

Poster presentations

(in alphabetical order, according to the first authors' last names)

Video game play changes spatial and verbal memory: rehabilitation of a single case with traumatic brain injury

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Few studies have shown the contribution of the use of 3D video games in memory rehabilitation. 3D video games are based on the virtual reality technology. It has been shown that navigation of a virtual environment allows participants to encode the spatial layout of the virtual environment and activate a network of areas as the hippocampus involved in memory processing (Maguire et al. 1998). The present study describes the rehabilitation of a 24-year-old man with traumatic brain injury presenting with memory deficits. The study's objective was to evaluate a video game training programme and to assess possible relationships between memory enhancement and fMRI increase of signal in hippocampal and extra-hippocampal brain regions. The video game was a driving simulator. During the training, the participant was requested to explore a complex virtual town from a ground-level perspective. The training consisted of 15, 1-h sessions three times a week (total length of intervention 5 weeks). The patient was evaluated before and after training by means of an fMRI and a standardised neuropsychological assessment. During scanning, the participant underwent some verbal and spatial memory tasks. Behavioural data show an increase in performance on both verbal and spatial memory tasks. Memory improvement appears to be present also in a follow-up testing (after 2 months). Further, fMRI data suggest that this training may increase the activation of hippocampal and parahippocampal brain regions. The results of this preliminary study indicate that the intensive video game training may result in an enhancement of memory function in brain-damaged adults.

Planned behavior and “local” norms: an analysis of the space-based aspects of normative ecological behaviour

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The role of spatial proximity in the construction of social norms is explored in the domain of ecological behaviour. An extended version of the theory of planned behaviour (TPB) is used to predict intentions

to recycle household waste. The aim was to assess the role of different kinds of social norms within the TPB model: injunctive norms, descriptive norms, group norms and local norms. Local norms refer to the normative influence people can exert on others by crossing, occupying or living in the same spatial context. Observing spatially proximal other's behaviour might prime and activate individual voluntary choices. This idea can be traced back to the early beginning of experimental and social psychology, as in W. James principle of ideomotor action. We argue here that this spatial normative influence should occur in the case of behaviours having collective implications (such as recycling household waste). The TPB should then work better if including also measures of local norms at different spatial scales (perceived behaviour of neighbours, inhabitants of the residential area, and inhabitants of the city). Four hundred and fifty-two participants filled in a questionnaire measuring the original TPB variables—attitudes (injunctive) subjective norms, perceived behavioural control, behavioural intentions—plus descriptive subjective norms and both descriptive and injunctive local norms. The results confirm the distinction between local and subjective norms showing their independent effects on ecological behavioural intentions. The spatial aspects involved in human cognition and action and the distinction of spatial local norms from other sources of normative influence are discussed.

Line bisection performances in apathy versus depression

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Given the well-documented left cortical hypoactivity in depression, some of its associated symptomatology could prove to result in corresponding bias in estimations of centers of lines. The performance using each hand on line bisection task have been compared in equivalent (in respect to usual psycho-demographic parameters) groups of right-handed, middle-aged persons, corresponding to each combination of depression (according to DSM-IV criteria and clinical cutoff scores of common severity measures) and apathy (estimated with “The Apathy Evaluation Scale” of Marin, Biedrzycki and Firinciogullari, 1991): with depression but no apathy ($n = 21$), with apathy but no depression ($n = 19$), with depression and apathy ($n = 20$), without any of the two ($n = 25$). A systematic bias in estimating the center of the lines was similar in depressives and non-depressives, but was significantly larger in the presence as compared to the absence of apathy (either alone or associated with depression). It seems that apathy but not depression is related with relevant errors on line bisecting.

Line bisection performances in depressives

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The recent theory of group cortical organization and activation (Carlstedt 2004) suggests that depressive subjects, with their well-known left cerebral hypoactivity, will err more leftward on line bisection; in present paper, we try to test this prediction. The performances using each hand in line bisection task have been compared in three equivalent (in respect of relevant demographic variables) groups of right-handed, middle-aged persons: non-depressive (euthymic) controls ($n = 19$ f + 19 m), dysphoric subjects ($n = 17$ f + 15 m), and depressive patients before the initiation of any treatment ($n = 16$ f + 16 m) [All the diagnosis were based on DSM-IV criteria and clinical cut-off scores of common severity measures of depression.] Despite a relatively constant more leftward deviation of the estimations from objective midpoint in depressive and dysphoric as compared to euthymic subjects, the data analyses revealed no statistically significant difference in performances with each hand in neither pairs of groups. Given the large heterogeneity of the depressive syndrome, such result pleads just for the need to develop a more sophisticated evaluation of the visuospatial correlates of the influence of depression on hemispheric asymmetry.

