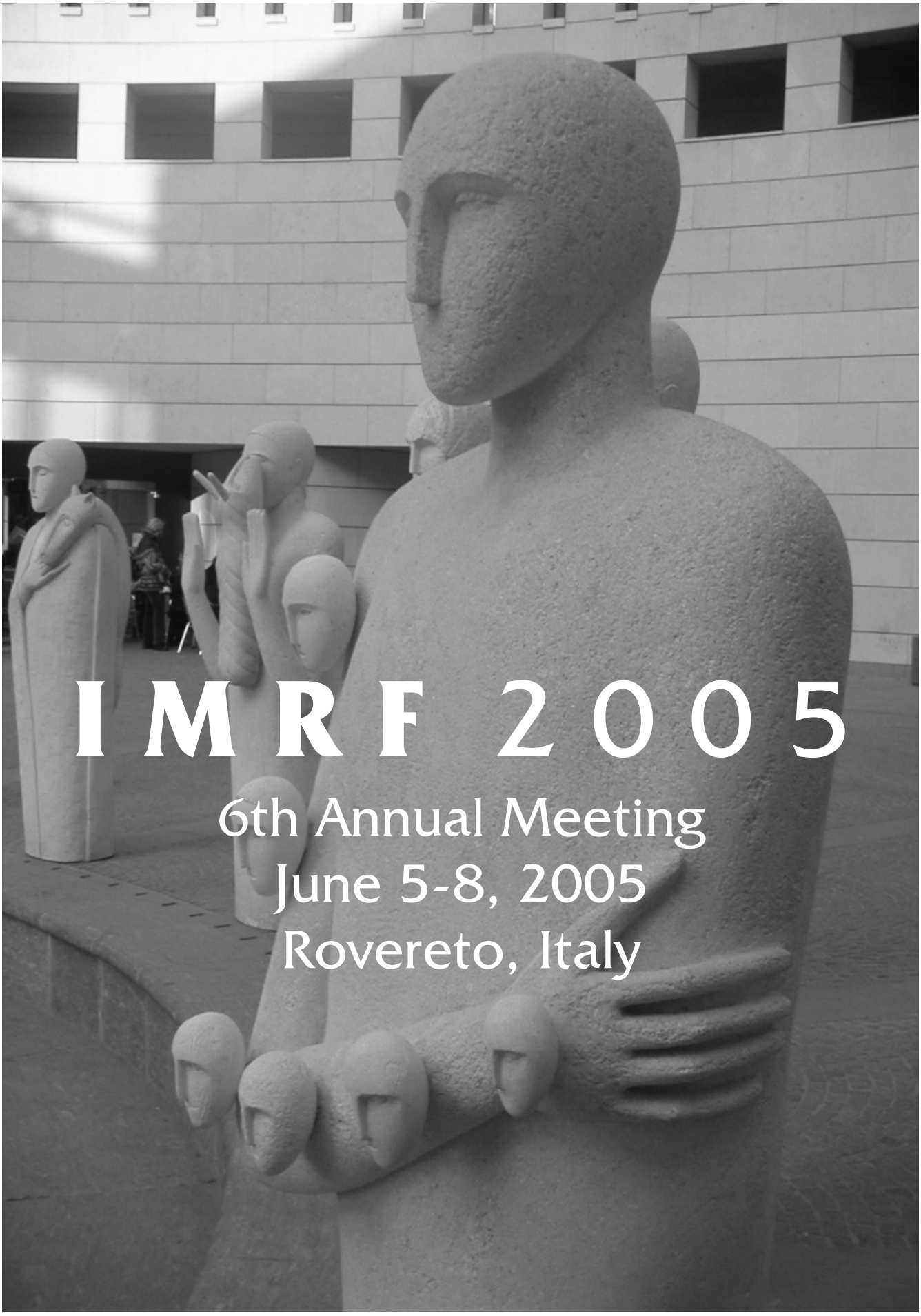

IMRF 2005

6th Annual Meeting
June 5-8, 2005
Rovereto, Italy

IMRF 2005

Conference Committee

Acknowledgements

We are most grateful to the following individuals for supporting the local organization of this meeting with their work and guidance: Gianpietro Berti, Remo Job, Alfonso Caramazza, Rino Rumiati, Daniela Tarolli, Alessandra Rossaro, Elisabetta Nones, Paola Bodio, Katia Ruaben, Maurizio Dalbosco, Massimiliano Zampini, Sara Dellantonio, Chiara Begliomini, Valeria Rausei, Chiara Andreolli, Carlotta Gaspari, Laura of APT Rovereto, Marco Rizzi, Trento School of Management. A special thank goes to Trudy Shore for her assistance with the website.

Cover image

Statues by Mimmo Paladino for the MART Museum (detail)

IMRF 2005

Key partners and Sponsors

We would like to acknowledge the following institutions and companies, who have kindly contributed to this 6th Annual Meeting of the IMRF:

Dipartimento di Scienze della Cognizione e della Formazione, Università di Trento

Facoltà di Scienze Cognitive, Università di Trento

Laboratorio di Scienze Cognitive, Università di Trento

Associazione Italiana di Psicologia

Associazione Italiana di Psicologia, Sezione di Psicologia Sperimentale

Comune di Rovereto

Fondazione Cassa di Risparmio di Trento e Rovereto

Cassa Rurale di Rovereto

Azienda per il Turismo (APT) di Rovereto

Museo di Arte Contemporanea di Trento e Rovereto (MART)

BIOSEMI, MMBiomedical, Neurospec

EMS

Neurobehavioral Systems

UNILEVER

Table of contents

General Information

Venue and meeting rooms

The conference will be held at the Museum of Contemporary Art of Trento and Rovereto (MART, Corso Bettini 43, Rovereto). Oral presentations will take place in the "Melotti" Auditorium. Poster presentation will take place in the covered balcony overlooking the main square of the museum. An elevator is available to reach the gallery (please ask a member of staff).

Registration

The IMRF desk is located in the hall giving access to the Auditorium. Conference delegates can register and collect the conference materials at the IMRF desk from 9.00 am on June 5th. The desk will remain open throughout the conference for assistance.

Instructions for talk presenters

Talks in **paper sessions** will be 15 minutes long, plus 5 minutes for questions. Talks in **symposium sessions** will be 20 minutes long, plus 5 minutes for questions. The Auditorium will be equipped with an LCD projector, loudspeakers and laptop computers (PC and Mac). An overhead projector will also be provided on request. However, due to the large size of the Auditorium, PC presentations are strongly encouraged for best results. We ask presenters using PowerPoint to download and check their presentation before the beginning of the session. Presenters can also bring their own laptops, but in any case please have a copy of your talk ready in a CD or memory stick. We ask presenters wishing to use any other kind of equipment during their talk to contact the organization as soon as possible.

Instructions for poster presenters

Maximum poster size is 100 cm wide, 140 cm tall (i.e., portrait orientation). There will be two poster sessions of 150 minutes on the covered balcony of the MART Museum, on Sunday June 5th and Monday June 6th, from 5:30 pm to 8:00 pm. Poster presenters will be required to stand by their poster for at least 1 hour on each day: odd abstract numbers during the first half (i.e., until 6.45 pm), and even abstract numbers during the second half of each session. Posters can be hung up from the beginning of the conference on Sunday June 5th at 9.00 am, and should be removed by the end of the conference (noon on Wednesday 8th June).

Social events

Sunday. Two buffet receptions included with registrations are scheduled for Sunday: at lunch time (1:00 pm) at Palazzo Fedrigotti, just outside the MART museum on Corso Bettini, see map on last page and dinner (8:00 pm) at the Café in the main square of the museum.

Monday. A guided tour to the MART museum will be offered in the evening (meeting at 8:00 pm at the museum entrance). Please register for this event at the IMRF desk on the first day of the meeting.

Tuesday. The conference banquet will be held at Castel Toblino Restaurant (www.casteltoblino.com). Castel Toblino is located 30 min from Rovereto. Free transports between Castel Toblino and Rovereto have been arranged. A bus service will leave at 7:00 pm from outside the MART museum. An earlier bus will leave at 6:00 pm for those delegates interested in a free tour with tasting at a local winery (Cantina Mori Colli Zugna) on the way to Castel Toblino Restaurant. For a visit to the winery please register by Sunday evening at the IMRF desk. **Notice for non-registered guests**: Delegates wishing to invite guests at the conference banquet must contact the IMRF desk by Sunday evening. The cost for non-registered guest is 40 Euros and includes transports to and from Castel Toblino Restaurant, and the optional visit to the local winery.

Wednesday. The IMRF business meeting is scheduled for Wednesday at 12:30 in the conference Auditorium.

Coffee breaks are scheduled between talk sessions (see program for details) and will include coffee, tea, juices and light snacks.

Conference Program: At a glance

	Sun 5 jun	Mon 6 jun	Tue 7 jun	Wed 8 jun
9:00 - 9:30	**Registration**	**Symposium**	**Graduate student symposium**	**Symposium**
9:30 - 10:00		Within-modal vs. cross-modal processes:	**(Chair: Micah Murray)**	Speech as a window to multisensory integration processes
10:00 - 10:30	**Tutorial lecture**	neurons behavior and clinical studies	Speakers: J Besle, ML Dematté, JX Maier, R Martuzzi	Organizer: Salvador Soto-Faraco (University of Barcelona, Spain)
10:30 - 11:00	Charles Schroeder (Nathan S. Kline Institute, USA)	Organizer: Elisabetta Làdavas	J Phillips-Silver, N Van Atteveldt	
11:00 - 11:30	**Coffee Break** (included with registration)	**Coffee Break** (included with registration)	**Coffee Break** (included with registration)	**Coffee Break** (included with registration)
11:30 - 12:00	**Paper session (Chair: Angelo Maravita)**	**Paper session (Chair: David Shore)**	**Paper session (Chair: David J Lewkowicz)**	**Keynote lecture**
12:00 - 12:30	Multisensory integration in tactile perception	Multisensory attention and awareness	Audiovisual interactions	Kevin G. Munhall (Queen's University, Canada)
12:30 - 13:00				**Business Meeting**
13:00 - 13:30				
13:30 - 14:00	**Lunch time**	**Lunch time**	**Lunch time**	
14:00 - 14:30	(buffet lunch included with registration)			
14:30 - 15:00				
15:00 - 15:30	**Symposium**	**Symposium**	**Paper session (Chair: Fiona Newell)**	
15:30 - 16:00	Experiencing objects through vision and touch	Can the blind see?	Multisensory contribution to object recognition an memory	
16:00 - 16:30	Organizer: Hendrik N.J. Shifferstein	Organizer: Alvaro Pascual-Leone	**Coffee Break** (included with registration)	
16:30 - 17:00			**Keynote lecture**	
17:00 - 17:30	**Coffee Break** (included with registration)	**Coffee Break** (included with registration)	Giacomo Rizzolatti (University of Parma, Italy)	
17:30 - 18:00				
18:00 - 18:30	**Poster session**	**Poster session**	**Visit to local winaries**	
18:30 - 19:00			(included with registration)	
19:00 - 19:30				
19:30 - 20:00				
20:00 - 20:30	**Buffet dinner**	**Guided tour to the MART museum**	**Conference banquet**	
20.30 - 21:00	(included with registration)	(included with registration)	Castel Toblino Restaurant	
21:00 - 21:30			http://www.casteltoblino.com/	
21:30 - 22:00			(included with registration)	
22:00 - 22:30				
22.30 - 23:00				
23.00 - 23:30				

Conference Program: Detailed

Sunday, June 5th

9:00 - 10:00 Registration

10:00 - 11:00 Tutorial lecture

USE OF ANIMAL MODELS TO DEFINE THE NEUROANATOMY AND PHYSIOLOGY OF MULTISENSORY PROCESSING
Charles E. Schroeder

11.00 - 11:30 Coffee break

11:30 - 13:00 Paper session

MULTISENSORY INTEGRATION IN TACTILE PERCEPTION
Chair: Angelo Maravita

11:30 - 11:50	Adele Diederich: Modeling spatial effects in visual-tactile saccadic reaction time
11:50 - 12:10	Fabrizio Doricchi: Effects of vestibular rotatory accelerations on covert attentional orienting in vision and touch
12:10 - 12:30	Krish Sathian: Visual cortical activity during tactile spatial discrimination in sighted and blind humans
12:30 - 12:50	Massimiliano Zampini: Spatial modulation of audiotactile temporal order judgments depends on whether stimuli presented from the front or rear
12:50 - 13:00	General discussion

13:00 - 15:00 Lunch time

A buffet lunch included with registration will be served at Palazzo Fedrigotti, just outside the museum main entrance, on Corso Bettini (see map on last page).

15:00 - 17:00 Symposium

EXPERIENCING OBJECTS THROUGH VISION AND TOUCH
Organizer: Hendrik Schifferstein

15:00 - 15:10	Introductory remarks
15:10 - 15:35	Soledad Ballesteros: Priming between modalities in normal aging and dementia
15:35 - 16:00	Marc O. Ernst: Resolving visual-tactual incongruity depends on sensory reliability
16:00 - 16:25	Geke Ludden: Visual – tactual incongruities as sources of surprise
16:25 - 16:50	Fiona Newell: Visual and tactile spatial information is updated with observer movement
16:50 - 17:00	General discussion

17:00 - 17:30 Coffee break

17:30 - 20:00 Poster session

20:00 - 22:30 Buffet dinner
(included with registration)

Monday, June 6th

9:00 - 11:00 Symposium

WITHIN-MODAL VS. CROSS-MODAL PROCESSES: NEURONS, BEHAVIOR AND CLINICAL STUDIES
Organizer: Elisabetta Làdavas

9:00 - 9:10	Introductory remarks
9:10 - 9:35	Terrence Stanford: Modeling the biophysical basis of multisensory integration in the superior colliculus
9:35 - 10:00	Mark Wallace: Developmental plasticity in multisensory representations
10:00 - 10:25	Elisabetta Làdavas: Acoustical vision in hemianopic patients
10:25 - 10:50	Nadia Bolognini: Multisensory localization of sounds: behavioral and neuropsychological evidences
10:50 - 11:00	Discussant: Barry Stein

11.00 - 11:30 Coffee break

11:30 - 13:00 Paper session

MULTISENSORY ATTENTION AND AWARENESS
Chair: David I. Shore

11:30 - 11:50	Daniel Berger: Effects of attention and cue conflict awareness on multimodal integration in self-rotation perception
11:50 - 12:10	Polly Dalton: Attentional capture in serial visual and audiovisual search tasks
12:10 - 12:30	Manuel Gomez-Ramirez: A high-density electrical mapping and fMRI investigation of biased intersensory attentional sets
12:30 - 12:50	Daniel Senkowski: The role of visual cortex in multiple speaker interference
12:30 - 12:50	General discussion

13:00 - 15:00 Lunch time

15:00 - 17:00 Symposium

CAN THE BLIND SEE?
Organizer: Alvaro Pascual-Leone

15:00 - 15:10	Introductory remarks
15:10 - 15:35	Amir Amedi: Neural correlates of visual-to-auditory sensory substitution in proficient blind users

15:35 - 16:00	Paul Bach-y-Rita: Tactile sensory substitution for blindness
16:00 - 16:25	Claude Veraart: Vision rehabilitation in case of blindness
16:25 - 16:50	Lotfi Merabet: Visual neuroprosthesis development: The implications of neuroplasticity
16:50 - 17:00	General discussion

17:00 - 17:30 Coffee break

17:30 - 20:00 Poster session

20:00 - 22:30 Guided tour to the MART museum
(included with registration; meeting at 8:00 pm in front of the museum entrance)

Tuesday, June 7th

9:00 - 11:00 Symposium

GRADUATE STUDENT AWARDS
Chair: Micah Murray

9:00 - 9:20	Julien Besle: Audiovisual interactions during the perception of speech recorded directly from the temporal cortex of epileptic patients
9:20 - 9:40	M. Luisa Demattè: Assessing colour-odour congruency using the implicit association test
9:40 - 10:00	Joost Maier: Multisensory processing of looming signals in primates
10:00 - 10:20	Roberto Martuzzi: Auditory-visual multisensory interactions modulate the dynamics of bold responses in unisensory cortices
10:20 - 10:40	Jessica Phillips-Silver: Perception of musical rhythm relies on auditory, motor and vestibular sensory systems
10:40 - 11:00	Nienke van Atteveldt: Binding of letters and speech sounds in the human auditory association cortex critically depends on temporal synchrony

11.00 - 11:30 Coffee break

11:30 - 12:40 Paper session

AUDIOVISUAL INTERACTIONS IN COMMUNICATION AND SPEAKER IDENTIFICATION
Chair: David J. Lewkowicz

11:30 - 11:50	Ville Ojanen: Common brain areas activated by hearing and seeing speech
11:50 - 12:10	Richard Reilly: Speaker identification based on automatic crossmodal fusion of audio and visual data

12:10 - 12:30	Katharina von Kriegstein: Behavioural relevance of activity in fusiform face area and anterior temporal lobe in multisensory person identity recognition
12:30 - 12:40	General discussion

12:40 - 15:00 Lunch time

15:00 – 16:00 Paper session

MULTISENSORY CONTRIBUTION TO OBJECT RECOGNITION AND MEMORY
Chair: Fiona Newell

15:00 - 15:20	Nicola Bruno: Proprioceptive reversible objects
15:20 - 15:40	Sophie Molholm: Direct human intracranial recordings reveal early multisensory integration in the ventral visual stream
15:40 - 16:00	Micah Murray: The brain uses single-trial multisensory memories to discriminate without awareness

16:00 – 16:30 Coffee break

16:30 – 17:30 Keynote lecture

THE MIRROR NEURON SYSTEM AND ITS ROLE IN UNDERSTANDING THE OTHERS
Giacomo Rizzolatti

18:00 – 19:00 Visit to local winery
(included with registration, but please register at the IMRF desk for this event; buses will leave at 6:30 PM from outside the MART museum for the winary, and continue to Castel Toblino Restaurant)

19:30 – 23:30 Conference banquet at Castel Toblino Restaurant
(included with registration; buses will leave at 7:00 PM from outside the MART museum)

Wednesday, June 8th

9:00 - 11:00 Symposium

SPEECH AS A WINDOW TO MULTISENSORY INTEGRATION PROCESSES
Organizer: Salvador Soto-Faraco

9:00 - 9:10	Introductory remarks
9:10 - 9:35	Salvador Soto-Faraco: Attention modulates multisensory integration: the case of audiovisual speech
9:35 - 10:00	Virginie van Wassenhove: 'Analysis-by-synthesis' in auditory-visual speech perception
10:00 - 10:25	Ruth Campbell: Seeing silent speech - cortical correlates in relation to visual processing requirements

10:25 - 10:50 Mikko Sams: Visual influences on auditory processing of speech

10:50 - 11:00 **Discussion**

11.00 - 11:30 Coffee break

11:30 - 12:30 Keynote lecture

AUDITORY AND VISUAL CONDITIONS THAT MAKE SPEECH A MULTISENSORY EVENT
Kevin G Munhall

12:30 – 13:30 Business meeting
(open to all delegates)

SUNDAY, June 5th

10:00-11:00 Tutorial lecture

USE OF ANIMAL MODELS TO DEFINE THE NEUROANATOMY AND PHYSIOLOGY OF MULTISENSORY PROCESSING

Charles E. Schroeder,
The Nathan Kline Institute, USA

Behavioral and neurophysiological experiments have established many of the critical parameters of multisensory processing in humans. Despite rapid technical advances, these studies are often limited in their ability to link behavioral and perceptual effects to their underlying neuronal mechanisms. Nonhuman animal models can help to bridge this gap, provided that appropriate cross-species equivalencies are established. This tutorial will describe the process of using the monkey as an experimental model for providing a detailed mechanistic description of the anatomy and physiology of multisensory processing in the brain. I will cover the means by which we: 1) establish human-simian homologies, 2) outline key brain regions and neural connections, and 3) identify relevant neuronal populations and physiological processes. I will also describe key linkages between monkey studies and those in other species, including both cats and humans. Finally, to illustrate the strengths and limitations of cross-species investigation and comparison, I will summarize what we know (or think we know) about multisensory interactions at early, putatively unisensory stages of cortical processing.

