logan, R.K. → KEYNOTE
Loney, N. → SYMPOSIUM 5
Longo, M.
→ SYMPOSIUM 9; Manser-Smith, K. (POSTER); Tamè, L. (SYMPOSIUM 7); Tucciarelli, R. (POSTER)
Longstaff, K.A. → Gilchrist, I.D. (SYMPOSIUM 16)
Lopez, A. → TALK; Caffò, A.O. (TALK)
Loy, F. → Frankenstein, J. (POSTER)
Lu, Z. → Fiehler, K. (POSTER)
Lucero, B. → TALK
Luck, G. → Simon, A. (TALK)
Lugli, L. → Piccardi, L. (POSTER)
Lum, J. → Palmer, B. (SYMPOSIUM 15)
→ Boncompagni, I. (POSTER); Chacón Candia, J.A.(TALK)
Lupiáñez, J.
Luyat, M. → Polidoro, L. (TALK)
Macé, M.J-M. → Vergnieux, V. (TALK)
Maffei, L. → Iachini, T. (POSTER)
Man, K. → Grossnickle Peterson, E. (POSTER)
Manser-Smith, K. → POSTER
Marcus, M. → Polinsky, N. (POSTER)
Marotta, A. → Boncompagni, I. (POSTER); Chacón Candia, J.A. (TALK); Favieri, F. (POSTER)
Marsh, K. → SYMPOSIUM 14
Martella, D. → POSTER
Martinie, O. → Morgado, N. (POSTER)
Martinuzzi, M. → Farnè, A. (SYMPOSIUM 9)
Maselli, A. → SYMPOSIUM 7
Masi, S. → Miglietta, S. (SYMPOSIUM 16); Trapanese, C. (SYMPOSIUM 16)
Masolo, C. → Stufano Melone, M.R. (TALK)
Masullo, M. → Iachini, T. (POSTER)
Mavros, P. → Jazuk, K. (TALK); Li, H. (TALK)
McNamara, T. → Zhao, J. (TALK)
Meloni, C. → Delogu, F. (TALK)
Meneghetti, C. → SYMPOSIUM 13; POSTER; Barhorst-Cates, E. (TALK); Pazzaglia, F. (POSTER)
Menzel, C. → Dolins, S. F. (SYMPOSIUM 3)
Meredith, G. → TALK
Merkt, M. → Gussmann, M. (POSTER)
Mermillod, M. → Francois, C. (POSTER)
Merrill, E. → Yang, Y. (TALK)
Meunier, H. → Trapanese, C. (SYMPOSIUM 16)
Miglietta, S. → SYMPOSIUM 16
Miglino, O. → Cerrato, A. (TALK)
Miklashevsky, A. → TALK
Milde, C. → SYMPOSIUM 7
Minear, M. → Zhao, J. (TALK)
Mirolla, M. → TALK
Molfese, D. → Delahunty, T. (SYMPOSIUM 5)
Molto, L. → TALK; Morgado, N. (POSTER)
Moore, R. → Bohnemeyer, J. (SYMPOSIUM 15)
Moors, P. → Goetschalckx, L. (TALK)
Morales, P. → Lucero, B. (TALK)
Morgado, K. → Lucero, B. (TALK)
Morgado, N. → POSTER (2x); Francois, C. (POSTER); Molto, L. (TALK)
Morgagni, S. → Durupt, C. (TALK)
Morikawa, K. → Muto, H. (POSTER)
Moussavi, Z. → Kimura, K. (POSTER); Ranjbar Pouya, O. (TALK)
Muffato, V. → SYMPOSIUM 12
Muggianu, V. → Delogu, F. (TALK)
Mula, S. → Delogu, F. (TALK)
Munion, A. → TALK
Muñoz-Quezada, M.T. → Lucero, B. (TALK)