Monitoring changes in the spread of spatial attention following loss of situation awareness

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This experiment examined whether a sudden loss of “situation awareness” induces a change in the spread of spatial attention, either leading to a narrowing or alternately a widening of attentional focus, reflecting strategies or bias in information sampling. To explore this question, a simulated military situation was used in which knowledge about a target item was built over phase 1 of the task and then violated on phase 2. On phase 1, a display appeared on each trial, with quadrants representing areas of terrain being monitored for hostile enemy vehicles. A target item (the enemy) or a distractor item (a friendly) appeared on each stimulus trial in one of the four quadrants and Ps had to decide if a target was present. The critical variable in defining a target was location (i.e., the specified quadrant). Following the each trial, feedback was given as to hits, misses, correct rejections or false alarms. True–false probe questions assessed attention to central and peripheral information in the arrays. Once Ps had achieved the criterion for the target items, the locations of target and distractor were then reversed on phase 2 of the task and the spread of spatial attention was again assessed with probe questions to determine if the spatial focus had now narrowed to the central spatial field or alternately widened to the peripheral field. The results are considered in terms of the effect of information sampling bias on attention to the spatial environment.

Age differences in spatial orientation ability: what is preserved in the elderly?

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The research investigates the role of age in spatial orientation ability measured using a pointing task. Two groups of adults, young ($M = 22.62$) and older ($M = 64.67$), were required to point in the direction of (1) landmarks within their home town, (2) villages close to their town, and (3) other Italian towns. Half of the landmarks were aligned and the other half counter-aligned with respect to the perspective adopted by the participants (north oriented). A series of spatial tasks were also administered. The results revealed that older people, unlike their younger counterparts, showed the typical alignment effect: aligned pointing was easier than counter-aligned pointing. However, older adults performed as well as younger people in pointing towards places within their own town, and even better in judging the direction of villages close to their town. Visuospatial abilities are differently related to the pointing task in aligned and counter-aligned conditions. The overall finding is that older adults preserve spatial orientation ability for places and environments close to where they live but have the difficulty in pointing to towns of which they have no direct experience. Performances in spatial orientation tasks are differently sustained by visuospatial ability.

Visual search and visual feedback in Williams' syndrome and typical development

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Across the two experiments, we investigated whether visual search performance represents a peak or a trough within the visuospatial domain in Williams' syndrome, and whether performance can be improved using feedback. Performance was compared with that of a group of typically developing children matched on non-verbal ability. Experiment 1: basic visual search. A single target shared one (feature search) or two (conjunction search) properties with 6, 10, or 14 distracters (set size). Patterns of performance were consistent with the literature for both the groups (response times [RT] were longer in the conjunction, than in the feature condition, and conjunction RT increased as set size increased). Experiment 2 investigated whether level of performance could be improved using visual feedback. Participants clicked on four targets amongst 4, 8, or 12 distracters that were similar or dissimilar in size to the targets. In the feedback condition, but not the control condition, targets changed colour once they had been clicked. Feedback facilitated performance in both groups to a similar extent, in terms of both RT and accuracy. More specifically, feedback reduced the number of repeated clicks on each target, but did not reduce the number of clicks on distracters. This pattern was consistent across the groups. These experiments demonstrate that visual search in WS shows a typical pattern of performance, but is delayed to the level that you would expect given their general level of non-verbal ability. Importantly, we have also shown that individuals with WS are able to respond to visual feedback in a typical manner.

Word retrieval activations related to the contextual spatial tasks (navigation and allocentric) performed during their encoding: preliminary fMRI results

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We aimed at detecting activation during word retrieval. The words were encoded according to two spatial tasks: navigation (self to object relations) and allocentric (object to object relations). We hypothesized that word retrieval will activate the same regions as those classically activated by each spatial task. Outside the magnet, participants learned 36 words within specific contextual spatial tasks (navigation or allocentric). Each learning condition was composed of four phases: a movie presentation, a word presentation, a spatial test, and a verbal recall of the word presented. This verbal recall insured the binding of the word to the contextual task. Navigation movies were recorded from “observer walking through the environment” perspectives, allocentric movies were recorded from “aerial observer” perspectives. Although, the contextual information presented across conditions were equivalent and thus conditions only differed on the type of spatial processing done. During the fMRI examination, we measured the cerebral activity during an event-related word recognition task (half previously learned, half new). Random-effect group analyses were performed with the SPM5 software. Regions of interest were identified and the parameter estimates (% of the signal intensity variation between conditions) were extracted from each ROI within a 5 mm³ box. The values were compared by means of a one-way ANOVA analysis with the “spatial contextual learning of words” as within-subject factors. In line with the allocentric processing studies, the middle cingulate gyrus was significantly more activated by words encoded in the allocentric than in the navigation condition. Congruent with navigation processing studies, the right inferior parietal lobule was significantly more activated by words encoded in the navigation than in the allocentric condition. These preliminary results suggest that word retrieval seems to be intimately related to the spatial contextual task performed during their encoding.