11:30-13:00 Paper session

MULTISENSORY INTEGRATION IN TACTILE PERCEPTION

Chair: Angelo Maravita
University of Milan-Bicocca, Italy

MODELING SPATIAL EFFECTS IN VISUAL-TACTILE SACCADIC REACTION TIME

Adele Diederich1 & Hans Colonius2
1. School of Humanities and Social Sciences International University Bremen; 2. Department of Psychology University of Oldenburg.

Saccadic reaction time (SRT) to visual targets tends to be faster when non-visual stimuli are presented in close temporal or spatial proximity even when subjects are instructed to ignore the accessory input. The present study investigated visual-tactile interaction effects on SRT using a focused attention paradigm. Saccadic responses to bi- modal stimuli were reduced by up to 30 ms compared to responses to unimodal visual targets. In contrast to previous findings with visual- auditory stimulation, the amount of multisensory facilitation was not decreasing with the physical distance between target and non-target but depended on (i) whether both stimuli were presented ipsi- or contralateral, (ii) the eccentricity of the stimuli, and (iii) the frequency of the vibrotactile non-target. A recent time-window-of-integration (TWIN) model (Colonius & Diederich, 2004) allowing to separate effects of peripheral processing differences from multisensory interaction effects is presented and tested on the data. We evaluated 8 different versions of the TWIN model, differing with respect to their assumptions on the nature of the spatial effects, with respect to the data.

EFFECTS OF VESTIBULAR ROTATORY ACCELERATIONS ON COVERT ATTENTIONAL ORIENTING IN VISION AND TOUCH

Fabrizio Doricchi & Francesca Figliozzi
Dipartimento di Psicologia 39 - Università "La Sapienza" Roma - Fondazione Santa Lucia

Using temporal order judgements to pairs of simultaneous or asynchronous stimuli presented in the left and right egocentric space, we evaluated the influence of leftward and rightward vestibular rotatory accelerations on covert attentional orienting. In a first experiment, we presented visual stimuli in the left and right hemifield. In a second experiment, tactile stimuli were presented to hands lying on their anatomical side or in a crossed position across the sagittal body midline. Stimuli were presented while subjects suppressed or did not suppress the vestibulo-ocular response (VOR) evoked by head-body rotation. Independently of VOR suppression, visual and tactile stimuli presented on the side of rotation were judged to precede simultaneous stimuli presented on the side opposite the rotation. When limbs were crossed, attentional facilitatory effects were only observed for stimuli presented to the right hand lying in the left hemispace during leftward rotatory trials with VOR suppression. In a third control experiment we demonstrated that temporal prioritization of stimuli presented on the side of rotation was not determined by response bias linked to spatial compatibility between the directions of rotation and the directional labels used in temporal order judgments (i.e. "left" or "right" first).

VISUAL CORTICAL ACTIVITY DURING TACTILE SPATIAL DISCRIMINATION IN SIGHTED AND BLIND HUMANS

Krish Sathian, Randall Stilla, & Erica Mariola
Dept. of Neurology, Emory Univ Sch Med

The blind recruit visual cortical activity in many non-visual tasks. However, the significance of such recruitment for perception remains uncertain, since many previous studies have focussed on linguistic tasks. Further, sighted subjects recruit visual cortical regions during tactile perception, and it is unclear whether the blind differ in this regard. The present study investigated visual cortical activity during tactile spatial discrimination in blind and sighted humans. The stimulus was a linear 3-dot array, with the central dot offset to the right or left, presented to the immobilized index fingerpad using a pneumatic stimulator. In the experimental task, subjects discriminated left from right offsets. In a control task, an array without offset was presented and subjects discriminated stimulus duration. Functional magnetic resonance imaging was performed while subjects performed these tasks in a block design. Relative to the control task, tactile spatial discrimination by sighted subjects evoked activity in parietal somatosensory regions, the frontal eye fields and the lateral occipital complex bilaterally. In the blind, in addition to activity in these areas, there were extensive activations in ventral visual cortical areas. We conclude that the blind recruit larger expanses of visual cortex into tactile spatial perception than the sighted.

SPATIAL MODULATION OF AUDIOTACTILE TEMPORAL ORDER JUDGMENTS DEPENDS ON WHETHER STIMULI PRESENTED FROM THE FRONT OR REAR

Massimiliano Zampini1,2 Norimichi Kitagawa2,3, David I. Shore4, & Charles Spence2
1. University of Trento, Italy; 2. University of Oxford, England; 3. NTT Corporation, Japan; 4. McMaster University, Canada.

Performance in audiovisual and visuotactile TOJ tasks is typically worse when the stimuli in the two sensory modalities are presented from the same location rather than from different locations. Here, we investigated whether audiotactile TOJs exhibit a similar spatial modulation in front and rear space. Participants made unspeeded TOJs regarding pairs of auditory and electrocutaneous stimuli presented at varying SOAs. In separate experiments, the auditory stimuli were presented from loudspeakers placed on the left and right in front of the participants or just behind their head. The electrocutaneous stimuli were presented to either index finger or earlobe directly in front of the loudspeakers on either the same or opposite side. The results revealed a spatial modulation of audiotactile TOJs (i.e., higher accuracy when the stimuli were presented from different positions than from the same position) when the stimuli were presented from behind the participants' head, but crucially not when the stimuli were presented from in front of participants. These results provide support for recent suggestions, based on both neurophysiological and neuropsychological data, that audiotactile spatial interactions may be more prevalent in the region behind the head than in the region in front of the head.

15:00-17:00 Symposium

EXPERIENCING OBJECTS THROUGH VISION AND TOUCH
Organizer: Hendrik Schifferstein
Delft University of Technology, Nederland

Overview. Some object characteristics can be perceived through both vision and touch. However, this does not imply that visual and tactual information is equivalent. In some cases, the information perceived by the two senses may conflict. This symposium brings together a number of researchers that present behavioral studies of how people perceive and evaluate objects through vision and touch. Some studies focus on the comparison of visual and tactual sensory input, whereas others focus on the integration of these inputs. Questions addressed include: How do people react to visual-tactual incongruities? How do people resolve the incongruities, to form a coherent percept? To what extent does the current percept depend on information presented previously and how is it updated? The various, complimentary approaches presented in this symposium provide us with a rich understanding of how vision and touch work together in gathering information about the objects that surround people.

PRIMING BETWEEN MODALITIES IN NORMAL AGING AND DEMENTIA

Soledad Ballesteros, José Manuel Reales, Montserrat González, & Beatriz García
CEEN Research Institute UNED

Previous studies have shown that the perceptual representations of visual and haptic objects that mediate repetition priming are not modality specific (Reales & Ballesteros, 1999). Complete cross-modal facilitation between both modalities was found in young adults. More recently, we have reported (Ballesteros & Reales, 2004) complete haptic priming in normal young and older healthy adults and in Alzheimer´s disease (AD) patients. However, the influence in priming of changing modalities in normal and pathological aging has not been investigated. In this study we tested the hypothesis that cross-modal priming between vision and touch exists in normal aging and AD patients because implicit memory depends on extraestriates areas preserved in these groups. Results from these studies will be discussed in terms of the memory systems account.

RESOLVING VISUAL-TACTUAL INCONGRUITY DEPENDS ON SENSORY RELIABILITY

Marc O. Ernst1, Johannes Burge2, & Martin S. Banks2
1. Max Planck Institute for Biological Cybernetics; 2 School of Optometry, Vision Science Program, UC Berkeley

The visuomotor system recalibrates when visual and motor maps are in conflict, bringing the maps back into correspondence. For recalibration to occur, a conflict has to be detected. Here we investigate the effect of signal reliability on the rate of recalibration. In a first study we showed that the rate of recalibration in a one-dimensional visually guided pointing task depends on the uncertainty of the feedback: faster recalibration with less uncertainty. We further also examined two-dimensional recalibration and how the specific form of visual feedback affects it. Subjects pointed with an unseen hand to a brief visual target. Visual feedback was given indicating where the point landed. We introduced a constant incongruity between pointing (tactual) and feedback (visual) location and examined the changes in pointing as the subject recalibrated. With this task we asked whether differential vertical and horizontal uncertainty in the visual feedback affects recalibration rate differentially, or whether rate is determined by the total uncertainty. We also varied feedback uncertainty in two ways. (1) We blurred the visual feedback, thereby reducing its localizability; in this condition, uncertainty could be determined on-line from one feedback stimulus. (2) We introduced random trial-by-trial perturbations in the feedback; in this condition, uncertainty had to be learned over time. In both cases, the distributions determining the vertical and horizontal uncertainties were 2D Gaussians. Recalibration profiles (changes over time in the point location relative to the visual feedback) changed only in response to changes in localizability. Recalibration was slowest in the direction of greatest uncertainty when uncertainty was due to blur, but rate was unaffected by trial-by-trial variation. This means that subjects do not estimate uncertainty over time in order to adjust reaching. Rather, they adjust trial by trial based mostly on feedback from the previous trial.

VISUAL – TACTUAL INCONGRUITIES AS SOURCES OF SURPRISE

Geke Ludden, Rick Schifferstein, & Paul Hekkert
Industrial Design, Delft University of Technology

The perception of a product through one sensory modality can create an expectation on what will be perceived through other modalities. However, the sensory information perceived may disconfirm the expectation formed, resulting in a surprise reaction. In a series of experiments, we studied users' reactions to products with visual – tactual incongruities. We distinguish between two groups of products that are hypothesized to evoke two different surprise types. Products in the Visible Novelty group look unfamiliar and, therefore, yield an uncertain expectation. Products in the Hidden Novelty group look familiar, but appear to be very different when touched. In addition, we included a control group of products without visual – tactual incongruities. Several measures were used: self-reports of the intensity and the pleasantness of the surprise, analysis of exploratory behaviour, and analysis of facial expression. We found a clear difference in users' reactions between the control group and the two surprise groups in most measures. In most cases, the surprises were evaluated as pleasant, but in some cases they appeared unpleasant. Reactions towards products in the two surprise types differed only slightly. We discuss our findings with reference to theories on the integration of sensory information and the aesthetic appreciation of products.

VISUAL AND TACTILE SPATIAL INFORMATION IS UPDATED WITH OBSERVER MOVEMENT

Fiona Newell1, Achille Pasqualotto1, & Ignace Vendrell2
1. Department of Psychology, Trinity College Dublin; 2. Institute of Neuroscience, Trinity College Dublin

Previous studies have reported that as an observer moves around their world the egocentric representation of that visuospatial scene is constantly updated to compensate for changes in the encoded information. In a series of experiments, we found that spatial updating is not specific to the encoding modality but that observer movement can compensate for changes in both vision and touch. Moreover, in a cross-modal task, we found evidence that observer movement allows for updating across both modalities together. Our results suggest that observer movement updates egocentric representations of multisensory spatial information. This finding has implications for not only our understanding of multisensory spatial cognition but also for real-world scene and object recognition.

17:30-20:00 Poster session

See page 31 for poster abstracts

Monday, June 6th

9:00-11:00 Symposium

WITHIN-MODAL VS. CROSS-MODAL PROCESSES: NEURONS, BEHAVIOR AND CLINICAL STUDIES

Organizer: Elisabetta Làdavas
University of Bologna, Italy

Overview. The symposium will consider the latest neurophysiological, behavioural and neuropsychological contributions to this field. Barry E. Stein will introduce the topic by discussing the differences in the mechanisms underlying the integration of information from different senses and from within the same sense. The first speaker (Terry Stanford), using a simple circuit model, will show how the superior colliculus neuron accomplishes multisensory integration, why the underlying circuitry produces a difference between cross-modal and within-modal integration and why only the former depends on influences of cortex. The second speaker (Mark Wallace) will show how experience with cross-modal cues impacts this neuron and determines the nature of its multisensory interaction later in life. The remainder of the symposium will deal with how these multisensory processes are manifested in human behavior and how cross-modal stimulation reinforce the innate ability of the human brain to perceive multisensory events, hidden in the normal condition in which the unimodal process is sufficient for perception. Làdavas will review neuropsychological data underlining the relevance of cross-modal audio-visual integration in enhancing visual processing in patients with a unisensory visual deficit. Bolognini will discuss the relevance of multisensory integration in localizing auditory stimuli in normals and in patients with auditory localization deficits.

MODELING THE BIOPHYSICAL BASIS OF MULTISENSORY INTEGRATION IN THE SUPERIOR COLLICULUS

Terrence Stanford, Benjamin Rowland, & Barry Stein
Wake Forest Univ. Sch. of Med.

Neurons in the superior colliculus play a primary role in effecting orientation to stimuli in the environment. "Multisensory enhancement" refers to the phenomenon where the multisensory response is greater than the largest unisensory response. We present a new model that links the physiological response to specific predictions for the internal structure of the superior colliculus. This model can explain several counterintuitive findings regarding multisensory enhancement, including results showing that the elimination of descending cortical influences renders SC neurons incapable of integrating apparently intact unisensory influences. We present a simple analysis of the model and simulations that support the assumptions of this analysis. We also present preliminary data from anatomical studies that directly support the unique predictions of this model.

DEVELOPMENTAL PLASTICITY IN MULTISENSORY REPRESENTATIONS

Mark Wallace
Neurobiology & Anatomy, Wake Forest Univ Sch Med

Multisensory neurons and multisensory integration develop gradually during postnatal life, suggesting that the sensory experiences received during this period shape the maturation of multisensory processes. To directly test this hypothesis, we have raised animals in sensory environments in which visual-nonvisual cross-modal experiences are altered. An examination of both subcortical (i.e., superior colliculus [SC]) and cortical (i.e., anterior ectosylvian sulcus [AES]) structures following such rearing reveals a marked impact on multisensory development. Whereas manipulating sensory experience has little impact on the appearance of multisensory neurons in SC and AES, the type of manipulation has striking consequences for multisensory integration. Whereas eliminating visual-nonvisual experience abolishes multisensory integration, raising animals in an environment in which visual-auditory cues are always physically separate alters the spatial constraints of multisensory integration. In contrast to

these findings, if multisensory experiences are altered in adulthood, there is little discernible impact on multisensory processes. Together, these results highlight the importance of the sensory experiences received during early postnatal life in the functional maturation of multisensory processes.

ACOUSTICAL VISION IN HEMIANOPIC PATIENTS

Elisabetta Làdavas
Department of Psychology University of Bologna

The relevance of multisensory integration in recovering visual disorders will be presented. In a first study we investigate the possibility that bimodal stimulation of the affected hemifield can improve perception of visual events in the blind hemifield of hemianopic patients. When patients were asked to detect visual stimuli presented alone or in combination with auditory stimuli that could be spatially aligned or not with the visual ones, the results showed an enhancement of visual detection in crossmodal condition (spatially aligned condition) comparing to unimodal visual condition. Moreover, in a second study, we developed a new rehabilitation approach based on the audiovisual stimulation of the impaired visual field. The results showed an improvement of visual detection in the blind field and a transfer of the treatment gains to functional measures assessing visual field defect and to daily-life activities. These results show the important adaptive meaning of multisensory integration and are very promising with respect to the possibility to recovery from visual deficits.

MULTISENSORY LOCALIZATION OF SOUNDS: BEHAVIORAL AND NEUROPSYCHOLOGICAL EVIDENCES

Nadia Bolognini
Department of Psychology University of Bologna

Multisensory neurons play a specific role in superior colliculus (SC) mediated behaviours because they form the mayor component of the output circuitry of the SC. Thus, those spatial stimulus configurations that enhance stimulus salience in SC would increase also orientation behaviours. In the first experiment, data from normal subjects show that a spatially coincident visual cue can improve the accuracy to localize degraded auditory targets, hard to localize when presented alone. In contrast, no improvement was found when the two stimuli were presented in separate loci. The spatial specificity of these crossmodal effects closely parallels the neurophysiological data, suggesting the involvement of multisensory neurons in bimodal localization. In the second experiment the ability of a visual stimulus to improve the localization of sounds was investigated in a patient with a selective deficit of auditory spatial localization. The results show an amelioration of patient's localization performance after the bimodal stimulus presentation. Moreover, the magnitude of facilitation varied in a spatial specific way. This study demonstrates that a multisensory integrated system coding both visual and auditory stimuli can play a specific role in the modulation of spatial representational deficits in patients with a deficit in auditory modality.

11:30-13:00 Paper session

MULTISENSORY ATTENTION AND AWARENESS
Chair: David I. Shore
McMaster University, Canada

EFFECTS OF ATTENTION AND CUE CONFLICT AWARENESS ON MULTIMODAL INTEGRATION IN SELF-ROTATION PERCEPTION

Daniel R. Berger & Heinrich H. Bülthoff
Max Planck Institute for Biological Cybernetics, Tuebingen

We investigated how the influence of visual and body cues on the perception of yaw rotations depends on focusing attention to either cue, and on becoming aware of conflicts between the two modalities. Participants experienced passive whole-body yaw rotations and concurrent visual rotations on a motion platform. They then had to turn back actively, while attending to either visual rotation or

body rotation. During return we introduced a conflict between visual and body rotation by means of a gain factor. After each return, participants had to respond whether or not they had noticed a conflict. We found that the weight of the visual cue on the response was significantly higher for small than for large rotations. It was also significantly higher when participants attended to the visual rotation compared to platform rotation, showing that attention has a significant influence on the weights in the integration mechanism. Further analysis revealed that the effect of attention on the cue weights was significantly larger if participants noticed conflicts than if they did not. We conclude that participants can use attention to bias the cue weights in self-motion perception towards the attended modality, and that this effect is increased when a conflict between the cues is noticed.