Effects of action observation on movement execution

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Behavioural studies have demonstrated that action observation modulates action execution (see for example Kilner et al. 2003; Edwards et al. 2003). These data demonstrated that the observation of congruent conditions resulted in less within movement variance or faster action initiation times. In the studies reported here, we were interested in whether the nature of the congruent observed action could modulate the degree of effect. Specifically, does the spatial matching of action have a greater effect than movement (kinematic) matching? In the first study presented, we replicated the Kilner et al. (2003) study, and in addition contrasted the relative natural spatial and kinematic matching of the observed and executed movements. The second study also manipulated observed action spatial positioning and movement kinematics on execution, but this time contrasted natural movements with movements that were purposefully non-natural (e.g., a higher reach trajectory than naturally used).

For both experiments, the data demonstrated that both spatial and kinematic matching modulated performance, even when the observed action was non-natural. The data are discussed in terms of the neural representations for observed and executed action processes.

The effect of age on egocentric and allocentric spatial frames of reference

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Spatial memory plays a fundamental role in everyday human activities and is a basic component of several cognitive abilities. Little is known about its developmental course, although this topic would be of clinical and theoretical relevance. The purpose of this research is to investigate the effect of ageing on the frames of reference necessary to represent spatial information in memory. Frames of reference are usually divided into egocentric and allocentric. Egocentric frames define spatial information with respect to the body or its parts, while allocentric frames specify spatial information on the basis of external objects (Kosslyn 1994). Our experiment involved 140 participants divided into seven age groups from 20 to 89 years (groups 20–29, 30–39 and so forth), matched by education and sex. Participants were first submitted to a test of general cognitive abilities (MMSE) as inclusion criterion; then, to a spatial task that compared directly the capacity to use egocentric and allocentric frames of reference. After memorizing triads of actual 3-D objects (20 s), participants had to give egocentric (“which object is closer to you?”) and allocentric judgments (“which object is closer to the pyramid?”). The results showed that egocentric judgments were more accurate and faster than allocentric ones. However, the allocentric component looked relatively preserved; the egocentric component showed a significant decline starting from the sixties. The results suggest that the two components are supported, at least partially, by neural areas that are differently vulnerable to normal ageing processes.

How do we use distance representation based on spatial terms?

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Understanding spatial terms involves computing the distance between objects. For example, when we judge the acceptability of the description “a cat is near the table,” the distance between the cat and the table is important. In this case, the acceptable distance between them should be within a certain definite representational distance defined as “near” in scene. It is supposed that each spatial term defines a typical representational distance and that we use that term as a unit of measurement when we understand distance descriptions. However, how we actually use such terms is unclear. We hypothesized that the representational distance communicated by spatial terms would have the same cognitive characteristics as our visual distance perception. To examine this hypothesis, we conducted two psychological experiments using a three-dimensional computer graphics space and six Japanese spatial terms that convey different distance relationships between objects. In Experiment 1, the distance representations of the terms were measured in five directions from a reference object, and in Experiment 2, a distance adjustment task was conducted using various distances collected in Experiment 1 for each

term as standard stimuli. We then compared the distance data of Experiments 1 and 2. The results showed that the distance representation conveyed by a spatial term has almost the same characteristics as does visual distance perception. This suggests that when we understand spatial terms, we measure distance between objects by means of certain representational units that are derived from a spatial term in the same way we recognize distance visually.

Eye movements and mental models in reasoning with cardinal directions

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Eye movements can be seen as a reflection of internal attention shifts and can, therefore, give indications about the structure of mental representations that correspond to a spatial problem the person has to solve. Within this contribution, we will present an eye tracking experiment to investigate mental representations used in reasoning with cardinal directions. We have tracked the eye movements of subjects while they were solving three term series problems regarding eight cardinal directions (north, northeast, east, southeast, south, southwest, west, northwest). Premises and questions were presented verbally and participants were facing a white wall during the tasks. In line with the theory of mental models, previous research showed that humans use mental models in spatial reasoning. Some mental models are used significantly more often than other possible models in a specific reasoning problem (e.g., Knauff et al. 1995). These models, therefore, were termed preferred mental models (PMM). The present study aims at investigating a possible correlation between eye movements and the used mental models in the given reasoning tasks. In particular, we are interested in whether eye movements occur according to the given directions in the premises, the directions in the questions, and the answers of the subjects. Further we will explore if and to which extent the preferred mental models will be reflected in the eye movements. This poster will present the experimental details, the analysis of the eye movements, the results, and a discussion concerning potential PMM.

Employing eye-gaze and arrow as cue to attention: two different modes of attentional selection

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The origin of any differences between the encoding and the function of eyes and arrows is important for researchers who investigate the sociobiological importance of a gaze-cue. In fact, the arrow has a directional property just like gaze, but without any biological significance. This study aimed to evaluate the type of attentional selection (space and/or object based) triggered by central non-informative spatial cues. Two rectangular objects were presented in the visual field, and subjects' attention was directed to a location on one rectangle via the observation of non-informative directional arrows or eye-gaze. Similar experiments with peripheral cues (Egley et al. 1994) have shown an object-based effect: slower target identification when the target was presented on the uncued object, even when the spatial proximity of the target's and the cue's location was controlled. The experiment reported here show a space-based cueing effect in all

conditions, replicating several studies with non-predictive gaze and arrow cues. However, an object-based effect occurred only when an arrow cue was presented. In light of literature regarding the spatial cueing, it seems that attention is directed to nearby objects when a non-informative arrow is used as cue, whereas it is selectively directed to a cued location when non-informative eye-gaze is used.

The situational influence of location and body orientation on the recall of survey knowledge

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The theories of situated and embodied cognition have been gaining more and more attention recently. We examined the influence of the current situation (i.e., location and orientation) on accessing spatial memory of locations within one's city of residence. Tübingen residents produced a simple map of the city centre, by arranging small badges representing well-known locations on a sheet of paper or a computer screen. Participants produced the maps at different locations relative to the city centre (north of, east of, etc.) and in different body orientations (facing north, east, etc.). We analyzed the orientation of these maps (north up, east up, etc.). We found an influence of location and body orientation on the orientation of the maps. Participants produced maps in the orientation they were facing more often than expected by chance (i.e., produced a north up map when facing north, an east up map when facing east, etc.). Participants also oriented the maps according to their viewpoint more often than expected by chance (i.e., produced a north up map when located south of the city centre, an east up map when located west, etc.). These results indicate that some participants either selected one of multiple long-term representations or they adopted a single long-term spatial representation according to the current situation.

The VR-Maze test: an interactive tool for the assessment of "survey to route" spatial organization ability in elderly population

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Spatial cognition is generally agreed as the human capacity of orient oneself in and to cope with everyday environments. Despite this definition, up to now spatial ability was evaluated with neuropsychological tests that not allow an immediate and direct interaction with a three-dimensional environment. This evidence generally constitutes the point of force for those who prefer ecological assessment even if it requires to avoid problems such as the variables monitoring and/or the difficulty to modify the environment for evaluation purposes. In the last years, the growth and diffusion of computer-based interactive technologies, such as virtual reality, allowed to individuate new ecologically like scenarios able to support complex interactions and provide meaningful everyday-like experiences. According to this vision, we propose to integrate classical neuropsychological evaluation tools with a virtual reality based one. In order to evaluate complex environments, navigational capacity we tested not cognitively impaired elderly subjects with the VR-Maze test (Morganti et al. 2007)

that provides us with the possibility to evaluate the “survey to route” spatial organization ability by requiring participants to perform way-finding task both in an allocentric and egocentric perspective. Collected data were analyzed according to the participants’ age, gender and educational level. VR-Maze test performances were compared with neuropsychological tests (such as MMSE, Tower of London, Trial Making Test, Corsi’s span and Supraspan) in order to evidence positive and negative correlations with general cognitive level, planning, attention and spatial memory abilities in elderly population.

Hearing the “time is space” conceptual metaphor: a cross-cultural study

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To test whether the left past/right future mapping of time is due to the direction of reading/writing habits, we compared two groups differing in their directional orthographic system (Spanish and Hebrew native speakers) in the same experimental task: they were asked to judge, by pressing a left or right key, the past or future temporal reference of the words (verbs and adverbs of time) presented to their left or right ear (via headphones). Words were auditorily presented in order to control for any possible bias linked to the action of reading itself. As expected, Spanish participants were faster responding to past words with their left hand and to future words with their right hand, whereas Hebrew participants showed the opposite pattern. However, contrary to previous the findings with visual stimuli (Santiago et al. 2007; Psychol Bull Rev 14:512–516), the left or right stimulus location did not facilitate the semantic access for past and future meanings. We hypothesized that it was due to the relative salience of auditory and visual cues. If so, increasing the salience of the auditory spatial frame of reference and decreasing the salience of the visual spatial frame should reduce the influences of the latter on the former. Effectively, by presenting words via two external speakers (to the left and right of the participant) instead of headphones and by asking Spanish participants to perform the same task blind-folded, temporal meaning interacted with both stimulus location and response side.