ATTENTIONAL CAPTURE IN SERIAL VISUAL AND AUDIOVISUAL SEARCH TASKS

Polly Dalton1, Nilli Lavie2, & Charles Spence1
1. Department of Experimental Psychology, University of Oxford; 2. Department of Psychology, University College London

The phenomenon of attentional capture by unique yet irrelevant "singleton" distractors has typically been studied in spatial visual search tasks. Recently, however, Dalton and Lavie (2004) demonstrated that auditory attention could also be captured by a singleton item in a rapidly-presented sequence of tones. In the present research, we investigated whether these findings extend to serial search tasks using either visual or audiovisual stimuli. Participants had to search a centrally-presented visual stream for targets defined on a particular dimension (e.g. size). Task performance was compared in the presence versus absence of a singleton distractor that was unique on an irrelevant dimension (e.g. duration). Both visual and auditory singleton distractors interfered with visual task performance. However, if the singleton feature coincided with the target item, search was facilitated. These results suggest that visual attention can be captured both by visual and by auditory singleton items in nonspatial search tasks.

A HIGH-DENSITY ELECTRICAL MAPPING AND FMRI INVESTIGATION OF BIASED INTERSENSORY ATTENTIONAL SETS

Manuel Gomez-Ramirez1, Glenn Wylie2, & John Foxe1
1. Cognitive Neuroscience Program at The City College of The City University of New York; 2. Nathan S. Kline Institute

Studies of selective attentional deployment to different sensory modalities have typically used so-called "endogenous" cueing paradigms where symbolic cues are presented on a screen or over headphones. Typically, it is thought that these symbolic cues selectively direct the subject's attention to one of two or three sensory modalities where a difficult discrimination task is performed within the cued modality. We contend that such cues are only minimally effective in inducing endogenous attentional mechanisms because they are externally presented and thus are not generated under the control of the subject's attentional "mind set". In the present EEG and fMRI study, we introduce a modified inter-sensory attention task where we give control back to the subjects and allow them to initiate a trial whenever they "feel ready to make an effective attentional deployment" to the sensory modality of their choosing. In contrast to the traditional paradigm, these "cues" are internally generated and entirely under control of the subject. Indeed, we find enhanced attentional modulations under this novel paradigm. For example, attended visual stimuli presented under this novel paradigm elicited greater C1 and N1 responses when compared to stimuli presented under the traditional paradigm. One implication of our results is that selective attentional filtering may be deployed to earlier processing stages when attentional deployment is "truly" voluntary.

THE ROLE OF VISUAL CORTEX IN MULTIPLE SPEAKER INTERFERENCE

Daniel Senkowski1, Dave Saint-Amour1, Thomas Gruber2, & John J. Foxe1,3
1. Nathan Kline Institute for Psychiatric Research, The Cognitive Neurophysiology Lab; 2. Universität Leipzig, Institut für Allgemeine Psychologie; 3. City College of the City University of New York, Department of Psychology, Program in Cognitive Neuroscience

Humans have the extraordinary ability to follow a conversation while disregarding similar competing visual and auditory signals. To date, the neuronal mechanisms responsible for this ability are not well

understood. Here we used a new approach to investigate visual processing in a realistic speech interference situation. Sustained brain activity in cortical networks was monitored by steady-state visual evoked potentials (SSVEPs) while subjects were presented with aligned speakers that produced syllables. Subjects were instructed to detect a target (/ba/) from an attended central speaker while ignoring two surrounding distractor speakers. SSVEPs of target and distractor speakers were simultaneously monitored in an interference condition (syllables from all three speakers) and a non-interference condition (syllable from center speaker only). For the center speaker, we observed a larger decrease in SSVEPs in the interference condition as compared to the non-interference condition over lateral-occipital scalp regions, indicating an amplification of the attended center speaker. Strikingly, an increase in SSVEPs was observed over occipito-temporal scalp regions for the distractors speakers with the highest amplitudes in the interference condition, suggesting an enhanced suppression of the distracter speakers. Our study demonstrated the essential role of amplification and suppression in visual cortex during multiple speaker interference.

15:00-17:00 Symposium

CAN THE BLIND SEE?
Organizer: Alvaro Pascual-Leone
Harvard Medical School, USA

Overview. Monet wished he had been born blind, because he believed that it would have enhanced his artistic perception of the world. Picasso stated that painting was a blind man's profession, as blind people have a clearer vision of reality. Dramatic plastic changes take place in the brain following loss of sight, which contribute to the adaptation to blindness and result in behavioral advantages for the blind. However, does the recruitment of visual cortex for tactile and auditory processing imply that blind people can see? Do the 'qualia' evoked by touch or sound become visual? What does this imply for rehabilitation of the blind and restoration of vision? What does this teach us about the fundamental organization of the human brain and the perception of reality? These questions will be addressed from the perspective of visual sensory substitution, neurorehabiltiation in the blind, and restoration of sight through neuroprostheses.

NEURAL CORRELATES OF VISUAL-TO-AUDITORY SENSORY SUBSTITUTION IN PROFICIENT BLIND USERS

Amir Amedi1 & Peter Meijer2
1. Harvard Center for Non-Invasive Magnetic Brain Stimulation; 2. Philips Research, Eindhoven, Netherlands

Sensory substitution devices (SSD) can play a role in rehabilitation of the blind with restoration of visual functions by: (1) assisting in daily-life activities such as recognizing visual objects (2) 'guiding' visual cortex to interpret information arriving from visual prostheses. We report here behavioral and neuroimaging results in blind expert users of 'The vOICe' visual-to-auditory SSD, which transforms live camera views into "soundscapes" by encoding key image aspects. Object recognition versus location processing of visual shapes encoded by 'The vOICe' was compared to tactile object identification. A right-hemisphere lateralized network appears to participate in processing soundscapes. Interestingly, differential activation of ventral V1/V2 is associated with shape versus location tasks. These results suggest that similar to visual processing, soundscapes activate the ventral visual stream to process shape information, while posterior parietal cortex contributes to location processing. We will discuss these results within the context of visual rehabilitation and restoration efforts.

TACTILE SENSORY SUBSTITUTION FOR BLINDNESS

Paul Bach-y-Rita1, & Kathi Kamm2
1. Departments of Orthopedics and Rehabilitation Medicine and B; 2 Department of Occupational Therapy, University of Wisconsin-Milwaukee

The brain is perfectly capable of substituting one sense for another. We see with our brain, not our eyes, as we stated in 1972, since in normal vision the image does not get beyond the retina, where it

is turned into pulses along the optic nerve. This was well-demonstrated in our 1969 NATURE paper. Blind subjects can navigate in rooms and halls and perform complex hand-"eye" coordination tasks (whether it is "vision" or vision has been the subject of several philosophic studies; some philosophers such as Morgan consider it to be real vision) such as catching a ball rolling across a table. But the delay in acceptance and practical use was in part related to the absence of a really practical human-machine interface (HMI), and the wait for smaller, inexpensive components. The development of an excellent tongue HMI, and miniature components (our latest version uses a goggle-mounted tiny cell-phone camera) has led to a practical device. The late brain plasticity mechanisms have been evaluated and include unmasking of previously existing pathways (both animal and human studies) and volume transmission, among others.

VISION REHABILITATION IN CASE OF BLINDNESS

Claude Veraart, Anne De Volder, & Jean Delbeke
Neural Rehabilitation Engineering Laboratory, Universite de Louvain

Perspective of vision rehabilitation in case of blindness depends on the time of occurrence of the visual loss. In case of early blindness sensory substituting systems could be helpful. These are non-invasive artificial vision systems that pick up and process visual information and transform it into stimulation of an intact sensory system such as audition or tact using a suitable translation code. On the other hand, provided the visual system has been fully developed before blindness occurrence, a visual prosthesis could be considered. Visual prostheses are invasive artificial vision systems that pick up and process visual information and translate it into electrical stimulation of a supposedly intact part of the still functional visual system of a completely blind person. Vision rehabilitation results obtained using either sensory substitution in case of early blindness, or optic nerve stimulation in case of retinitis pigmentosa are reported and discussed in this paper.

VISUAL NEUROPROSTHESIS DEVELOPMENT: THE IMPLICATIONS OF NEUROPLASTICITY

Lotfi Merabet1 & Joseph Rizzo2
1. Neurology and Ophthalmology, Harvard Medical School Neuro-ophthalmology; 2. Massachusetts Eye and Ear Infirmary

Sophisticated microelectronic devices have been developed in the hopes of restoring functional vision in the blind. All visual neuroprostheses designs share the premise that patterned sensations of light ("phosphenes") can be produced by stimulating intact structures of the visual pathway. Initial work has been encouraging however, the demonstration of truly restored functional vision awaits conclusive evidence. We believe that the greatest impediment to future development are not the remaining technical challenges but rather, our ignorance of how best to introduce meaningful information to the visually deprived brain. Growing experimental evidence indicates that the occipital visual cortex undergoes profound changes in response to the loss of sight. We propose that sensory information obtained by other sources (namely touch and hearing) may assist in developing a sensory-neural interface for blind patients learning to use a visual prosthesis and enhance the merger between what is perceived visually with what is generated electrically.

17:30-20:00 Poster session

See page 31 for poster abstracts

Tuesday, June 7th

9:00-11:00 Symposium

GRADUATE STUDENTS AWARDS
Chair: Micah M. Murray
University Hospital Center Lausanne, Switzerland

AUDIOVISUAL INTERACTIONS DURING THE PERCEPTION OF SPEECH RECORDED DIRECTLY FROM THE TEMPORAL CORTEX OF EPILEPTIC PATIENTS

Julien Besle1, Catherine Fischer2, Olivier Bertrand1, Marie-Hélène Giard1
1. INSERM Unité 280 ; 2. Hôpital Neurologique de Lyon

Even-related potentials were recorded directly from multichannel depth electrodes implanted in the temporal cortex (including the primary and associative auditory cortices and the Superior Temporal Sulcus, STS) of five epileptic patients while they were performing an auditory recognition task among four different natural syllables presented randomly in the auditory, visual or congruent audiovisual conditions. Visual-only syllables elicited long-lasting potentials that were distributed all over temporal recorded sites, including the auditory cortex. In contrast, auditory alone and audiovisual syllables elicited several phasic middle-latency components in the auditory cortex that began before the arrival of visual information. Comparing the activity elicited by the auditory and the audiovisual syllables, we found that, in three of the patients, some of the auditory components were modulated by the presence of visual information. These were primarily recorded from 75 to 150 ms of auditory processing between the planum temporale and the posterior part of Heschl's Gyrus. These results bring new insights on the way visual information can directly modulate the early processing of speech information in the auditory cortex.

ASSESSING COLOUR-ODOUR CONGRUENCY USING THE IMPLICIT ASSOCIATION TEST

M. Luisa Demattè1,2, Daniel Sanabria2, Francesco Pavani1, Charles Spence2
1. Department of Cognitive Sciences and Education, University of Trento; 2. Department of Experimental Psychology, University of Oxford

To date, few studies have attempted to study the nature of any crossmodal associations between colours and odours. What's more, all previous studies in this area have relied on people explicitly matching specific colours to odours. In the present study, we investigated whether associations between odours and colours are robust enough to affect performance using an indirect measure of association (the Implicit Association Test). The use of the IAT has the advantage that participants are not directly asked about their colour-odour associations. Instead, people made speeded discrimination responses to a random sequence of visual (pink vs. turquoise) and olfactory (strawberry vs. spearmint) target stimuli. Participants responded more rapidly (and made fewer errors) when matching colours and odours (e.g., the strawberry odour and the pink colour) shared the same response key than when they did not (e.g., when the strawberry odour was paired with the turquoise colour). These findings demonstrate that systematic and robust associations exist between odours and colours, and provide a novel crossmodal extension of the IAT.

MULTISENSORY PROCESSING OF LOOMING SIGNALS IN PRIMATES

Joost Maier, Nikos Logothetis, Asif Ghazanfar
MPI Biological Cybernetics

The world is full of rapidly approaching danger. In order to survive in such a dynamic and dangerous environment, one must perceive and respond appropriately such events. Looming signals are those sensory cues that indicate the rapid approach of objects. Many animal species possess behavioral biases toward visual and auditory looming signals. However, the ability to integrate looming signals

across modalities has not been directly studied and is the subject of the presented work. First, using a preferential looking paradigm, we found that rhesus monkeys naturally integrate auditory-visual looming signals, using simple motion-in-depth cues (dynamic intensity change and visual expansion/contraction). Second, in a psychophysical study in humans, we found that humans also spontaneously integrate auditory-visual motion-in-depth signals. Finally, to investigate the neural correlates of this integration, we recorded local field potential (LFP) activity in the monkey temporal lobe while the subject was presented with auditory, visual and bimodal looming and receding signals. Preliminary analysis of LFP signals shows multisensory effects in auditory cortex, and increased coherence between simultaneously recorded LFP signals in auditory cortex and STS during bimodal stimulation. These results might suggest that the brain integrates information across modalities by synchronizing activity from different sensory areas.

AUDITORY-VISUAL MULTISENSORY INTERACTIONS MODULATE THE DYNAMICS OF BOLD RESPONSES IN UNISENSORY CORTICES

Roberto Martuzzi1, Micah Murray2, Christoph Michel3, Philippe Maeder1, Jean-Philippe Thiran4, Stephanie Clarke2; Reto Meuli1
1. Department of Radiology, University Hospital, Lausanne, Switzerland; 2 Division of Neuropsychology, University Hospital, Lausanne, Switzerland; 3 Department of Neuroscience, University of Geneva, Geneva, Switzerland; 4. Signal Processing Institute, EPFL, Lausanne, Switzerland

Multisensory inputs improve performance, and interactions occur early after stimulus presentation. We used event-related fMRI to investigate the loci and BOLD dynamics of auditory-visual interactions. Ten subjects performed a simple reaction time task at 3T, with three randomly intermixed conditions: visual alone, auditory alone, and simultaneous auditory-visual stimulation. Stimuli were presented for 150ms with an inter-stimulus interval varying from 14.2-17.8s in steps of 200ms to estimate the BOLD dynamics. Reaction times were significantly faster for multisensory stimuli. BOLD responses within the left lingual gyrus (BA19) were stronger to multisensory stimuli than either other unisensory condition. The posterior part of the superior temporal gyrus bilaterally (BA22), the insula bilaterally (BA13), and motor-related areas (BA4/24) responded sub-linearly. Peak latencies of the BOLD signal in the left visual cortex (BA17) were significantly earlier for multisensory than either visual ($p<0.05$) or auditory ($p<0.05$) stimuli. In the left superior temporal gyrus (BA22), the multisensory BOLD response peaked earlier than the visual ($p<0.05$), with a tendency versus the auditory response ($p<0.10$). Peak latencies from auditory and visual conditions did not differ. These results provide evidence for multisensory interactions and BOLD dynamic modulations between auditory-visual stimuli within specific, low-level unisensory areas.

PERCEPTION OF MUSICAL RHYTHM RELIES ON AUDITORY, MOTOR AND VESTIBULAR SENSORY SYSTEMS

Jessica Phillips-Silver & Laurel J. Trainor
McMaster University Department of Psychology

In music we hear melody, but we feel the beat. We report the first studies to investigate multisensory interactions between auditory and motor systems that are critical to rhythm perception in music. Phillips-Silver and Trainor (under review) showed that movement of the body influences the auditory encoding of an ambiguous rhythm pattern in infants. Concurrent movement and listening experienced by infants determined whether they interpreted the pattern as a march (3 groups of two beats) or as a waltz (2 groups of 3 beats). Here we show similar effects in adults who bounced by holding hands and bending their knees in synchrony with an experimenter. Adults who bounced on every second beat chose as familiar an auditory version of the rhythm pattern that had strong auditory accents on every second beat (march), while those who bounced on every third beat chose a version with accents on every third beat (waltz). In subsequent experiments we demonstrated (1) that this effect does not rely on visual information, and (2) that movement of the subject's own body is in fact critical to the effect. We discuss the implications of these findings for the role of vestibular and motor systems in musical rhythm perception.

BINDING OF LETTERS AND SPEECH SOUNDS IN THE HUMAN AUDITORY ASSOCIATION CORTEX CRITICALLY DEPENDS ON TEMPORAL SYNCHRONY

Nienke van Atteveldt1, Elia Formisano1, Leo Blomert1, Rainer Goebel1,2
1. Dept. of Cognitive Neuroscience, Faculty of Psychology, Maastricht University, The Netherlands; 2. F.C. Donders Centre for Cognitive Neuroimaging, Nijmegen, The Netherlands

Temporal proximity is a critical determinant for cross-modal integration by multisensory neurons, as is shown by single cell recordings in different animal species. Information content occurs as additional binding factor for multisensory information of increasing complexity. We used fMRI to investigate the relative importance of these different factors for successful multisensory integration of letters and speech sounds. For this purpose, we manipulated both temporal relation and information content (congruency of letters and speech sounds) within the same experimental design. Our results reveal that temporal relation and information content interact when causing fMRI responses to multisensory stimuli in the human auditory association cortex (planum temporale). In this region, multisensory integration was only observed when the information from the two modalities was delivered simultaneously. These results highlight the importance of timing in the efficient binding of learned relations between auditory and visual linguistic information. Furthermore, the strong resemblance of the revealed temporal windows in the planum temporale to those demonstrated by single cell recordings in animals support the hypothesis that basic integration rules apply to the binding of learned multisensory associations without natural correspondence. Finally, the present study shows the suitability of fMRI to study temporal aspects of multisensory neural processing.

11:30-12:40 Paper session

AUDIOVISUAL INTERACTIONS IN COMMUNICATION AND SPEAKER IDENTIFICATION

Chair: David J. Lewkowicz
Florida Atlantic University, USA

COMMON BRAIN AREAS ACTIVATED BY HEARING AND SEEING SPEECH

Ville Ojanen1, Johanna Pekkola2, Iiro, P. Jääskeläinen1, Riikka Möttönen1, Taina Autti2, Veikko Jousmäki3, Mikko Sams1
1. Helsinki University of Technology, Laboratory of computational engineering; 2. Helsinki University Central Hospital, Department of Radiology; 3. Low temperature laboratory, Helsinki University of Technology

We used 3T fMRI to map brain areas activated during both listening to and lipreading speech (Finnish vowels /a/, /o/, /i/ and /y/) in 13 healthy subjects. Both types of speech perception activated the premotor and/or primary motor cortex. Other common areas were Broca's area, left inferior parietal area, posterior superior temporal gyrus/sulcus (STG/STS) bilaterally, left dorsolateral prefrontal cortex, and left anterior cingulate cortex. The center of activation in the motor areas, Broca's area and inferior parietal area during visual speech perception was significantly different from that during auditory speech perception. This is interpreted as evidence of both unimodal and audiovisual "mirror neurons" in these areas and as tentative evidence of somatotopic activation of the mirror neuron system during auditory and visual speech perception. This system might transform auditory and visual speech inputs into articulatory-based representations.