Pure imagery neglect for places and for objects

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Representational neglect is a well-known imagery disorder, but its nature is not still clear and several interpretations have been proposed. It has been considered as a bias in exploring mental images or as a damage in processing environmental information, or as a deficit in the working memory system. However, the mental imagery abilities in patients with representational neglect have not been analyzed more thoroughly. Thus, it is unclear whether representational neglect is an isolated mental imagery deficit or one aspect of a more complex imagery disorder. For this reason, we analyzed the mental imagery abilities of two patients with imagery neglect for places (Patient 1) and imagery neglect for objects (Patient 2). The patients were submitted to

a battery including tests of mental generation and manipulation of objects and real places. In respect to a group of control subjects, Patient 1 failed in many place imagery tasks, while Patient 2 failed only in some tests involving the generation and the manipulation of objects. These data suggest that representational neglect could not be due to a working memory deficit, because if it was the case our patients should fail both the object and place imagery tasks. Furthermore, although it is unwise to draw conclusion from two single cases, in line with fMRI evidences, our results underline that places and objects can be represented separately and independently affected.

Visual and verbal creativity and their relationship with visuospatial and verbal proficiency

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Creativity is one of the most important forms of human information processing, being relevant for many different task at both the individual and social level. Here, we raised the issue on how modality-specific are creative abilities? Subjects were asked to perform on a variety of visual and verbal tasks, in order to understand what characterizes creative ability, and which mental operations are specific to visual and verbal creativity, and which generalize between these two fields. For visual creativity, Finke’s figural combination task and figural completion task were used. In the former task, people were instructed to combine three elements to produce a “creative” object, in the latter they were asked to add details to a given stimulus to form different objects. For verbal creativity, the creative generation task, requiring generating a creative story from three words, and the alternative uses task, asking describing different uses of common objects were administered. Two independent judges scored the products of the Finke’s task on originality and practicality, and those of the creative generation task for originality and richness of information. The figural completion and alternative uses tasks were scored for fluency, originality, flexibility and elaboration, according Guilford’s advice. In addition, the visual vividness imagery questionnaire, visual tasks (mental rotation, mental inspection, restructuration, visual working memory), and verbal tasks (vocabulary, similarities, comprehension, and digit span test from WAIS-R) were used to investigate correlations between creativity performances and visual and verbal processes. We will report on the outcome of this study.

Age and sex differences in a virtual version of the reorientation task

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The older population is the least studied group for cognitive sex differences, and findings are inconsistent regarding whether men and women differ in age-related cognitive decline (Rowe et al. 2004). Indeed, the majority of studies on human cognitive aging focuses on age-related decline in psychometric measures (e.g., Maitland et al. 2000), thus there have been relatively few studies assessing the relationship between gender and age in spatial navigation tasks across life

span (Driscoll et al. 2005). In order to improve the knowledge on this topic, 150 aged healthy participants, balanced by gender, were considered. Participants were young (age 20–39), middle (age 40–59), young old (60–69) and old-old (70–79) adults and they were admitted to perform a navigation task in a virtual environment. We employed the virtual version of the reorientation task (Bosco et al. 2008). Participants were required to search a hidden target on the basis of layout cues, featural cues or both. The results showed gender and age-related effects in navigation performance. Regarding the effect of age, young people performed better than old when featural information was available. Conversely, the ability of elaborating layout information remained intact across life span. Regarding the effect of gender, men tended to perform better than women. In particular, gender differences emerged in the old-old group as effect of the presence of one or two spatial cues. In the former condition, men outperform women. In the latter, men and women were comparable. These findings promoted knowledge on the differential decline of navigational ability between men and women.

What kind of mental images are spatial forms?

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For some people, thinking about members of certain sequences (e.g., months, days, numbers) is accompanied by the experience that the concept member occupies a precise location in imaginal or peripersonal space. This location is in turn part of a spatially extended pattern which can be very complex and idiosyncratic. These spatial forms remain a poorly understood individual difference in everyday visuospatial imagery. Should spatial forms should be considered as a variety of synaesthesia, or as an extreme on the continuum of everyday mental imagery? Are they associated with benefits or disadvantages? What type of visuospatial representation are they? Behavioural and self-report data address these issues. First, by self-report, people with spatial forms show above average everyday visual, but not spatial, imagery. In addition, high scores on a questionnaire that taps spatial form experience in the general population also correlate positively with self-reported general imagery. Second, mental imagery instructions can induce control groups to show similar behavioural patterns to people with spatial forms in laboratory experiments. Third, spatial forms do not confer strong advantages in tests that might be expected to benefit from inspectable visuospatial models of the layout of the forms. In these tests, loading visuospatial components of working memory also fails to selectively impair performance of spatial form groups. Tentatively, it seems spatial forms may be vivid automatised visual images at the end of the spectrum of individual differences in visual imagery, but are not spatial cognitive maps of the type that some introspective reports would initially suggest.

Which kind of attention is necessary for perceiving gaze direction? Evidence from the locus of slack method

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Several researchers have studied how we process and perceive gaze direction. However, it is still a matter of debate whether or not the perception of gaze direction requires attention to function. We report

two experiments in which we use the locus of slack method to test whether and when attention is necessary to perceive gaze direction. In Experiment 1, we used the spatial cueing paradigm to investigate if gaze direction judgment (easy vs. difficult judgement) can be carried out while spatial attention is diverted. In Experiment 2, we used the psychological refractory period paradigm to determine whether gaze direction judgment (easy vs. difficult judgement) occurs at an early or late stage in information processing and involves central attention processes. The results indicate that the processing of averted gaze requires the action of attention, as we show that gaze direction discrimination occurs only after the viewer allocates spatial attention to the eyes. Interestingly, however, the discrimination of gaze direction can take place even if the observer is performing another task. The findings demonstrate that gaze perception requires spatial attention but not central attention. This ability is particularly important as it demonstrates that we can perceive gaze direction also when we are engaged in a different activity, for example, during a conversation. The results have also important implications for a better understanding of attentional deficits and social attention.

On the role of conceptual and linguistic ontologies in the production of way-finding dialogues

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Over the last 10 years, various standards for the representation of generated way-finding instructions have been proposed in the geographic information science (GIS) literature (Dale et al. 2005; Klippel et al. in press; Mabrouk 2005). The more advanced of these standards specify way-finding information types which may be rendered to users at various levels of granularity, and in multiple modalities. Although necessary and sufficient for the present generation of GI services, the integration of way-finding strategies with more general cognitive and mobility assistance systems will require that such descriptive standards be anchored within, or at least related to, other elements of a cognitive assistance framework. To progress us towards this goal in this talk, we analyse the ontological foundations of multimodal way-finding description standards and relate these to the state of the art in both linguistic and conceptual ontologies. Linguistic ontologies provide an interface to rich natural language processing resources, while conceptual ontologies provide a means by which the way-finding instructions can be directly related to other aspects of spatial modelling—including the spatial structures against which route instructions are generated. We report on our progress in this area, and on the relationship between way-finding description standards and the needs of the route interpretation community. Our analysis focuses in particular on the notion of action, place, and direction as used within way-finding description standards. The analysis presented is part of ongoing work into the integration of the state of the art in intelligent way-finding description methods with ontologically well-motivated cognitive dialogue systems.

Interaction between egocentric and allocentric frames of reference

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The aim of this research is to examine the role of egocentric and allocentric information in judgement tasks of relative positions: are they

used independently or do they interact? This question is important to understand the relationship between motor and perceptual/cognitive components in spatial cognition (Bridgeman 1991; Milner and Goodale 1995). The model proposed by Milner and Goodale (1995, 2006) suggests that vision for perception and vision for action are subserved by two separate cortical systems, the ventral and dorsal streams, respectively. The former codes spatial information egocentrically, that is, relative to the observer, whereas the functions of the ventral stream rely on an allocentric coding. Consistently, Neggers et al. (2005), (2006) showed an influence of irrelevant allocentric information on egocentric perceptual judgements and not vice versa. However, recent evidence highlighted the relevance of egocentric information in visuo-perceptual tasks (Schenk 2006; Ball et al. 2008). In our experiment participants had to judge the position of a dot inscribed in a circle with respect to their body-midline and with respect to the center of the circle, either in a condition of congruence or incongruence between egocentric and allocentric information. The response was given by pressing a button either after stimulus disappearance or with the stimulus online. It was found that allocentric irrelevant information influenced egocentric judgements and the reverse also occurred, irrespective of response condition. This finding suggests that egocentric components may play a role also in spatial tasks that do not require action.

Short- and long-term correlations in repetitive movements

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Time is an essential feature of everyday activities, such as walking or chewing. Notwithstanding the huge amount of the literature devoted to this issue, the mechanisms underlying the control of motor timing is still far from being elucidated. In the present study, 30 subjects underwent a finger-tapping task according to the well-known synchronization-continuation paradigm in which the participants have to tap in synchrony to a metronome, and successively continue to tap at the same rate without any external reference. By means of this paradigm, it is possible to assess participant's ability to produce both externally and internally triggered repeated movements. Our results show that the taps are mostly organized in binary and ternary patterns both in the synchronization and continuation phase, and that the tap time series are characterized by long-term correlations. As a consequence, the taps do not appear to be produced as single events, but rather as structured events according to context-dependent interactions across forward and backward-going time windows. These findings will be discussed within the framework of the recent theory of timing as an emergent property in a complex process.