SPEAKER IDENTIFICATION BASED ON AUTOMATIC CROSSMODAL FUSION OF AUDIO AND VISUAL DATA

Richard Reilly & Niall Fox
University College Dublin

It has long been reported that multimodal integration enhances our ability to detect, locate and discriminate external stimuli. Translating this automatic integration process to electronic systems and devices for speech or speaker recognition is of great research interest. In this paper an audio-visual

speaker identification system employing multimodal integration is reported, with the audio and visual speech modalities combined using automatic classifier fusion. The visual modality employs the speaker's lip information. The fusion uses a feedback mechanism that automatically adapts audio or visual information based on the output of reliability estimates from both the audio and the visual feedforward recognisers. The robustness of the system was assessed, employing additive white Gaussian noise for the audio modality and ten levels of JPEG compression for the visual modality. Experiments were carried out on a large data set of 251 subjects from an international audio-visual database (XMV2TS). The results show improved audio-visual speaker identification at all tested levels of audio and visual mismatch, compared to the individual audio or visual modality speaker identification. By combining multisensory information in this way, audio-visual speaker identification accuracies range from 99.2% for no audio and visual noise to 71.4% at the most severe mismatch levels. The automatic fusion of information from the different modalities based on this physiological model offers enormous benefit for speech identification, recognition and other applications.

BEHAVIOURAL RELEVANCE OF ACTIVITY IN FUSIFORM FACE AREA AND ANTERIOR TEMPORAL LOBE IN MULTISENSORY PERSON IDENTITY RECOGNITION

Katharina von Kriegstein1, Andreas Kleinschmidt2, Anne-Lise Giraud 3
1. Functional Imaging Laboratory, University College London, UK; 2. Cognitive Neurology Unit, J.W. Goethe University Frankfurt, Germany; 3. Departement d'Etudes Cognitives, Ecole Normale Superieure, Paris, France

During recognition of familiar persons' voices activity is enhanced in visual face regions via a direct connection between superior temporal sulcus (STS) voice regions and fusiform face area (FFA). This direct crossmodal activation could be the neural basis for better voice recognition after encoding voices with faces (compared to encoding with names) and for auditory-visual facilitation during person recognition. Here we report a functional imaging experiment in which the FFA was activated in subjects learning the voices with faces but not in subjects learning voices with names. The FFA activation to voices did however not correlate with the speed of the correct matching of a subsequently presented face. Instead, reaction times correlated with higher activity in left anterior temporal pole. This activation is not significantly different in face and name group suggesting that the anterior temporal lobe serves as a modality unspecific identity node. These results are in agreement with a previous study showing preserved crossmodal FFA activation and reduced left temporal pole activation in response to a deficit in familiar speaker's voice recognition in a prospagnosic subject. We integrate these findings in existing models of person identity recognition where early sensory association in response to familiar speaker's voices is not sufficient but necessary for speeded unimodal recognition.

15:00-16:00 Paper session

MULTISENSORY CONTRIBUTION TO OBJECT RECOGNITION AND MEMORY
Chair: Fiona Newell
University of Dublin, Ireland

PROPRIOCEPTIVE REVERSIBLE OBJECTS

Nicola Bruno & Alessandra Jacomuzzi
Dipartimento di Psicologia, Università di Trieste, Italy

Some objects reverse in depth during sustained visual observation. But suppose you were watching one while holding it in your hands. Will you experience reversals despite veridical information from touch and proprioception? We report two series of experiments aimed at answering this question and at exploring its implications for multisensory integration. The first series of experiments used a hand-held reproduction of Ames' window. It is known that during monocular observation while holding the window, bimodal judgments of slant are biased by vision despite unambiguous proprioception (Bruno, Dell'Anna and Jacomuzzi, Perception, in press). However, our data indicate that the bias is rather less than the apparent slant of the window when this is not held. The second line of experiments used a hand-held model of the Necker cube. It is known that experts can reverse the cube despite contrary information from touch (Shopland & Gregory, Q. J. of Exp. Psych., 1964). However, our data indicate that reversal rates are affected by the way one holds the cube. These findings argue against a "visual

capture" account, support an explanation in terms of bimodal integrative processes, and underscore the importance of supplementing phenomenological observation with objective measures.

DIRECT HUMAN INTRACRANIAL RECORDINGS REVEAL EARLY MULTISENSORY INTEGRATION IN THE VENTRAL VISUAL STREAM

Sophie Molholm1, Pejman Sehatpour1, Ashesh Mehta2, Beth Higgins1, Marina Shpaner1, Antigona Martinez1, Theodore Schwartz2, John J. Foxe1
1. The Cognitive Neurophysiology Laboratory of The Nathan Kline Institute; 2. Department of Neurosurgery, Cornell Medical Center

The different sensory elements of an object provide multiple and oftentimes redundant cues to its identity. A key question is when and where these multiple sources of information are integrated. In a previous scalp-recorded electrical study we found auditory effects on visual object recognition processes that were source localized to the lateral occipital complex (Molholm et al., 2004). However, scalp-recorded ERPs provide an indirect measure of the underlying neural generators. Here we used intracranial recordings to acquire precise localization of auditory-visual interactions in cortical regions associated with visual processing. Subjects were presented with randomly interleaved simple auditory and visual stimuli presented alone and simultaneously, while intracranial ERP recordings were acquired. Our data showed modulation of the visual response when a visual stimulus was paired with an auditory stimulus compared to when it was presented alone, in regions of the fusiform gyrus and lateral occipital complex. What's more, this modulation occurred in the timeframe of visual object recognition processes.

THE BRAIN USES SINGLE-TRIAL MULTISENSORY MEMORIES TO DISCRIMINATE WITHOUT AWARENESS

Glenn Wylie1, John Foxe1, *Micah Murray2
1. The Cognititve Neurophysiology Lab, The Nathan Kline Institute; 2. University Hospital Center Lausanne, Switzerland

Multisensory experiences enhance perceptions and facilitate memory retrieval processes, even when only unisensory information is available for accessing such memories. Using fMRI, we identified human brain regions involved in discriminating visual stimuli according to past multisensory versus unisensory experiences. Subjects performed a completely orthogonal task, discriminating repeated from initial image presentations intermixed within a continuous recognition task. Half of initial presentations were multisensory, and all repetitions were exclusively visual. Despite only single-trial exposures to initial image presentations, accuracy in indicating image repetitions was significantly improved by past auditory-visual multisensory experiences over images only encountered visually. Similarly, regions within the lateral-occipital complex – areas typically associated with visual object recognition processes – were more active to visual stimuli with multisensory than unisensory pasts. Additional differential responses were observed in the anterior cingulate and frontal cortices. Multisensory experiences are registered by the brain even when of no immediate behavioral relevance and can be used to categorize memories. These data reveal the functional efficacy of multisensory processing.
* Speaker

16:30-17:30 Keynote lecture

THE MIRROR NEURON SYSTEM AND ITS ROLE IN UNDERSTANDING THE OTHERS

Giacomo Rizzolatti
University of Parma, Italy

Humans are an exquisitely social species, whose survival critically depends on their ability to understand actions, intentions and emotion of others. In my talk I will present a series of data that indicate that our brain is endowed with a specific mechanism –mirror mechanism- that enables us to understand all these aspects of others' behavior. I will show first that, for the so-called "cold" actions (those devoid of a emotional content), the mirror mechanism is localized in specific parieto-frontal

circuits. Neurons of these circuits –mirror neurons- discharge both when we do a specific action (e.g., grasping an object) and when we observe another person performing the same action. I will present then a series of new data indicating that the activity of mirror neurons enables us not only to understand what another person is doing (the girls is grasping an apple), but also the intention of that person (the girls is grasping an apple in order to it, or to throw it away). Finally I will review evidence showing that the mirror mechanism exists also for understanding "hot" actions, such as disgust and fear. The mirror mechanism for these actions is located in a circuit whose nodal center is located in the insula. I will conclude discussing some social and ethical implications of these findings.

Wednesday, June 8th

9:00-11:00 Symposium

SPEECH AS A WINDOW TO MULTISENSORY INTEGRATION PROCESSES
Organizer: Salvador Soto-Faraco
Universitat de Barcelona, Spain

Overview. The audiovisual integration of speech, whereby seen lip movement information is bound to speech sounds, has been frequently considered as a special case amongst multisensory processes. Yet, the study of how the multisensory signal of speech is handled by the brain has often become one of the most successful test models from which multisensory processes are studied in the human brain. One of the examples is the existence of very early influences of the visual input in areas originally thought to be in charge of auditory processing. However, less is known about the actual mechanisms that, through these early interactions, are behind the classic phenomenological findings such as the McGurk illusion. This symposium will present recent advances on what the functional as well as the neural architecture of these mechanisms is, providing further insights to the general question of multisensory binding.

ATTENTION MODULATES MULTISENSORY INTEGRATION: THE CASE OF AUDIOVISUAL SPEECH

Salvador Soto-Faraco1, Agnès Alsius1, Jordi Navarra1, Ruth Campbell
1. Dept. Psicologia Bàsica - Facultat de Psicologia and Parc Científic de Barcelona, Universitat de Barcelona; 2. Human Communication Sciences, Univesity College London

The integration of auditory and visual speech signals, perhaps best illustrated by the classic McGurk illusion, has been traditionally considered as one of the prototypical examples of fast, automatic multisensory binding. Findings from behavioural studies, which have failed to find an effect of attention on the McGurk illusion, as well as the evidence for audiovisual interactions at early stages of processing, seem to provide support for the automatic nature of multisensory integration. Here, we have addressed a direct test of this idea using a novel approach based on the attentional load hypothesis. A dual task paradigm allowed us to manipulate the amount of attentional resources available during the presentation of dubbed audio-visual clips conducive to the McGurk illusion. We found that, when attentional resources are depleted by a concurrent task, the prevalence of the McGurk illusion suffers a dramatic decrement, as compared to situation where less demands are placed on attention. These results point to a role of attention in multisensory binding.

'ANALYSIS-BY-SYNTHESIS' IN AUDITORY-VISUAL SPEECH PERCEPTION

Virginie van Wassenhove
Department of Radiology, University of California, San Francisco

The 'analysis-by-synthesis' model of speech processing was described by Halle and Stevens in 1962. We build on this model through a series of electroencephalographic (EEG) and psychophysical experiments and argue that it provides a sensible framework for auditory-visual (AV) speech perception. First, the natural dynamics of AV speech permit visual information to be extracted prior to the auditory speech. Using EEG, we show that the latency of classic auditory evoked-potentials is systematically shortened as a function of preceding visual speech inputs, while their amplitude is independently reduced. Second, perceptual detection and identification of AV speech tolerate desynchronization larger than those observed for non-speech stimuli. The temporal window of subjective simultaneity points out to two fundamental units of speech: sub-phonetic (~25ms) and syllabic (~250ms). Third, the perception of temporal order in AV speech inputs is accompanied by spectro-temporal shifts of the EEG signals in the gamma and theta bands, supporting the view that in AV speech, these two units are extracted in parallel. We hypothesize that the spectro-temporal complexity and representational status of speech compared to non-speech signals is key to characterizing multisensory perceptual systems.

SEEING SILENT SPEECH - CORTICAL CORRELATES IN RELATION TO VISUAL PROCESSING REQUIREMENTS

Ruth Campbell
Department of Human Communication Sciences, University College London

Seeing silent speech activates cortical regions that support the processing of heard speech, including auditory cortex, posterior parts of the superior temple sulcus (including but not limited to Wernicke's area) and inferior frontal regions (including but not limited to Broca's area). However, the conditions of presentation (stilled speech images to natural speech movement) and the task conditions (online speech processing or offline categorisation of material) appear to affect the relative dominance of different parts of the circuit. This review will explore the idea that two visual processing streams may contribute to the processing of visual speech - an anterior (ventro-frontal) stream for fine specified mouth information (lip, tongue position, mouth shape), which makes use of the object processing capacities of the visual ventral stream and the capacities of the inferior frontal regions for specifying details of facial gesture - and a posterior/dorsal stream, especially sensitive to activation in V5, which makes use of the dynamic aspects of the display more directly via inferior parieto-frontal pathways. The streams may converge in p-STS and may have distinct frontal components.

VISUAL INFLUENCES ON AUDITORY PROCESSING OF SPEECH

Mikko Sams
Laboratory of Computational Engineering, Helsinki University of Technology

Seeing articulation improves speech perception in noise and may also modify auditory percepts, as occurs in the well-known McGurk effect. During the last 15 years, we have started to understand the brain mechanisms underlying audiovisual speech perception. Interactions of auditory and visual speech at posterior superior temporal areas have been found in numerous studies. Evidence has accumulated that visual speech modifies activity in the auditory cortex, even in the primary auditory cortex. Visual influences on cortical auditory processing can be quite early, occurring already about 100 ms from the onset of the auditory stimulus. Moreover, our recent results suggest that seeing speech may influence processing in the auditory brainstem at about 10 ms latency form the onset of the auditory stimulus. When considering such early effects, it is important to remember that in normal speech the onset of articulatory movements start often even 100 ms before the onset of acoustic speech stimulus. The nature of visual influences is far from clear. They might reflect both indirect attention-mediated effects (seeing speech generates expectations), as well as actual processing of visual speech in the auditory system. A summary and synthesis of recent research on effects of visual speech on auditory processing is provided.

11:30-12:30 Keynote lecture

AUDITORY AND VISUAL CONDITIONS THAT MAKE SPEECH A MULTISENSORY EVENT

Kevin G. Munhall
Queen's University, Canada

It has been recognized for many years that viewing the face during auditory speech perception can influence phonetic categorization. The intelligibility of degraded auditory speech is enhanced when listeners view a talker's face movements. Watching these face movements can also influence the perception of perfectly audible speech or be the sole basis of speech perception. In this talk I will present data about the perceptual processes involved in the McGurk effect, the perception of speech in noise and speechreading. In a series of studies I will show that the visual information used for speech perception is matched to the characteristics of speech production (low temporal and spatial frequency, low dimensionality and with separable prosodic and segmental streams). Using data from eye tracking studies and spatial-frequency filtered images we have found that the low to mid-range spatial frequency information is sufficient for increases of intelligibility of speech in noise and for demonstrating the McGurk effect. Further, our studies of eye tracking indicate that high-resolution information may not always be processed because of gaze tendencies. On the other hand, results from visual-only, speechreading shows different patterns with specific phonemes showing perceptual

benefits from subtle information available at higher spatial frequencies. Using these results and the lessons we have learned from our work creating facial animation, I will discuss the interaction between the visual and auditory modalities in speech perception and the linkage between speech production and perception.

Poster sessions

(Sunday June 5th & Monday June 6th, 17:30-20:00)

(1)

THE EFFECT OF AGEING ON CROSSMODAL SELECTIVE ATTENTION AND VISUOTACTILE SPATIAL INTERACTIONS

Ellen Poliakoff1, Sarah Ashworth1, Christine Lowe1, & Charles Spence2.
1. University of Manchester; 2. University of Oxford

We investigated whether ageing affects crossmodal selective attention (the ability to focus on a relevant sensory modality and ignore an irrelevant modality) and the spatial constraints on such selective processing. Three groups of 24 participants were tested: Young (19-25 years), Young-Old (65-72 years) and Old-Old (76-92 years). The participants had to judge the elevation of vibrotactile targets (upper/index finger & lower/thumb), presented randomly to either hand while ignoring concurrent visual distractors. In a second task, the role of the target and distractor modalities was reversed. When attending to touch, the addition of visual distractors had a significantly larger effect on error rates in both of the older groups compared to the Young group. Performance was impaired when the target and distractor were presented at incongruent as compared to congruent elevations in both tasks for all age groups. In certain conditions, participants in the two younger age groups found it harder to attend selectively to one modality, when target and distractor stimuli came from the same side rather than from different sides. However, no significant spatial modulation was found in the Old-Old group. This suggests that ageing compromises spatial aspects of crossmodal selective attention.

(2)

MULTISENSORY TEMPORAL PROCESSING AND SHORT-TERM MEMORY IN DEVELOPMENTAL DYSLEXIA

Marja Laasonen, Elisabet Service, Anita Vedenpää, & Veijo Virsu
Department of Psychology, University of Helsinki

Developmental dyslexia is a difficulty in learning to read that is often accompanied by difficulties of acquiring proficiency in writing and spelling. Impaired phonological processing is the most commonly accepted predictor of reading difficulties but difficulties in temporal processing and short-term/working memory have been suggested to co-exist. These possible temporal/memory difficulties could either cause the dyslexic impairments directly or via affecting phonological processing or all the difficulties could reflect a common underlying impairment. Yet another explanation states that it is not temporal processing which is impaired but memory functions which affect (among other things) performance in tasks used in this area of research. In a series of finished and ongoing studies with adult dyslexic and fluent readers, we investigated unimodal (visual, auditory, tactile) and multisensory (audiotactile, visuotactile, audiovisual) temporal processing and short-term memory. Our results suggest that developmentally dyslexic readers suffer from both unimodal and multisensory temporal processing difficulties that aggravate with increasing adult age. These temporal difficulties are related to their phonological processing impairments. Dyslexic readers suffer also from both unimodal and multisensory short-term memory impairments. However, short-term memory in a specific modality/combination does not explain temporal processing impairment of the same modality/combination.

(3)

MODIFYING SPEECH IDENTIFICATION THROUGH MCGURK INCONGRUENCE VS. SENSORY ADAPTATION

Paul Bertelson
Free University Brussels, Cognitive Neuroscience Unit

Exposure to incongruent auditory-visual pairs of speech tokens can produce both recalibration and selective adaptation of speech identification. In an earlier study, exposure to an ambiguous auditory token (intermediate between /aba/ and /ada/) dubbed onto the video of a face articulating either /aba/ or

/ada/, recalibrated the perceived identity of auditory targets in the direction of the visual component, while exposure to congruent non-ambiguous /aba/ or /ada/ pairs created selective adaptation, i. e. a shift of perceived identity in the opposite direction (Bertelson, Vroomen, de Gelder, 2003). Here, we examined the build-up course of the aftereffects produced by the same two types of bimodal adapters, over a 1 to 256 range of presentations. The aftereffects of non-ambiguous congruent adapters increased linearly across that range, while those of ambiguous incongruent adapters followed a curvilinear course, going up and then down with increasing exposure. This late decline might reflect selective adaptation to the recalibrated ambiguous sound, showing that the two phenomena can occur within the same task context.

(4)
COMPARING HAPTIC, VISUAL, AND COMPUTATIONAL SIMILARITY-BASED MAPS OF NOVEL, 3D OBJECTS

Theresa Cooke, Christian Wallraven, & Heinrich Bülthoff
Max Planck Institute for Biological Cybernetics

Do similarity relationships between objects differ for vision and touch? We investigated this fundamental question using psychophysical experiments in which subjects rated similarity between objects presented either visually or haptically. The stimuli were novel, three-dimensional objects which parametrically varied in microgeometry ("texture") and macrogeometry ("shape"). Multidimensional scaling (MDS) of the similarity data was used to reconstruct haptic and visual perceptual spaces. For both modalities, a two-dimensional perceptual space was found. Perceptual dimensions clearly corresponded to shape and texture. Interestingly, shape dominated for vision, whereas both shape and texture dominated for touch. In order to correlate these perceptual features with physical features, we extracted computational features from 3D object geometry and from 2D images. Similarity ratings were computed using these features and maps of the objects in these physical feature spaces were generated using MDS. Maps based on 2D subtraction, 2D correlation, and 3D subtraction correlated surprisingly well with visual maps. In contrast, maps based on edge detection and Gabor jets correlated poorly with both haptic and visual perceptual maps. This study presents a unique approach for quantitative analysis of visual and haptic similarity relationships, exploration of the physical basis of perceptual features, as well as perceptual validation of computational features.

(5)
SOUND ALTERS ACTIVITY IN HUMAN V1 IN ASSOCIATION WITH ILLUSORY VISUAL PERCEPTION

Susanne Watkins, Ladan Shams2, Shigeki Tanaka3, John-Dylan Haynes1, & Geraint Rees1
1. University College London; 2 UCLA Department of Psychology; 3 Jin-ai University, Japan.

The auditory induced double flash illusion shows that conscious visual perception can be dramatically altered by irrelevant auditory stimulation. When a single brief visual flash is accompanied by two auditory bleeps, the single flash is frequently perceived incorrectly as two flashes. Here, we used event-related functional MRI in conjunction with retinotopic mapping of early visual cortex to examine the neural basis of this illusory phenomenon. On each trial, participants were presented with either one or two successively flashed high contrast annuli around fixation, either alone or in association with one or two binaurally presented bleeps. Participants indicated on each trial whether they perceived either one or two flashes. Behaviorally, on a significant proportion of single flash trials that were accompanied by two bleeps, participants reported the perceptual experience of two flashes i.e. the illusion. We then compared brain activity evoked by physically identical but perceptually dissimilar (illusion versus no illusion) one-flash-two-bleep trials. In V1, there was significantly greater activation for illusion versus no illusion trials. Such activation cannot reflect a general auditory alerting effect as the trials in such a comparison are physically identical. Our findings indicate that multisensory interactions can occur at the very earliest stages of cortical processing in humans.

(6)
IS VISUAL/HAPTIC CROSSMODAL REPRESENTATION MODALITY-SPECIFIC OR MODALITY-INDEPENDENT?

Simon Lacey & Christine Campbell
School of Human Sciences & Communication, Southampton Institute, UK

Interference techniques have successfully been used to investigate representation in working memory (Baddeley & Hitch, 1974) but have only recently been applied to crossmodal memory. The representations underlying visual/haptic crossmodal memory may be modality-specific, either visual (eg

Zhang et al., 2004) or haptic (eg Reed et al., 2004), or modality-independent (eg Reales & Ballesteros, 1999). Since spatial information about objects, such as size and shape, can be perceived by both vision and touch (Walker-Andrews, 1994), this study tested these conflicting accounts using visual and haptic, spatial and non-spatial, interference. Participants (N = 180) performed a study-test task with an interference task during encoding. The results showed that interference effects did not depend on modality but on whether or not the interference task was spatial. This suggests that visual/haptic crossmodal memory relies on representations that are spatial and modality-independent rather than modality-specific. Spatial representation has explanatory power since spatial information is available to both vision and touch for both familiar and unfamiliar objects.

(7)

MCGURK EFFECTS IN DEAF SUBJECTS WITH COCHLEAR IMPLANTS

Julien Rouger1, Marie-Laurence Laborde2, Sebastien Lagleyre1, Yves Trotter1, Olivier Deguine2, Bernard Fraysse2, & Pascal Barone1.
1. Cerveau et Cognition CNRS UMR 5549; 2. Service ORL, Hopital Purpan

The "McGurk" effect demonstrates that visual information from lip movements profoundly modify the auditory perception of speech by normally hearing subjects. Using the "McGurk" effect to probe multisensory interactions, we have investigated whether similar patterns of interference extend to postlingually deaf patients using a cochlear implant (CI). Normal (n= 19) and cochlear implant subjects (Nucleus, n=19) were assigned to the presentation of visual, auditory and visuo-auditory congruent or non-congruent stop consonant speech syllables, and have to repeat what they had heard or seen. Phonetic categorization based on mode or place of articulation was performed on stimuli and answers. Results show that CI subjects present difficulties to associate auditory stimuli to their corresponding phonetic categories, with better performances for manner of articulation compared to mode (56% vs 42%). Visual stimuli produced similar phonetic categorizations between the two groups, with better performances for place of articulation (61% vs 36%). Visuo-auditory conditions induce higher performances for all categories (76% correct) as consequence of multisensory integration. Bimodal protocols (congruent and non-congruent) show that cochlear implant provides primarily cues for manner of articulation, whereas lip-reading provided cues for place of articulation. Our results suggest similar mechanism of complementarity between vision and audition in normal and CI subjects.

(8)

ROLE OF VISUO-AUDITORY INTEGRATION IN SPEECH COMPREHENSION IN DEAF SUBJECTS WITH COCHLEAR IMPLANTS

Sebastien Lagleyre1, Marie-Laurence Laborde1, Julien Rouger2, Yves Trotter2, Bernard Fraysse1, Pascal Barone2, Olivier Deguine1.
1. Service ORL, Hopital Purpan; 2. Cerveau et Cognition CNRS UMR5549

Because multisensory integration results in perceptual improvements by reducing ambiguity, we have investigated the role of visuo-auditory interactions in speech comprehension in deaf subjects that received a cochlear implantation (Nucleus). In a population of 56 cochlear implanted patients (CI) we performed a longitudinal post-implantation analyze of the performances in bisyllabic words recognition in three modalities : lipreading, speech and visuo-auditory. At time of implantation, patients show a greater word recognition using lipreading compared to control (36% vs 9%). In CI, lipreading performances remain important (37%) even 3 years after implantation. Cochlear implants generate a significant improvement in auditory speech recognition as expressed as an increase in performances from 45% at one month to 79% after one year, followed by a slight increase in the following years (85% at 3 years). Visuo-auditory stimulation is largely beneficent to speech recognition, the performances increasing to 85% at one month and reaching nearly 100% after one year. These results indicate that in CI the multisensory gain is maximum during the first months after implantation suggesting a functional reorganization of the neuronal network involved in speech comprehension during the corresponding period. Ongoing PET scan analysis will assess the nature of such cross-modal plasticity.

(9)

AUDIOVISUAL INTEGRATION DURING OBJECT RECOGNITION: AN ER-FMRI STUDY

Alexandra Fort1, Peter C. Hansen2, Thomas Thesen2, Gemma A. Calvert3
1. INSERM U280; 2. University Laboratory of Physiology, University of Oxford; 3Department of Psychology, University of Bath.

Behavioural studies have shown that correspondence in time is a key factor that determines whether two or more sensory cues will be perceived as emanating from a common object. By manipulating the

temporal onset of two audiovisual objects in an event-related fMRI study, we aimed to elucidate the brain areas responsible for the detection of crossmodal synchrony during an object recognition task. Subjects were instructed to determine on each trial whether an auditory, visual or audiovisual stimulus corresponded to one of two previously learned objects. In the audiovisual condition, the visual component could be presented either simultaneously with the auditory component (AV) or with a delay of 300 ms (AV-asy). Comparison of the AV condition against the combined sum of the two unimodal conditions failed to reveal any brain areas exhibiting a superadditive response, consistent with previous event-related imaging studies of crossmodal object integration (e.g. Beauchamp et al, 2004). However, areas where AV was greater than either the A or V condition alone included the superior colliculus and both auditory and visual cortices. These areas also formed part of the network of areas exhibiting a stronger response for AV vs AV-asy which additionally included the SMA, pulvinar and sensory-motor cortex adjacent to the central sulcus. The results of this study have implicated a network of multisensory integration sites that operate both at the input (sensory) and output (motor) stage during crossmodal object recognition.

(10)
INVESTIGATING THE CROSSMODAL SPATIAL CUING OF DRIVER ATTENTION
Cristy Ho1, Hong Z. Tan2, Charles Spence1.
1. Department of Experimental Psychology, Oxford University; 2Haptic Interface Research Laboratory, Purdue University

Previous research has shown that the presentation of spatially-predictive auditory and vibrotactile warning signals can facilitate driver responses to driving events seen through the windscreen or rearview mirror. In the present study, we investigated whether this facilitation reflects the priming of the appropriate response (i.e., braking vs. accelerating) or an attentional cuing effect (i.e., a perceptual benefit that facilitates subsequent behavioral responding). In the experiments reported here, participants had to discriminate the colour of a numberplate (red vs. blue) following the presentation of either spatially-predictive vibrotactile (Experiment 1) or auditory (Experiment 2) warning signals that indicated the likely location (front or back) of the visual target, while simultaneously performing a highly attention-demanding rapid serial visual presentation task. Numberplate discrimination performance was facilitated following the presentation of valid auditory cues but not following the presentation of equally informative vibrotactile cues. The use of an orthogonal cuing design enabled us to rule out a potential response priming account of these data. Our results suggest that while directional congruency between a warning signal and a target event may be sufficient to facilitate performance due to the priming of the appropriate response, attentional facilitation effects may require the co-location of the cue and target within the same functional region of space as well.

(11)
EARLY VISUAL AREA ACTIVATION IN TACTILE PROCESSING
Lotfi Merabet1, Jascha Swisher2; Stephanie McMains2, Mark Halko2, Amir Amedi1, Alvaro Pascual-Leone1, & David Somers2.
1. Neurology, Harvard Medical School; 2. Psychology, Boston University.

The contribution of early visual areas in tactile cross-modal sensory processing remains unclear. In a previous study, we employed rTMS to selectively disrupt somatosensory and occipital cortex processing while blindfolded sighted subjects performed a tactile task. Using arrays of raised dots of different inter-dot spacing, normally sighted subjects (blindfolded) were asked to rate the roughness and distance spacing between dot patterns presented in random order. rTMS delivered to somatosensory cortex impaired the overall perceived roughness while rTMS applied to the occipital cortex did not affect roughness but rather disrupted distance perception. As a follow-up to this study, we employed fMRI to investigate the contribution of early visual areas while subjects performed the same tactile task. Occipital cortex activation was evident in both hemispheres and for both roughness and distance determinations. Further ROI analysis revealed that activation was localized to V1 and that higher visual areas exhibited a pattern of progressive deactivation. Taken together, these results suggest that tactile discrimination implicates a network involving both somatosensory and visual cortical areas. Current studies are now investigating activation of V1 as a function of task difficulty and the role of this area in congenitally blind subjects.

(12)
VISUO-AUDITORY INTEGRATION IN THE MONKEY: BEHAVIORAL AND NEURONAL EVIDENCES IN THE PRIMARY VISUAL CORTEX

Ye Wang1, Simona Celebrini1, Christophe Joufrais2, Yves Trotter1, & Pascal Barone1.
1. Cerveau et Cognition, CNRS UMR 5549; 2. Institut de Recherche en Informatique de Toulouse.

Recent human imaging studies have revealed that multisensory interactions can occur in early stages of visual processing, a phenomenon probably mediated by the direct projections observed in the monkey, from auditory areas directly to V1. To investigate the influence of an auditory stimulus on visual responses of V1 neurons, a monkey was trained to maintain a passive central fixation while a peripheral visual or visuo-auditory stimulus was presented. From a population of 47 V1 neurons, there is no difference in the mean latencies or strength of visual responses when comparing visual or visuo-audiory conditions. In a second active task, the monkey was required to orient his gaze toward the visual or visuo-auditory stimulus. Behaviorally, in bimodal compared to visual condition, saccade latencies are significantly 10% shorter. From 48 cells recorded during this saccadic task, visual neurons present a significant reduction in response latencies in visuo-auditory condition compared to visual (mean 63,8 vs. 60,4ms) only when the visual stimulus was at low contrast. No effect was observed at high contrast. These results suggest that the behavioral improvement of performances in visuo-auditory conditions might be partly mediated by an integration of auditory information performed at the level of the primary visual cortex.

(13)
SYNAESTHESIA: A UNION OF THE SENSES

Kylie J. Barnett1, Ciara Finucane1, Aiden Corvin2, Kevin J. Mitchell2 , & Fiona N. Newell1.
1. Department of Psychology, TCIN, Trinity College Dublin; 2. Department of Genetics, Trinity College Dublin

Ordinarily a physical stimulus gives rise to a unitary perception that is confined to a single sense. In synaesthesia the senses are mixed and a single stimulus elicits a dual perceptual experience. The aim of our study was to assess synaesthetic associations that occur within or between modalities. Questionnaire data was collected as part of an ongoing study into the phenotypic and neurobiological characteristics of synaesthesia. We present findings based on individual and familial data from 56 individuals with synaesthesia. Respondents were predominantly female with a gender bias of 7:1. 54% of individuals report a positive family history of synaesthesia. Data were collected on age, gender, handedness, memory abilities, types of synaesthesia, co-existence of more than one type of synaesthesia, unidirectionality, and the relationship between inducers and concurrents. While any of the senses may combine in the synaesthete, the most common reports were of colour-phoneme and colour-grapheme synaesthesia. Experiences of coloured-taste, coloured-pain and coloured-personalities were rare. Our data suggest that individuals are unlikely to experience only one form of synaesthesia and that such experiences commonly involve colour and occur between modalities, for example coloured hearing and taste.

(14)
UNIMODAL AND BIMODAL NUMEROSITY JUDGMENTS

Alberto Gallace1, Hong Z. Tan2, & Charles Spence1.
1. Department of Experimental Psychology, Oxford University, Oxford, UK; 2. Haptic Interface Research Laboratory, Purdue University, West Lafayette, USA

Numerosity judgment research reveals a discontinuity in judgments of small (=4) versus large (>4) numbers of visual stimuli, consistent with people shifting from a strategy of subitizing to one of counting. In Experiment 1, we explored "tactile" numerosity judgments, briefly presenting 1-7 vibrotactile stimuli over the body surface. The accuracy of participants' estimates of the number of tactile stimuli presented decreased linearly as a function of the number of locations stimulated. However, no evidence of a discontinuity in tactile numerosity judgments was observed (arguing against subitization in tactile perception). In Experiment 2, we investigated numerosity judgments using both unimodal and bimodal displays consisting of 1-6 vibrotactile stimuli (presented over the body surface) and 1-6 visual stimuli (seen on the body via mirror reflection). Participants had to count the number of stimuli regardless of their modality of presentation. The accuracy of bimodal numerosity judgments was not predicted by performance on the unimodal displays. In fact, bimodal numerosity judgments were significantly worse than those for unimodal displays of equivalent number. These counterintuitive results are discussed in

relation to current theories of crossmodal integration and to the cognitive resources and/or common spatial representations possibly accessed by visual and tactile stimuli.

(15)
ASSOCIATIVE LEARNING IN MULTISENSORY INTEGRATION
Helen Bates1, Ricky van der Zwan2, & Stuart Smith1.
1. Psychology, Trinity College Dublin, Ireland; 2. Psycholgy, Southern Cross University, Coffs Harbour, Australia

A number of previous investigations have shown that perceptual learning can occur for a wide range of visual tasks including orientation discrimination, motion direction, spatial position detection and object recognition (review see Fine and Jacobs, 2002: Journal of Vision, 2(2),190-203). The present study investigates whether associative learning plays a key role in perception of bistable (Ternus) patterns when auditory information is integrated with the visual display. Our approach is situated within a Bayesian framework of perception, involving model-based matching of sensory data to stored "priors"/ data-independent knowledge. Associative learning mechanisms are hypothesized to provide perceptual systems with "prior" estimates of signal/modality reliability, which are used to guide optimal multimodal bindings. Following repeated presentation visual information ("Ternus" displays) with spatiotemporally coincident auditory information (high/low frequency tones) our data suggest that increasing probability of association between multimodal sources of information has a systematic effect on perceptual grouping phenomenon.

(16)
VISUAL RECOVERY OF TOUCH
Andrea Serino1, Alessandro Farné1, Patrick Haggard2, Cristina Morici1, Marco Borsotti1, Elisabetta Làdavas1.
1. Dipartimento di Psicologia & Centro studi e ricerche in Neuroscienze Cognitive, Università di Bologna; 2. Department of Psychology and Institute of Cognitive Neuroscience, UCL, London

Viewing the body is reported to improve tactile acuity (Kennett et al., 2001). The aim of the present study was to investigate whether this effect is dependent on the somatotopic congruency between the seen and touched body parts and whether it occurs only in subjects presenting low tactile sensitivity. Therefore, 33 normal subjects performed a two point discrimination task (2PDT) in three conditions: looking at their stimulated forearm (ARM condition), at a rubber foot (FOOT condition) or at a neutral object (NEUTRAL condition). The results showed that 2PDT accuracy was higher in the ARM condition, but only in subjects with lower tactile spatial sensitivity. Thus, it was hypothesized that the visual modality could improve tactile spatial sensitivity in subjects with tactile deficits. To test this hypothesis the same experiment was conducted on 10 brain damaged patients suffering a reduced somatosensory sensitivity. Again an amelioration of the performance was found in ARM condition. In conclusion, tactile sensitivity can be ameliorated in brain damaged patients by the sight of the stimulated body part, thus suggesting that the interaction between different sensory modalities might be effective in recovering deficits in single modalities.

(17)
AUDIOVISUAL SYNCHRONY PERCEPTION FOR COMPLEX STIMULI: HOW "SPECIAL" IS SPEECH?
Argiro Vatakis & Charles Spence.
Department of Experimental Psychology, Oxford University

This study investigated the perception of synchrony for realistic audiovisual events. A series of speech, music, and object-action video clips were presented at a range of stimulus onset asynchronies (SOAs) using the method of constant stimuli. Participants made unspeeded temporal order judgments (TOJs) regarding which modality (audition or vision) appeared to have been presented first. The perception of synchrony for object-action and guitar music differed from that of piano music, but no differences were reported between speech and piano music. Speech and piano music both required the auditory stream to be presented before the visual stream for the perception of synchrony to be experienced, while object-action and guitar music events required vision to lead. These results suggest that speech is not special in terms of the visual lag normally required for the perception of simultaneity. Response accuracy differed marginally for all video clips presented. These results show that the window for audiovisual integration is wider (i.e., the Just Noticeable Difference (JND) is higher) for more complex audiovisual

events, than for the simple point-light and tone-burst stimuli typically used in the majority of previous research on multisensory temporal perception.

(18)
SENSORY INTEGRATION IN THE PERCEPTION OF VERTICAL
Amelia Crossbrown1, Ricky van der Zwan2, & Stuart Smith1.
1. Psychology, Trinity College Dublin; 2.Psycholgy, Southern Cross University, Coffs Harbour, Australia

Understanding the mechanisms which process visual spatial orientation has long been a fundamental goal of research in vision science, involving a combination of psychophysical, neurophysiological and computational approaches. The visual cortex supports populations of neurons that are sensitive to visual contours defined by many different features (eg luminance, texture, disparity, colour, contrast). One of the computational tasks of the central nervous system is therefore to combine these multiple sources of information concerning object orientation. Recent work (Popple and Levi, 2004: Vision Research, 44, pp3081-3090) suggests that orientation discrimination using multiple cues is consistent with a weighted Bayesian decision process. Following recent application of this approach to perception of objects defined by multiple sources of sensory information, we investigate whether the perceived orientation of a visual object could be modulated through the addition of auditory orientation cues. Our results suggest that simultaneous presentation of auditory cues improves the certainty of orientation discrimination of a visual object. Furthermore we show that the perceived orientation of a visual object can also be systematically modulated by an oriented auditory source.