A meta-analysis on the correlation between measurements of spatial tasks and standardized tests of environmental spatial abilities

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Environmental or large scale spatial abilities usually are measured by task behavior. Environmental spatial abilities are complex where more than one skill is involved in solving spatial task. Most spatial

tasks used in prior studies require more than one spatial ability; hence, it is important to identify which task behavior is most appropriate to measure a certain skill. This meta-analytic review reported on studies that investigate test and task measurements of spatial abilities. The analysis examined the effect sizes relationships between spatial abilities and their spatial tasks or tests. The purpose of this meta-analysis is to identify which large scale tasks have been consistently employed to measure particular skills. One hundred and two studies were included in the meta-analysis. The effect size estimation was computed for each independent study, and it ranged from 0.08 to 3.84, the median being 0.6. The result indicates significant effect sizes of two environmental spatial abilities, namely spatial updating and landmark recognition. In particular, the most appropriate spatial task for spatial updating skill appears to be pointing to unseen landmarks (effect size of 0.61), while map reconstruction is the most appropriate task for landmark recognition (effect size 0.85). We hope our research will lead in developing a standardized assessment tool for environmental spatial abilities. This will benefit in various disciplines where assessment of people's spatial abilities is relevant, such as architecture, town planner and mobile computing.

Multimodal device for assessing children orienting behavior in ecological environments

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Orienting behaviors towards sound or visual stimuli involve sensory-motor coordinations. Alterations in sensory-motor domains (perception, processing, integration, interpretation of the information) can affect orienting and spatial cognition (Berthoz et al. 1992). The most important senses involved in orienting behavior are sight (how the eyes and the brain work together to intake and organize visual information), hearing (how the ears and the brain work together to intake and organize auditory information) and vestibular (orienting of head position and sensory organs responsibility to the environment). We proposed a multimodal device for investigating orienting behavior in very young children, from 12 to 24 months of age. It has been developed within the TACT (Thought in ACTION) project and it is designed in agreement with three principles (Campolo 2008): (1) unobtrusivity; (2) minimal structured and ecological operating environment; (3) multimodality. It works like an artificial audio-visuovestibular system: mounted on the child's head, it localizes active sound source around him, it senses child's head orientation, angular velocity and acceleration and estimates gaze direction by detecting eye orientation. Preliminary results on healthy children in a day-care centre are presented showing the acceptability of the device and its potential application to early diagnosis of attention disorders and for studying the development of perception and cognition of intramodal and crossmodal spatial cues.

Construction of complex mental images

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The human ability to create, manipulate and inspect complex, i.e., multipart, mental images is fundamental for reasoning about several visuospatial problems, e.g., in architectural design. The process of

constructing complex mental images involves the interplay of distinct functional components: for example a long-term memory, working memory representations and an internal focus of attention. We have developed the conception for a cognitive model of this construction process, which will allow us further insight into the involved mental representations and processes as well as the overall control between the components. We aim at a model that is cognitively plausible and therefore extend Kosslyn's (2004) description of the relevant functional components with the necessary details for a computational implementation and with concrete hypotheses about how the construction process is controlled. We will develop our model as part of our cognitive architecture Casimir, which already contains a long-term memory implementation. The structure of the working memory is designed as a visuospatial representation that is built up from distinct visual entities and spatial relations between them. Guided by an internal focus of attention, which shifts between represented objects, information from long-term memory is successively retrieved and inserted to allow the construction of arbitrary mental images. This process is hypothesized to use similar mechanisms as those in object recognition during visual perception. We will at first evaluate our model by comparing its behaviour to well-known imagery phenomena like scanning and zooming.

Reference frame activation in spatial language: temporal dynamics

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Spatial sentences and relations can be understood from an abstract (based on cardinal directions) relative (seen from the viewer) or intrinsic (seen from the located object) frame of reference. When communicating, interlocutors have to align their frame of reference in order to understand each other. In a verification paradigm subjects were asked to compare a sentence, e.g., “the ball is left of the car” and a picture, while the inter-stimulus interval was systematically varied. Data informed on both the activation of reference frames and their subsequent selection. Reference frames appear to be activated after the picture and that process takes approximately 500 ms. In Experiment 2, we introduced a cue at different moments that instructed which reference frame to use and the interval was fixed at 500 ms. The data provide insight into the interaction and timing of the processes. In sentence-picture both activation and selection start earlier, compared with Experiment 1, while in picture-sentence only selection starts earlier and subjects seem to adopt a strategy focussing on intrinsic processing.