(19)
ASSESSING THE INFLUENCE OF A SCHEMATIC DRAWING OF THE HAND ON TACTILE DISCRIMINATION PERFORMANCE
Yuka Igarashi1, Norimichi Kitagawa2, Charles Spence3, & Shigeru Ichihara1.
1. Department of Psychology, Tokyo Metropolitan University; 2. NTT Communication Science Laboratories, NTT Corporation; 3. Crossmodal Research Group, Department of Experimental Psychology, University of Oxford.

Seeing one's own body parts (either directly or indirectly) can influence visuotactile crossmodal interactions. Recently, we showed that even a simple line drawing of a hand can also modulate such crossmodal interactions, as if the picture of the hand somehow corresponds to the participants' own hand. In the present study, we assessed the effect of the picture of a hand on speeded tactile discrimination performance. Participants had to discriminate the location of brief vibrotactile targets presented to either the tip or base of their forefinger, while trying to ignore simultaneously-presented visual distractors positioned horizontally. We compared the modulatory effect of the picture of a hand with that seen when the visual distractors were presented next to words describing the tip and base of the forefinger (Experiment 1), or were superimposed over arrows (i.e., another kind of directional stimulus; Experiment 2). Tactile discrimination performance was modulated in the hand picture condition, but not in either of the word or arrow conditions. These results suggest that visuotactile interactions were specifically modulated by the image of the hand rather than by cognitive cues such as simply semantically referring to the relevant body sites and the visual orientational cue of the hand.

(20)
CROSS-MODAL PERCEPTION OF EMOTION BY FACE AND VOICE: AN ERP STUDY
Michela Balconi & Alba Carrera.
Department of Psychology, Catholic University of Milan

Emotion perception constitutes a case of processing of cues from multiple channels. Particularly, we focus our attention on the simultaneous processing of the tone of voice and the facial expression. Behavioral and neuropsychological studies indicate that, when we have to decode emotions on the basis of congruous visual and vocal information, a cross-modal bias, similar to that of speech reading, has place. Indeed, when the visual and the auditory stimuli are incongruent, subjects operate an integration. This integration is observed also when subjects are explicitly required to ignore one of the sources. It has been suggested that this cross-modal integration arises in a very early perceptual step of information processing. Moreover, the processing of emotional cues would take place outside the scope of awareness. In order to investigate this hypothesis, we conduced an ERP study comparing the subliminal and supraliminal perception of simultaneous visual (facial expressions of happiness, sadness, fear, anger, surprise and disgust) and auditory (words pronounced in an affective tone) emotional stimuli, in both the condition of congruence and incongruence. Differences in terms of ERPs (peak and latency

variations) and behavioral response (RT) were found, due to condition (congruence/incongruence) and stimulation (supraliminal/subliminal) type.

(21)
SOUND AFFECTING VISION: TEMPORAL ASPECTS
Jean Vroomen
Tilburg University

A sound presented in close temporal proximity to a visual stimulus can alter the perceived temporal occurrence of that visual stimulus[1] (i.e. temporal ventriloquism. The conditions under which this crossmodal interaction occurs (spatial and temporal disparity between sound and light, grouping of the sound), and its neural consequences[2] (ERPs) will be discussed. Our results challenge the commonly held view that similarity in space and time are necessary and sufficient conditions for crossmodal interactions to occur[3]. 1. Vroomen, J. and B. de Gelder, Temporal ventriloquism: Sound modulates the flash-lag effect. Journal of Experimental Psychology-Human Perception and Performance, 2004. 30(3): p. 513-518. 2. Stekelenburg, J.J., J. Vroomen, and B. de Gelder, Illusory sound shifts induced by the ventriloquist illusion evoke the mismatch negativity. Neuroscience Letters, 2004. 357(3): p. 163-166. 3. Vroomen, J., Ventriloquism and the nature of the unity decision, in Cognitive contributions to the perception of spatial and temporal events, G. Aschersleben, T. Bachmann, and J. Müsseler, Editors. 1999, Elsevier: North Holland. p. 389-394.

(22)
THE EFFECT OF TASK-IRRELEVANT VISUAL INFORMATION ON THE MEMORY OF HAPTIC SCENES
Achille Pasqualotto & Fiona N. Newell
Department of Psychology and Institute of Neuroscience, University of Dublin, Trinity College

Does task-irrelevant visual information improve our memory for tactile scenes? We investigated the effects of noninformative vision on haptic memory of layouts of objects arranged in a scene. Using touch alone, participants first learned a scene and were subsequently tested on their recognition of that scene. Participants could either see the surrounding room or were blindfolded. We predicted better recognition when the participants could see the task-irrelevant visual information. In Experiment 1 we found that noninformative vision improved haptic scene recognition. Moreover, this benefit transferred to the subsequent condition where the participant was blindfolded. In Experiments 2 and 3 we investigated whether wearing a blindfold reduced performance but we found no evidence of this. In Experiment 4 we investigated whether the benefit for noninformative vision again transferred to the blindfolded condition. Here, however, the participant moved to a new environment for the blindfold condition. Unlike Experiment 1, we found no transfer of the effect of noninformative vision on haptic scene recognition performance. Our results suggest that vision provides the reference frame to which haptic scenes are encoded. Noninformative vision enhances recognition performance for haptic scenes provided that the same visual information is available throughout the task.

(23)
THE SPATIOTEMPORAL DYNAMICS OF AUDITORY 'WHAT' AND 'WHERE' PROCESSES IN HUMANS REVEALED BY ELECTRICAL NEUROIMAGING
Laura De Santis1,2, Raphaël Meylan2, Eric Tardif2,3, Stephanie Clarke2,3, Micah M. Murray2,4
1. The Functional Electrical Neuroimaging Laboratory; 2. Division Autonome de Neuropsychologie, CHUV, Lausanne; 3.Institut de Physiologie, Université de Lausanne, Lausanne ; 4. Service Radiodiagnostique et Radiologie Interventionnelle, CHUV, Lausanne

The auditory system, like its visual counterpart, is comprised of at least two parallel functional pathways - one specialized for the treatment of a sound's identity and the other for its spatial attributes (so-called 'what' and 'where' pathways, respectively). While both neuro-anatomical and hemodynamic imaging data support this subdivision, several issues remain unresolved. One is the time course of differential activity and if such entails the recruitment of distinct brain regions. Another is whether such differential activity occurs automatically. Here, electrical neuroimaging during a passive 'oddball' paradigm identified the spatiotemporal dynamics whereby auditory 'what' and 'where' processes differ in humans. On separate blocks, stimuli either varied in their pitch, independently of their perceived location, or in their perceived location, independently of their pitch. Participants completed 4 blocks of trials, fully counterbalancing the design and ensuring effects were not due to acoustic differences between conditions. At ~95ms, neural responses to these conditions significantly differed topographically, indicating the activation of

distinct processing pathways and regions. These findings are consistent with models of automatic parallel processing along functionally specialized pathways within the auditory system and provide important considerations on when and where spatial and identity information con be conjoined across sensory modalities.

(24)
EVIDENCE FOR CONFIGURAL PROCESSING IN CROSSMODAL FACE MATCHING
Sarah J Casey & Fiona N Newell.
Department of Psychology/TCIN, University of Dublin

Visual researchers often cite configural face processing, and its disruption due to inversion, as evidence of a face-specific processing mechanism. Recently a haptic face inversion effect was demonstrated suggesting that the haptic system also relies more on the processing of configural information during the recognition of upright faces. Previously we reported that familiar and unfamiliar faces could be matched successfully across the visual and haptic modalities. Here we tested whether this crossmodal matching ability is facilitated more by a featural or configural information contained in the faces. In Experiment 1 participants had to match a haptic facemask to a successively presented visual face image. The visual stimuli were either intact, blurred, or scrambled faces. We found a cost in matching performance for facemasks matched to scrambled stimuli relative to that for both intact and blurred images. In Experiment 2 this effect was extended to a vision-to-touch crossmodal matching task. Our findings suggest that configural face information is encoded by both the visual and haptic modalities and that this information underpins more efficient face matching across the modalities.

(25)
AN IDENTIFICATION TASK REVEALS BODY-RELATIVE MAPS LINKING TOUCH TO VISION
Alessandra Jacomuzzi & Nicola Bruno
Dipartimento di psicologia, Università di Trieste

When an object is touched and then seen, the perceptual system must link the neural signals across the two sensory modalities and across time. In the traditional view of the functional architecture of cognition, links from touch to vision use abstract, modality independent representations computed in "associative" areas. In more recent approaches, they instead exploit object structural descriptions possibly in extriate areas involved in object recognition. We studied links between touch and vision with random-dot stereograms that cointained a carefully calibrated amount of stereonoise. Contrary to either of the commonly accepted views, in our studies identification times for seen forms preceded by touched forms revealed haptic interference but no facilitation. Moreover, this intersensory effect occurred only when (i) touched forms were actual surfaces as opposed to raised letters (identifying the names of the seen forms); and when (ii) seen forms were in the same location relative to the participant's body. Given that perceiving forms in the stereogram required solving the stereo correspondence problem (a process that is generally believed to occur in the primary visual areas) these findings suggests that touch and vision can interact at an earlier level than suggested by previous studies of semantic or structural cross-modal priming.

(26)
ATTENTION DOES NOT AFFECT MULTISENSORY CUE WEIGHTING
Hannah Helbig & Marc Ernst
Max Planck Institute for Biological Cybernetics

Humans gather information about their environment from multiple sensory channels. It seems that cues from separate sensory modalities (e.g., vision and haptics) are combined in a statistically optimal way according to a maximum-likelihood estimator (Ernst & Banks, 2002). Ernst and Banks showed that for bi-modal perceptual estimates, the weight attributed to one sensory channel changes when its relative reliability is modified by increasing the noise associated to its signal. Here we address the question as to whether selectively increasing the attentional load of one sensory channel does affect the weighting of cues from different sensory channels. In our experiment, subjects' main-task was to estimate the size of a raised bar using vision alone, haptics alone, or both modalities combined. Their performance in the main-task condition alone is compared to the performance obtained when a concurrent visual 'distractor'-task is performed. We found that vision-based estimates are more affected by a visual 'distractor' than the haptics-based estimates. Thus, attention is indeed selectively detracted from the visual modality. Moreover, we found that the cue weighting is not affected by adding the visual 'distractor'-task. Therefore we can conclude that multisensory integration occurs at an early stage of processing and is not affected by attention.

(27)
AN INVESTIGATION OF VISUO-HAPTIC INTEGRATION USING A TEXTURE DISCRIMINATION TASK
Jason Chan
Institute of Neuroscience, University of Dublin, Trinity College

In this study, we investigated the role of visuo-haptic integration using a series of complex stimuli that were discriminable by surface texture only. The visual and haptic stimuli were taken from a continuum of two partially overlapping surfaces each defined by different component texture elements. A continuum referred to the amount of available information in the stimulus that was relevant to the task such that at the midpoint of the continuum the stimuli were ambiguous. The task for the participant was to indicate which of the upper or lower surfaces in a stimulus was overlapping the other. The visual surface stimuli were each composed of lines of different orientations whereas the haptic surface stimuli were each composed of different dot densities. In Experiment 1 the task was conducted entirely within either the visual or haptic modalities. We found that as stimulus ambiguity increased, participants found it more difficult to determine which surface overlapped the other in each modality. In Experiment 2 we examined if whether a combination of the senses could improve performance by resolving the conflict between the ambiguous stimuli. Our initial findings suggest that multisensory integration reduced uncertainty and resulted in improved performance relative to within modal performance.

(28)
PROJECTING A SENSATION TO AN ALIEN LIMB INVOLVES THE SOMATOSENSORY CORTEX
Michael Schaefer, Herta Flor, Hans-Jochen Heinze, & Michael Rotte.
Department of Neurology II, Otto-von-Guericke University Magdeburg, Magdeburg, Germany

Previous work has shown that the body image can be distorted as a consequence of injury (e.g., phantom sensations). A number of studies suggest similar illusions in healthy subjects. The present study investigated an illusion in which tactile sensations are referred to an alien limb. Subjects watched a video, which showed a hand where the first digit (D1) was stroked by a stick. At the same time subjects were stimulated on D1 either synchronously or asynchronously to the hand in the video. Subjects reported an illusion of tactile sensation in which the real hand stimulation was referred to the hand in the video. During the experiment the topography of the functional organization of the primary somatosensory cortex (SI) related to tactile stimulation of D1 was assessed using neuromagnetic source imaging. The cortical representation of D1 moved to a more inferior location during synchronous in comparison to asynchronous stimulation and rest. This modulation of the map in SI was significantly positively correlated with the feeling of the alien limb. Our data suggest that somatosensory cortical maps contribute to the experienced illusion in which the subjects seemed to feel the touching of the hand on an alien limb.

(29)
FEATURE-BASED POST-ATTENTIVE PROCESSING FOR TEMPORAL SYNCHRONY PERCEPTION OF AUDIOVISUAL SIGNALS REVEALED BY RANDOM PULSE TRAINS
Waka Fujisaki & Shin'ya Nishida.
NTT Communication Science Labs, NTT Corporation

The visual motion or stereo perception with spatially dense random dot patterns is regarded as evidence of pre-attentive signal matching without explicit identification of matching features. In contrast, we found that audiovisual temporal synchrony perception, tested by means of synchrony-asynchrony discrimination, was nearly impossible with an analogous stimulus - a temporally dense random pulse train made of luminance and sound-amplitude modulations. This suggests that audiovisual temporal synchrony perception is a post-attentive feature-matching process. The following observations further support this hypothesis. (a) Removing high temporal frequency components from the dense pulse train, or reducing the pulse density, made the synchrony judgments easier. This suggests the importance of temporally sparse features. (b) Even for dense pulse trains, the synchrony judgment was considerably improved when the stimulus included temporally sparse distinctive stimuli - a sparse pulse train made of red flashes and high-pitch pips embedded in a dense pulse train made of white flashes and low-pitch pips. Another experiment using more complicated pulse sequences indicated that prior knowledge about a matching attribute improves the synchrony judgment. These results suggest that audiovisual temporal synchrony perception is based on temporally sparse features that are made salient by stimulus-driven processes or top-down attention.

(30)
ASSESSING THE AMOUNT OF VIOLATION OF THE RACE MODEL INEQUALITY
Hans Colonius1 & Adele Diederich2.
1. Department of Psychology University of Oldenburg; 2. School of Humanities and Social Sciences International University Bremen

The race model inequality (RMI) proposed in Miller (1982) has become a standard testing tool in many multisensory reaction time (RT) studies. It stipulates that the RT distribution function for bimodal stimuli is nowhere larger than the sum of the RT distributions for the unimodal stimuli. Its violation indicates that RTs in the bimodal condition are faster than predicted by a race model assuming that the termination of the first of several parallel processes determines the response, and it is interpreted as an indicator of a neural summation (or coactivation) mechanism. A single-valued index of the amount of violation is desirable when several different experimental conditions are to be compared. A widespread practice is to take the area under the function obtained by subtracting the right-hand side of the RMI from its left-hand side. Here we show that this area is equal to the mean RT predicted by a race model with maximally negative dependence between the processes, minus the observed bimodal mean RT. We also present an extension of this result to trimodal stimulation.

(31)
NEUROIMAGING OF CROSSMODAL PRIMING
Desiree Gonzalo & Christian Büchel.
Universitätsklinikum Eppendorf, Hamburg University

Many objects have a visual and an auditory representation. We investigated whether consecutive presentation of the same object ("concept") in different sensory modalities would lead to priming effects. During scanning (fMRI) 13 healthy volunteers were tested in a forced choice same/different task with four crossmodal conditions (visual then auditory and auditory then visual, either congruent or incongruent) and two intramodal conditions (visual/visual and auditory/auditory, either congruent or incongruent). Stimuli consisted of concrete objects (tools, animals, musical instruments, etc.). In the intramodal conditions two stimuli were presented, which represented the same "concept" but were not physically identical. Our behavioural data show that reaction times were significantly shorter for the congruent than for the incongruent conditions, indicating a priming effect. Our neuroimaging results show an interaction between the factor cross/intra modalities and congruency with major activations observed in the superior temporal cortex bilaterally and the extrastriate cortex bilaterally, including the fusiform gyrus. Previous data have highlighted the role of superior temporal cortex in multimodal object recognition. Our present data additionally suggest an interplay between this brain region and extrastriate/fusiform cortex, which seems to be relevant to the task of matching across and between modalities.

(32)
DOES OBJECT-RELATED VISUAL CORTEX 'LISTEN' TO NATURAL SOUNDS?
Marcus Johannes Naumer, Michael Wibral, Wolf Singer, Lars Muckli.
Department of Neurophysiology, Max Planck Institute for Brain Research, Institute of Medical Psychology, Frankfurt Medical School, and Brain Imaging C

We investigated the neural basis of object-related audio-visual integration. We hypothesized an involvement of ventral occipito-temporal regions (visual 'what' pathway) even during unimodal auditory stimulation. As these regions are largely invariant to the exact physical stimulus features, but are sensitive to context information and object category, we employed a category-related design. Natural sounds and gray-scaled pictures of sportsmen, animals, and cars were presented in separate stimulation blocks during BOLD-fMRI measurements at 3 Tesla. Inter-individual variation in cortical gyrification was corrected using cortex-based inter-subject alignment (BrainVoyager QX). We employed conjunction analyses of single-subject and group-averaged (n=10) data and searched for cortical regions that showed an object category preference during both unimodal visual and unimodal auditory stimulation. We found distinct peak activations in ventral occipito-temporal cortex for sportsmen, animals, and cars, respectively. BOLD signal increases in these regions were found to be significantly larger during presentation of visual as compared to auditory objects. Interestingly, these visual regions did not only show the respective category preference during unimodal visual stimulation, but also during unimodal auditory stimulation. Thus, these regions are involved in object category-related audio-visual integration that might reflect learned associations between radically different object features that co-occur very often in everyday life.

(33)
SPATIAL ATTENTION MODULATES SPATIOTEMPORAL INTERACTIONS BETWEEN VISION AND AUDITION
Daniel Sanabria1, Salvador Soto-Faraco2, & Charles Spence1.
1. Department of Experimental Psychology, University of Oxford; 2. University of Barcelona

We investigated whether audiovisual spatiotemporal interactions could be modulated by the orienting of endogenous and exogenous spatial attention. Participants were asked to discriminate the direction to which an auditory stream appeared to move (left-to-right or right-to-left) while ignoring a synchronously-presented visual stream that could move either in the same (congruent) or opposite (incongruent) direction as the target auditory stream. Both target and distractor streams could be presented either above or below (15cm) a fixation point. In Experiment 1, attention was endogenously oriented either to the top, bottom or both spatial locations by manipulating the proportion of trials presented at a given location within a block. In Experiment 2, attention was endogenously oriented to the top or bottom location by means of a predictive peripheral visual cue. In Experiment 3, attention was exogenously attracted to the top or bottom location by means of a non-predictive peripheral visual cue. Consistently, in all three experiments the congruency effect (measured as the difference in accuracy between congruent and incongruent direction trials) was reduced in the attended location as compared to the unattended location. To our knowledge, this is the first demonstration of an attentional spatial modulation of spatiotemporal interactions between audition and vision.

(34)
RECALIBRATION OF AUDITORY SPEECH BY LIPREAD VERSUS LEXICAL INFORMATION
Sabine van Linden & Jean Vroomen
Department of Psychonomics, Tilburg University

Bertelson, Vroomen & de Gelder,(Psychological Science, 2003) demonstrated that lipread speech can recalibrate auditory speech identification. Exposure to an ambiguous sound intermediate between /aba/ and /ada/ dubbed onto a face articulating /aba/ or /ada/ increased the proportion identification responses consistent with the visual stimulus on subsequent posttests, revealing recalibration. Others have recently reported similar effects using lexical information. Here, we directly compared the magnitude and the dissipation of aftereffects induced by lipread and lexical information, using the same different materials and procedures. This allowed us to check whether there is a fundamental difference between bottom-up perceptual information and top-down lexical knowledge.

(35)
EARS, EYES AND BODIES: AUDIOVISUAL PROCESSING OF BIOLOGICAL MOTION CUES
Anna Brooks1, Biljana Petreska1, Aude Billard1, Lucas Spierer2, Stephanie Clarke2, Ricky van der Zwan3, & Olaf Blanke1
1. Ecole Polytechnique Federale de Lausanne; 2. Centre Hospitalier Universitaire Vaudois; 3. Southern Cross University

In recent years, research into inter-sensory and in particular visual/auditory relationships has intensified. Interest has at least in part been fuelled by neurophysiological evidence of facilitatory cross-modal relationships at the sub-cortical level; some cells only exhibit a strong non-linear or 'super-additive' response to stimuli presented in the audiovisual domain (King et al 1987). At the behavioural level, however, evidence regarding the nature of this cross-modal relationship is mixed. Data suggest facilitatory interactions observed sub-cortically are preserved at relatively low levels of audiovisual processing (eg Frens et al 1995). In contrast, higher-order tasks appear not to benefit from a facilitatory relationship; at least two reports indicate that presentations in the audiovisual domain do not enhance performance in detecting coherent global motion (Meyer et al 2001; Alais et al 2004). For various reasons the generalisability of these latter data is, however, limited. Consequently, effects of inter-sensory relationships on many tasks requiring 'higher-order' perceptual processing require clarification. Here, we address this issue in relation to the task of detecting biological motion. Using a new psychophysical technique, thresholds were established for auditory and visual stimuli moving in congruent and conflicting directions. Data are discussed in relation to their implications for the neural mechanisms underlying biological motion perception.

(36)
THALAMOCORTICAL CONNECTIVITY FOR MULTISENSORY AND MOTOR INTEGRATION IN THE MACAQUE MONKEY
Céline Cappe1,2, Pascal Barone2, & Eric M. Rouiller1
1.University of Fribourg, Switzerland; 2. University of Toulouse, France

Although mutisensory integration has been shown to take place essentially in the cerebral cortex and the superior colliculus, the thalamus may play a role as well. To address this question, seven neuroanatomical tracers were injected in one monkey in the auditory cortex (rostral (RP) and caudal (CP) parabelt areas), the posterior parietal cortex (areas MIP and PEC), the prefrontal cortex (area 46) and the premotor cortex (PMd-c and PMv-c) to assess their thalamocortical connectivity. Thalamocortical projections, distinct from specific unimodal sensory ones, were observed from motor thalamic nuclei, such as the ventroanterior nucleus (VA) and the medial part of the ventrolateral nucleus (VLM) to CP and RP. These territories of projections in VA and VLM were adjacent or partly overlapping clusters of thalamocortical cells projecting to PMd-c, MIP and PEC (only in VLM). The anterior pulvinar nucleus projects to MIP, the lateral pulvinar nucleus projects to MIP and PEC and the medial pulvinar nucleus projects strongly to CP and RP and weakly to MIP. These data suggest the presence of thalamic territories integrating different sensory modalities with motor attributes. Furthermore, considering the corticothalamic projections, the thalamus may also represent a pathway of communication between cortical areas of different modalities.

(37)
SPATIAL DISPARITY DOES NOT AFFECT TEMPORAL VENTRILOQUISM.
Mirjam Keetels & Jean Vroomen
Dept. of Psychology, Tilburg, The Netherlands

A sound presented in close temporal proximity to a visual stimulus can alter the perceived temporal occurrence of that visual stimulus (i.e. temporal ventriloquism). Here, we explored the conditions under which this cross-modal interaction occurs using a visual temporal order judgement (TOJ) task. Participants judged which of two lights appeared first, while they heard an irrelevant sound before the first and after the second light. Visual TOJ performance was most accurate (i.e., the lowest just noticeable difference, JND) when the interval between the sound and light was 100 ms. Introducing spatial disparity between the sound and light had no effect on temporal ventriloquism. These results challenge the commonly held view that similarity in space is an important condition for cross-modal interactions to occur.

(38)
VISUAL EFFECTS OF THE INTENDED ACTION GOAL INFLUENCE MANUAL CHOICE REACTION TASKS IN VIRTUAL ENVIRONMENTS
Luca Falciati1, Mariaelena Tagliabue2, Carlo Arrigo Umiltà2, Stefano Massaccesi2.
1. Department of Philosophy and Social Sciences University of Siena, 2. Department of General Psychology University of Padova

We investigated whether visual effects of the intended action goal influence manual choice reaction tasks in virtual environments. Particularly, we examined two spatial compatibility effects: the spatial compatibility between a visual stimulus and the related action goal (S-G effect), and the spatial compatibility between a stimulus-related action goal and the manual response it requires (G-R effect). Three experiments were conducted by means of a Virtual Reality system simulating car driving tasks. In Experiment 1, effects of practicing during a non-immersive spatially incompatible task, usually determining no Simon effect or a reversed Simon effect (Proctor and Lu, 1999; Tagliabue, Zorzi, Umiltà and Bassignani, 2000), affected also 3D virtual navigation tasks. In Experiments 2 and 3, virtual navigation tasks respectively simulating a spatial compatibility task and a Simon task were developed in order to investigate whether situations similar to human real life elicit S-G and G-R effects (Hommel, 1993; Kunde, 2001; Ansorge, 2002). The findings showed that spatial incompatibility tasks delay performances in the virtual environment. Moreover, the Simon task showed a S-G correspondence effect. Finally, both spatial compatibility and Simon tasks showed a G-R correspondence effect. Our results support the assumption that voluntary actions are linked to their perceivable consequences.

(39)
A COMPARISON BETWEEN CROSSMODAL INTEGRATION OF MOVING AND STATIC SIGNALS USING EVENT-RELATED POTENTIALS
Neil Harrison, Georg Meyer, & Sophie Wuerger
School of Psychology, University of Liverpool

Behavioural studies have suggested that multisensory integration of dynamic stimuli can occur at a perceptual level of processing. Using event-related potentials (ERPs), the present study aims to test whether cortical integration elicited by motion-onset audiovisual stimuli differs from integration elicited by static audiovisual stimuli. By analysing the differences between audiovisual moving and non-moving integration using the 'additive' model (i.e. subtracting the sum of the unimodal conditions from the bimodal condition separately for moving and static stimuli) the contribution of specifically motion information to audiovisual integration can be isolated. A, V, and bimodal AV static and motion-onset stimuli were presented on an array of 31 LEDs and loudspeakers. The experimental task was to press a button in response to rare stimuli that either began moving instantly or that moved to the left. Results show that the pattern of crossmodal integration effects remains similar for both moving and static signals up until around 170 ms post-stimulus. At this point the neural integration patterns of the static and moving conditions begin to diverge, suggesting that the presence of motion affects neural integration mechanisms during late sensory processing.

(40)
DIFFERENTIAL NEURONAL ACTIVITY DURING PERCEPTION OF CONGRUENT AND INCONGRUENT AUDIOVISUAL MOTION
Oliver Baumann & Mark Greenlee
University of Regensburg/Dep. for Experimental Psychology

We investigated the cortical activations associated with coherent visual motion perception in the presence of a stationary or moving sound source. Twelve subjects judged 5s-episodes of random-dot motion containing either no (0%), meager (3%) or abundant (16%) coherent direction information. Simultaneously a moving auditory noise was presented. In a 4AFC response paradigm, subjects judged whether visual coherent motion was present, and if so, whether the auditory sound source was moving in-phase, was moving out-of-phase or was not moving. T2-weighted images were acquired using a 1.5 T Siemens Sonata. To eliminate interference with the noises created by the gradient system, a sparse imaging design was employed. An SPM2 fixed-effects analysis revealed significant BOLD clusters in extrastriate and associational visual cortex that increased with visual coherence level. Auditory motion activated an extended region in the STG. Combined audio-visual motion led to significant activation in the supramarginal gyrus and STG and the effect size is larger with congruent movement direction. Our findings indicate that the lateral parietal and superior temporal cortex underlies our ability to integrate audio-visual motion cues.

(41)
DIVIDING ATTENTION BETWEEN VISION AND AUDITION IN A WORKING MEMORY TASK
Camille Koppen & Charles Spence
Oxford University, Department of Experimental Psychology

Studies of crossmodal divided attention have a long history in experimental psychology. However, to date, results have been mixed, with some researchers claiming that people can monitor auditory and visual streams just as easily as they can monitor a single unimodal stream. One factor common to the majority of published research in this area is that participants have typically only been required to monitor simple stimuli (such as light flashes and tone bursts), or over-learnt stimuli (such as speech sounds and alphanumeric characters). In the present study, we investigated people's ability to monitor more complex stimuli, consisting of rapidly presented streams of complex environmental sounds and pictures. Participants had to monitor the streams for auditory repetitions, for visual repetitions or both kinds of repetition. Repetitions could be perceptual (i.e., repeated color or rhythm) or semantic (i.e., categories such as people, household items, animals, musical instruments etc) in nature. People showed profound performance deficits when trying to monitor stimuli in two modalities simultaneously, despite finding the unimodal monitoring task easy. These results are discussed in terms of recent theories of perceptual resources and divided attention costs.

(42)

THE INFLUENCE OF PSYCHOPHYSICAL PROCEDURE ON ESTIMATES OF HUMAN PERFORMANCE IN DETECTING AUDIO-VISUAL ASYNCHRONY

Rob L.J. van Eijk, Armin Kohlrausch, & Steven van de Par
Human-Technology Interaction, Eindhoven University of Technology

Human performance in audio-visual synchrony perception is typically characterized by two quantities: the point of subjective equality (PSE) and the human sensitivity. The PSE can be derived from the 50% point in a temporal order judgement (TOJ) procedure or from the maximum synchrony response in a synchronous-successive response paradigm. Sensitivity is derived from the steepness of the response curve in the TOJ paradigm. In this contribution we present data that show that PSE estimates derived from TOJ measurements are much more variable across observers than those based on synchronous-successive data. Two synchronous-successive methods were used with different response categories: 1) 2 categories: asynchronous, synchronous, 2) 3 categories: audio first, synchronous, video first. Both synchronous-successive methods yielded similar results. Furthermore, we compare discriminability values derived from TOJ and synchronous-successive curves with values obtained with a 2-alternative forced-choice procedure. Results indicate that discriminability is better near the edge than in the middle of the synchronous response category. This suggests that categorical perception may play a role in audio-visual synchrony perception.

(43)

BAYESIAN INFERENCE UNDERLIES HUMAN AUDITORY-VISUAL PERCEPTION: A UNIFYING AC-COUNT OF SENSORY INTEGRATION-SEGREGATION

Ladan Shams1 & Wei Ji Ma2.
1. UCLA Department of Psychology; 2. Brain and Cognitive Science, University of Rochester

Temporally coincident signals in the different sensory modalities do not always originate from the same source, and thus, should not-and do not-always get integrated. However, previous models of cross-modal interactions have exclusively focused on conditions in which the signals of the different modalities do get fused, and are unable to account for conditions in which the signals do not get integrated. We developed an ideal observer model which uses Bayesian inference to make inference about the causes of the various sensory signals. We tested the model in a paradigm in which subjects were asked to report the number of brief flashes and beeps. The human observers' auditory-visual perception was surprisingly consistent with the ideal observer, indicating that the rule used by the nervous system for when and how to combine auditory and visual signals is statistically optimal. These results provide the first unifying account for the entire spectrum of cue combination, ranging from no integration, to partial interactions, to complete fusion. Our findings also show that the sound-induced flash illusion (in which a single flash is perceived as multiple when accompanied by multiple sounds) is an epiphenomenon of this general, statistically optimal strategy, as opposed to a processing error.

(44)

THE VENTRILOQUIST ILLUSION IS BAYES-OPTIMAL

Ulrik Beierholm1, Steven Quartz1, & Ladan Shams2.
1. CNS, Caltech; 2. Dept. Psychology, UCLA

The human nervous system constantly receives input from several senses and has to quickly decide whether and how to integrate the multisensory information. Dependent on the temporal and spatial congruity between the cues, the visual and auditory cues can either be perceived as originating from one source (integration) or different sources (segregation). We have previously developed an ideal observer model that through Bayesian inference determines whether and how to integrate or segregate the sensory signals. The model allows complete segregation, complete fusion as well as partial integration. We examined whether this model can explain the ventriloquist illusion which involves spatial perception. The visual stimulus and auditory stimulus were presented at the same or different locations, each at one of five locations. The subject's task was to indicate the location of the visual stimulus as well as the location of the auditory stimulus in each trial. The subjects' auditory and visual responses were highly consistent with the ideal observer in all conditions ($R2=0.93$). This degree of consistency is remarkable considering the fact that the model is predictive, with no free parameters. We propose that Bayesian inference is a general principle underlying multisensory perception.

(45)
TOUCH-INDUCED VISUAL ILLUSION
Artem Violentyev1, Shinsuke Shimojo2, & Ladan Shams1.
1. Psychology Dept., University of California Los Angeles; 2. Division of Biology, California Institute of Technology

Although vision is considered the dominant modality, recent studies demonstrate the influence of other modalities on visual perception. We report an original illusion demonstrating a significant change in visual perception due to task irrelevant tactile stimulation, what we call the "touch-induced flash illusion." Methods: Subjects reported the number of peripheral visual stimuli while ignoring tactile stimulation, provided by a refreshable Braille cell to the tip of the left index finger. A factorial design was used with two factors: the number of flashes (1 or 2), and number of taps (0, 1, 2). Thirty trials of each condition were presented in random order to nine naïve subjects. Results: On average, observers reported seeing two flashes on 62.6% of trials when a single flash was accompanied by two taps, compared to 20.7% of trials when it was presented in the absence of taps. Furthermore, signal detection theory analysis indicated that double taps caused a change in sensitivity in visual discrimination. This radical change in perception was consistent across all subjects tested. Conclusion: These findings provide further evidence challenging the notion that visual perception is independent of activity in other modalities.

(46)
THE FUNCTIONAL ORGANISATION OF NEAR PERIPERSONAL SPACE
Alessandro Farné1,2, M. Luisa Demattè3, & Elisabetta Làdavas 1,4.
1. Department of Psychology University of Bologna; 2. INSERM U534; 3. Dept. of Cognitive Science and Education, University of Trento; 4. CsrNC Cesena

Recent findings demonstrated that a limited sector of space surrounding our body, i.e. the near peripersonal space, is represented through multisensory processes. In humans, multisensory coding of near peripersonal space has been revealed by showing that cross-modal visual-tactile extinction is mainly limited in the space near the hand, or the face. Here we addressed the question of whether the modular organisation of space also applies to the near peripersonal space representation. To this aim, cross-modal extinction has been assessed in a group of right brain-damaged patients with left tactile extinction trough several combinations of ipsilesional-visual and contralesional-tactile stimuli presented both between homologous body-parts (the two hands & sides of the face), and between non homologous body-parts (right hand + left face & right face + left hand). The results support the hypothesis that the near peripersonal space representation is not unitary, but rather organised in a modular fashion, and consists of (at least two) different spatial representations, one near the hand and another near the face. The relationship between visual-tactile and tactile extinction will be also discussed in the light of the present findings.

(47)
THE BODY POSTURE MODIFIES THE VISUO-TACTILE INTEGRATION
Taku Konishi1, Kumiko Enokizono1, Takaji Matsushima1, & Satoshi Maekawa2.
1. Department of Psychology, Kobe University; 2. National Institute of Information and Communications Technology

We examined the multisensory integration process of visual, tactile, proprioceptive information. In Experiment 1, participants performed vibrotactile choice reaction time task with the stimulated hand in their own hemispace(arm uncrossed) or their opposite hemispace(arm crossed), while visual distractor was simultaneously presented in the same or different hand. The responses in the crossed condition were slower than those in the uncrossed condition regardless of presented position of the distractors. Especially in the crossed condition visual distractors had stronger cross-modal interference effect on tactile responses than the uncrossed condition. In Experiment 2, we focused on the 'temporal' modulation of the interference effect by varying the SOAs between target and distactor (-150, -100, -50, 50, 100, 150 ms). We found this effect was varied as a function of the SOA, and, interestingly, the SOA at which the effect was most salient was different between the crossed and the uncrossed conditions. Those results suggest the importance of proprioceptive information on the temporal integration process of visual and tactile information.

(48)

AUDITORY CAPTURE OF VISUAL TEMPORAL PERCEPTION WITH FOCUSING ON SPATIAL CONGRUENCE -ACTUAL SOUND SOURCE CONDITION

Yuki Hongoh1 & Shinichi Kita2
1. Graduate School of Letters, Kobe University, Depertment of Psychology; 2. Faculty of Letters, Kobe University

We examined the effect of auditory perception on visual temporal-order judgment by investigating the spatial congruence between auditory and visual stimuli (i.e., right or left). Visual stimuli were presented successively at a short interval, and auditory stimuli were presented before and after them. A pair of speakers was used for auditory stimuli in order to represent the actual environment more properly than a preceding research of ours in which a headset was used (Hongoh & Kita, 2005). In the first experiment, the accuracy of visual temporal-order judgment was enhanced in the congruent condition that two visual stimuli and two auditory stimuli were presented from the right to the left, and reduced in the incongruent condition that two visual stimuli were presented from the left to the right and two auditory stimuli were presented from the right to the left; and vice versa. In the second experiment, the auditory stimulus presented before the visual stimuli was shown to be more effective. These results replicated the preceding research except a slight difference of weaker enhancements in the congruent condition compared with the preceding research, and consequently confirmed the important role of spatial congruence in the auditory capture of visual temporal-order judgment.