Architecture as interaction factor on virtual museums design

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The concept of virtual museums has brought about many discussions, and one of the most expressive is related to the possibility of having interactive elements inserted in the virtual environment. However, research in this field is scarce and the efforts are concentrated in the area of product design, only available a few studies in the graphic and

digital design field. This study contributes for the fulfilling of this gap in the knowledge of design, aiming at identifying the categories of interactivity, kinds of virtual museums and check how to offer the user new possibilities of interaction. The literature review focused on concepts of physical and virtual museums, interaction design, and theories from other fields. The research followed a qualitative methodological approach of an interpretative nature, divided into three phases: interviews with museum's visitors and sponsors and museum websites analysis. With these research data, the matrix of value was applied, in order to identify advantages and disadvantages of real museums, as well as innovative tools for a virtual one, as well as in order to help interaction design of virtual museums with educational purposes. The results emphasize the importance of architecture as an interaction factor in designing virtual museums, as well as the need of considering and respecting cultural factors, besides the environmental, technical, social and economic ones, in order to cater for people's needs and yearnings in interacting with museums.

Components of visual neglect: attentional bias versus spatial working memory impairment

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Visual neglect is a complex syndrome including deficits of spatial attention and spatial working memory, which concerns about half of the patients with right hemisphere damage. These patients behave as they ignore the left half of the space. In this study, we tried to dissect these two hypothetical components of neglect using a computerized search task. Seventeen right-hemisphere damaged patients, of whom nine showed signs of visual neglect on paper and pencil tests, searched for circles displayed on a touch screen. In three experimental conditions, the touched circles (1) disappeared; (2) did not change; (3) became more perceptually salient. Neglect patients made more omissions in the no change condition, no matter the side (left or right) of presentation, suggesting a non-lateralized deficit of spatial working memory. In the increased saliency condition, neglect patients had more perseveration, suggesting an effect of attentional capture from the already touched circles. We concluded that both a non-lateralized deficit of spatial working memory and an attentional bias towards the right side contribute to the syndrome of visual neglect.

Embodying spatial relations in action and perception: a computational model

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Recent studies have indicated that relational representations might be grounded in the dynamics of the sensory-motor loops of cognitive agents. In this study, we present a computational model which posits

that spatial relations are encoded by the dynamics of the interaction between perceptual input and motor activity related to attentional control. Thus, the role of action is to temporarily associate attended visual stimuli with relevant conceptual structures. The model is accommodated within the integrated cognitive architecture DUAL which allows for modeling the interplay of spatial relations apprehension and other cognitive processes. Three simulation studies have been conducted in order to demonstrate how the proposed embodied representations of spatial relations are exploited in various perceptual and reasoning tasks. In Simulation 1, it is shown how the sensory-motor dynamics helps to disambiguate between two possible interpretations of a given stimulus. Simulation 2 demonstrates that top-down pressure may lead to re-representation of a target stimulus by rendering support to certain spatial relations and inhibiting others. Simulation 3 accounts for how irrelevant information may intrude the evaluation of spatial relations. The results of the three simulations are related to contemporary theoretical and empirical findings. Finally, the model is compared to other approaches to reasoning with spatial relations and its advantages, as well as drawbacks, are highlighted.

From visual perception to place

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The concept of place is essential to the way humans represent and interact with spatial environments. This raises the question of how

“being at a place” can be inferred from sensory information. Vision is an important part of this sensory information, as shown by neurobiological research on place cells. Our goal in this paper thus is to identify the basic determinants of vision-based place recognition and to discuss whether these are sufficiently accounted for in existing systems. We start by showing what qualifies place recognition as a distinct problem and how it differs from other pattern recognition problems. This distinction especially affects the desired invariance properties and, as a consequence, the selection of suited image processing techniques. We investigate the problem of place recognition along three major axes. First, we distinguish between methods for extracting highly informative local features (e.g., landmarks) on the one hand and methods for analyzing scenes in a holistic fashion on the other. In the second dimension, we consider to what degree the spatial configuration of features is preserved after processing (template vs. bag of features). The third dimension reflects the level of generalization, i.e., whether a representation is geared towards recognition of single instances or more generic categories. We discuss the intrinsic advantages and shortcomings of existing place recognition approaches along these dimensions, with a specific focus on holistic scene representations. In addition, we present a method for systematically evaluating desired place-specific invariance properties since holistic bag of features approaches in particular lack such evaluation.