(49)

THE BRAIN'S FINGERS AND HANDS

Marisa Taylor-Clarke1, Clare Press1, Keiko Kitadono2, & Patrick Haggard1
1. Institute of Cognitive Neuroscience, University College London; 2. Department of Psychology, University College London

The brain keeps track of the changing positions of body parts in space using a spatial body schema. When subjects localise a tactile stimulus on the skin, they might either use a somatotopic body map, or use a body schema to identify the location of the stimulation in external space. Healthy subjects were touched on the fingertips, with the hands in a range of postures: the right hand could be vertically above the left, or the fingers of both hands interwoven. In addition the right palm could face the left or the right. Subjects made speeded verbal responses to identify either the finger or the hand that was touched. Interweaving the fingers significantly impaired hand identification across several experiments, but had no effect on finger identification. Our results suggest that finger identification involves a somatotopic representation or finger schema. Hand identification uses a general body schema, and is influenced by external spatial location. This dissociation implies that touches on the finger can only be identified with a particular hand after a process of assigning fingers to hands, based on proprioceptively-sensed external spatial location. Our results suggest a role of the proprioceptive body schema in the organisation and interpretation of touch.

(50)

BIMODAL BEATS

Georg Meyer1, Sophie Wuerger1, Johannes Zanker2
1. Cognitive Neuroscience Group, School of Psychology, Liverpool, UK; 2. Department of Psychology, Royal Holloway University of London, UK

Cross-modal interactions have direct correlates in behavioural as well as neurophysiological data. If visual and auditory signals are combined non-linearly, then the electroencephalogam (EEG) should show activity not only at the visual and auditory stimulus frequencies, but also at the difference between these frequencies (beats). We recorded steady state EEG signals in response to audio-visual stimulation from 10 healthy volunteers using an EGI 128 channel recording system. Subjects were presented with visual, auditory and audio-visual stimuli in three conditions: 5 Hz and 6 Hz, 8Hz and 12 Hz and 17Hz and 25Hz (visual / auditory). The signals were presented unimodally as well as bimodally and consisted of white noise as the auditory stimulus and an LED as the visual stimulus. Both signals were presented 60cm in front of the observer. An analysis of the EEG signals shows no evidence for response components at the beat frequency in the spectrum, spectral coherence or phase coherence of the responses. Cross-modal responses, however, are not linear sums of the underlying unimodal responses.

(51)
TACTILE FACILITATION OF AUDITORY STIMULUS DETECTION
Helge Gillmeister & Martin Eimer
School of Psychology, Birkbeck College, University of London

Our previous investigations have shown that simultaneous irrelevant touches enhance the perceived loudness of tones. In line with a multisensory interpretation, this enhancement was contingent on the simultaneity of auditory and tactile stimuli, was systematically modified by their relative intensities, and had direct and early physiological correlates, evident in the event-related potentials to the sounds. However, the method of comparing behaviour in unimodal situations with that in bimodal situations does not exclude the possibility that processes other than multisensory integration were measured in these studies. Here we used a criterion-free forced-choice task to show that the mechanisms underlying the contribution of touch to the perception of loudness can improve people's ability to detect sounds. Observers had to indicate in which of two adjacent temporal intervals a tone was present. Tones could have one of three near-threshold intensities. Both intervals contained a tactile stimulus, which could occur at varying stimulus-onset asynchronies with respect to the tone, if present. Results showed that the detection of tones was facilitated by simultaneous touches, compared to touches occurring earlier or later in the interval. These findings demonstrate that the tactile contribution to the perception of loudness is a genuine multisensory phenomenon.

(52)
VISUAL, VESTIBULAR AND BODY CUES TO UPRIGHT ARE WEIGHTED IN PROPORTION TO THEIR RELIABILITY
Laurence Harris1, Richard Dyde, & Michael Jenkin3.
1. Psychology, York Univ; 2. Centre for Vision Research, York Univ; 3. Dept. Computer Science and Engineering, York Univ.

We measured the perceptual upright whilst manipulating the orientation of the visual background and posture of the observer to assess the relative contributions of the body axis, visual background and gravity. Subjects made forced-choice decisions identifying the character 'p' shown in various orientations as either a 'p' or a 'd'. The orientations of maximum ambiguity were derived from psychometric functions of the probability of choosing one or other identity as a function of the character's orientation. The perceptual upright was defined as midway between these two orientations. The perceptual upright was modeled as the vector sum of the orientations of the body, visual background and gravity with weightings of 2.6: 1.2: 1 respectively. The variances of each cue were obtained from the psychometric functions for conditions where the body only (supine with no background), body and gravity (upright with no background) and all three cues (upright with upright background) contributed. The ratio of the reliability of each cue derived from these variances agreed well with the ratio of the weightings obtained from the vector model. This correlation is in line with models which propose that the reliability of a cue is predictive of its importance in multisensory integration.

(53)
ANALYSES OF SENSORY-RELEVANCE OF ADJECTIVE PAIRS FREQUENTLY USED IN SEMANTIC DIFFERENTIAL STUDIES
Jiro Gyoba1, Miho Suzuki1, Hideaki Kawabata2, Hiroshi Yamagichi3, & Hiroshi Komatsu4.
1. Department of Psychology, Graduate School of Arts ans Letters, Tohoku University; 2. Department of Psychology, Faculty of Education, Kagoshima University; 3. Department of Psychology, Faculty of Humanities and Social Sciences, Iwate University; 4. Department of Psychology, Tohoku Fukushi University

The semantic differential (SD) method developed by C.E. Osgood has been widely used and found to be very useful for measuring the affective contents of various stimuli. As Osgood pointed out, the affective reaction system generating responses for adjectives in the SD method is assumed to be deeply based on synaesthetic processing. However, the synaesthetic properties related to the adjectives used in the SD method have not undergone precise quantitative analyses. In the present study, three hundred participants were asked to rate the relevance of eighty adjective pairs to various sensory modalities using 7-point scale. Consequently, we found that the adjective pairs can be classified into the following groups. One can be regarded as multi-sensory adjectives that show generally higher relevance magnitudes to various modalities and have strong relations to the Evaluation factor. The other groups of adjectives show high relevance to specific modalities such as tactile or kinesthetic sensation and contain the properties associated with the Potency or the Activity factor. These results were discussed in

relation to the brain activities during the SD task that were measured by the near-infrared spectroscopy (Suzuki, Gyoba, and Sakuta, 2005).

(54)
MULTIMODAL APPARENT MOTION
Vanessa Harrar1, Rebecca Winter1, & Laurence Harris
1. Psychology York University; 2. Centre for Vision Research

Apparent motion has been demonstrated in the visual, auditory, and somatosensory domains, but it is less clear whether true apparent motion can be obtained between combinations of light, sound and touch. We presented subjects with unimodal and bimodal stimulus pairs of lights, sounds and touches (produced by mini solenoids) with a range of stimulus onset asynchronies (SOAs). Based on subjects' forced-choice decisions between all combinations of SOAs, we determined the SOAs that evoked the most convincing unimodal and bimodal apparent motion. In another experiment, subjects made forced-choice decisions about the perceived direction of apparent motion. Psychometric functions provided the SOAs for apparent motion thresholds. We looked at how the optimal and threshold SOAs for apparent motion varied with distance between the pairs, and with duration and intensity of the stimuli. These variables are known to affect visual apparent motion, according to rules first outlined by Korte in 1915. By comparing the effect of these variables on unimodal and bimodal stimuli, we determined differences and similarities between unimodal and bimodal apparent motion. These data will be discussed in the context of emerging research revealing cross-modal influences on unimodal motion.

(55)
THE EFFECT OF LUMINANCE ON THE SACCADIC RESPONSE INDUCED BY AUDITORY AND VISUAL STIMULI AND THE DEVELOPMENTAL CHANGES IN THE EFFECT
Masaharu Kato1, Mizue Matsumoto2, Hifumi Tsubokura1, & Yukuo Konishi1
1. Tokyo Women's Medical University; 2. Yokohama National University

The saccadic response time (SRT) decreases more in response to spatially congruent auditory visual stimuli than to visual or auditory stimuli only. Moreover, the SRT increases in response to spatially incongruent auditory visual stimuli more than to visual or auditory stimuli only. These facilitatory and inhibitory effects are regarded as the consequence of auditory and visual spatial integration in the brain. Here, we investigated the influence of luminance on these effects in human adults and infants. In adults, we found that the change in the SRT with spatial disparity of the auditory visual stimuli was modified by the luminance of the visual stimuli. For infants aged between 4 and 10 months, stronger luminance in the incongruent condition delayed the saccade in all age groups, while weaker luminance delayed the saccade only in 8- and 10-month-old infants. In the congruent condition, no facilitatory effect was observed in any age group. These results suggest that there is an optimal luminance level that maximizes these effects in adults, and that the maturation involved in the process of the saccade in response to an auditory visual stimuli has two steps: the inhibitory process of the saccade matures first, and the facilitatory process comes later.

(56)
CROSS-MODAL RECOGNITION OF HUMAN BODY POSE: INTERACTION OF MOTOR AND VISUAL INFORMATION
Yasuyuki Inoue1 & Michiteru Kitazaki2.
1. Department of Knowledge-based Information Engineering, Toyohashi University of Technology; 2. Research Center for Future Vehicle / Department of Knowledge-based Information Engineering, Toyohashi University of Technology

Recognition of human body is a special case of object recognition, since human body is very familiar and can be encoded with motor (self-body movement) as well as visual information. We aimed to investigate the effects of visual and motor encoding of body poses on visual recognition. Half of the subjects learned 16 different poses (8 front views and 8 back views) with visual observation. The others learned the same poses with visual observation and body action in that they imitated the presented posture by own body. 4 repetitions of the learning session were followed by a visual recognition test, in which a learned pose and a novel pose were presented and the subject judged which was learned one. We varied the view difference (0-180deg) of the learned poses between the learning session and the recognition test. For visual-encoding subjects the recognition performance with front-view encoding was significantly better than with back-view encoding, but for visual-and-motor-encoding subjects there was no difference. It is suggested that the visual encoding of human body has advantage in front-view

encoding while the motor encoding has advantage in back-view encoding. Thus, we can learn novel postures view-independently by using both visual and motor information.

(57)
EXTINCTION OF AUDITORY STIMULI IN HEMINEGLECT: SPACE VERSUS EAR
Lucas Spierer & Stephanie Clarke
Division de Neuropsychologie, CHUV, Faculté de Biologie et de Médecine, Université de Lausanne, Switzerland

Unilateral extinction of auditory stimuli, a key feature of the neglect syndrome, was investigated in 9 patients with right (3) or bilateral (6) hemispheric lesions using a verbal dichotic condition, in which each ear received simultaneously one word, and a interaural-time-difference (ITD) diotic condition, in which both ears received both words spatially separated by means of ITD. Additional investigations included sound localisation, visuo-spatial attention and general cognitive status. Three patients presented a significant asymmetry in both diotic and dichotic tasks, associated or not with deficits in sound localisation. One other patient had normal performance in all three. Two patients presented a significant asymmetry in the dichotic test, due to a significant decrease of left-ear reporting while right-ear reporting was normal; no asymmetry was found in diotic listening. Three other patients presented a significant asymmetry in the diotic test due to a significant decrease of left-hemispace reporting. No asymmetry was found in dichotic listening, although there was a significant decrease of reporting from either ear. The double dissociation between asymmetric extinction in the dichotic vs diotic tasks suggests that different mechanisms govern the suppression of information from one ear and the extinction that operates at the level spatial representations.

(58)
DOES STIMULUS LOCATION INFLUENCE A VISUAL ILLUSION INDUCED BY SOUND?
Kaisa Tiippana & Mikko Sams
Laboratory of Computational Engineering, Helsinki University of Technology

Multisensory interactions are generally stronger when stimulation arises from a similar location in space. This study investigated the effect of stimulus side on an audiovisual illusion in which a single flash is often perceived as two when accompanied by two rapid beeps (Shams & al, 2002, Cogn Brain Res 14, 147-152). 1-3 flashes and beeps were presented to the left or right side of fixation either alone or together in a factorial design. The latter presentations could be either congruent so that both auditory and visual stimuli were on the same side, or incongruent so that the stimuli were presented on opposite sides of fixation. Subjects were instructed to count the flashes, and to ignore any beeps. The results replicated the illusion, and showed that the congruence of stimulus location did not affect subjects' performance. The fact that audiovisual speech perception is not influenced by stimulus location (Jones & Munhall, 1997, Canad Acoust 25, 13-19), either, suggests that categorical perception may be much less sensitive to stimulus location than many other audiovisual tasks based on continuous perception of stimulus qualities.

(59)
IMITATION AND CROSS-MODAL INTEGRATION IN SPEECH PERCEPTION
Maurizio Gentilucci, Paolo Bernardis, & Luigi Cattaneo
Neuroscienze, Università di Parma

We aimed to determine whether audiovisual integration in speech perception is based on either imitation or on supra-modal binding functions. In the first experiment observers were required to repeat a string of phonemes acoustically or visually (i.e. an actor mimicked pronunciation of the string) or audio-visually presented. In the visual presentation the lip kinematics and in the acoustical presentation the voice spectra of the observers were influenced by the actor's lip kinematics and voice spectra, respectively. In the audiovisual presentation the effects decreased. In a second experiment in which the McGurk paradigm was used three distinct patterns of response were observed: fusion of the two stimuli, repetition of the acoustically, and, less frequently, of the visually presented string of phonemes. The analysis of the latter two responses showed that the voice spectra always differed from those in the congruent audiovisual presentation (i.e. when the articulation mouth gestures were congruent with the string of phonemes) and approached those of the other modality. The lip kinematics were influenced by those mimicked by the actor, but only when executed to pronounce a labial consonant. The data suggest that both imitation and supra-modal integration participate to perception at different stages of stimulus elaboration.

(60)
THE EFFECT OF HAPTIC INFORMATION ON VISUAL ILLUSION WHEN VISUAL AND HAPTIC STIMULI WERE PRESENTED IN THE SAME SPATIAL ORIENTATION
Keiko Omori1, Yuji Wada2, & Kaoru Noguchi2,
1. School of literature and Social Sciences, Nihon University; 2. Department of Psychology, Nihon University

Our previous study demonstrated that information given by touch altered the appearance of visual illusion despite dominance of visual experience (Omori et al., 2003). In the previous study, however, the spatial orientation of visual and haptic stimuli was not controlled. The present study, therefore, was designed to investigate the effect of haptic information on visual illusions for the Hering and Wundt figures under the conditions where visual and haptic stimuli were the same in spatial orientation. Wooden pieces with various curvatures were used as haptic stimuli. Participants were asked to judge the apparent curvature of each test illusion figure, with or without haptic stimuli. It was found that the visual illusions were biased to the direction of the information given by touch. The results also showed that haptic information influenced visual illusions most markedly under the condition in which both visual and haptic stimuli were presented in the same spatial orientation.

(61)
MODALITY AND SPATIAL SELECTIVITY OF ATTENTIONAL CAPTURE BY BODY SHADOWS
Francesco Pavani1 & Giovanni Galfano2.
1. Dipartimento di Scienze della Cognizione e della Formazione, Università di Trento; 2. Dipartimento di Psicologia dello Sviluppo e della Socializzazione, Università di Padova

We have recently shown that cast shadows of the body capture attention even when task-irrelevant. Here, we examined whether such phenomenon is selective for tactile stimuli at the body or rather involves any stimulus presented in the hemispace occupied by cast shadow. Participants performed an up-down discrimination task, while viewing the shadow of the left or right hand cast in front of them, lateralised and unpredictable. The target was either tactile (a touch to thumb or index finger of either hands), visual near the body (a light delivered near thumb or index finger of either hands), or visual far from the body but near the cast shadow (a light delivered near the thumb or index finger of the cast shadow). Time interval between shadow and target onset was 1750 ms. The three target conditions were equiprobable and varied on a trial by trial basis. The results revealed that up-down discrimination was significantly faster at the hand casting the shadow than at the no-shadow hand selectively for tactile targets. When participants wore shaped gloves that projected an unnatural shadow (Exp.2), a shadow-driven attentional capture emerged again selectively for tactile targets, but only with prolonged exposure to the unnatural cast-shadow.

(62)
THE COLAVITA EFFECT REVISITED: SENSORY DOMINANCE WITH COMPLEX STIMULI
Scott Sinnett1, Salvador Soto-Faraco1, & Charles Spence2.
1. Dept. de Psicologia Bàsica - Facultat de Psicologia and Parc Cientific de Barcelona, Universitat de Barcelona; 2. Department of Experimental Psychology, University of Oxford

One of the most striking, although perhaps less well understood, demonstrations of visual sensory dominance was reported by Colavita (1974). In Colavita's original study, participants performed a speeded detection task on both unimodal (auditory or visual) targets and on occasional bimodal (audiovisual) targets for which no particular instruction had been given. Reaction times (RT) were faster for unimodal auditory targets than unimodal visual targets, but on the majority of bimodal targets, participants only responded to the visual stimulus (as if the occurrence of the light somehow 'extinguished' the participant's perception of the sound). We explored this visual dominance effect with visual, auditory and audiovisual targets interspersed amongst streams of drawings and sounds (instead of single beeps and flashes). We replicated the Colavita effect (e.g., faster unimodal auditory responses, yet more errors consisting of visual responses on bimodal trials), and also demonstrated that the effect can be modulated by focusing attention to a particular sensory modality. These results will be discussed in relation to current theories of sensory dominance.

(63)

TEMPORAL ORDER JUDGEMENTS IN NEGLECT PATIENTS: EVIDENCE FOR A DISSOCIATION BETWEEN VISUAL AND AUDITORY NEGLECT.

Scott Sinnett1, Robert Rafal2, Montserrat Juncadella3, Elena Azañón1, & Salvador Soto-Faraco1.
1. Dept. de Psicologia Bàsica - Facultat de Psicologia and Parc Cientific de Barcelona, Universitat de Barcelona; 2. School of Psychology, University of Wales, Bangor; 3. Hospital Bellvitge

Patients with right hemisphere brain lesions often suffer from spatial neglect symptoms that can be manifested in different sensory modalities. It has recently been claimed that an association exists between visual and auditory neglect in these patients (Pavani, Husain, Ladavas, & Driver, 2004). These authors found positive correlation rates between performance on clinical tests of visual neglect (i.e., cancellation and bisection tasks) and various tests of auditory neglect. However, it should be noted that the visual and auditory tasks varied greatly in both response type and levels of sensitivity. We present evidence indicating a group dissociation between auditory and visual neglect that was measured using a common task for both sensory modalities. Patients were required to identify which of two events had been presented first in a temporal order judgement task (TOJ) involving the lateralized presentation of pairs of auditory or visual stimuli. When compared to age and education matched control participants, the patients needed, on average, the contralesional stimulus to be presented before the ipsilesional stimulus to achieve the point of subjective simultaneity (PSS; 190 ms visually and 68 ms auditorily). However, an association between visual and auditory neglect amongst the patients was not observed. Rather, the data suggests an independence between sensory modalities for neglect symptoms.

(64)

OCCIPITO-PARIETAL INVOLVEMENT FOR AUDITORY SPATIAL PROCESSING

Olivier Collignon1, Marco Davare2, Anne G. De Volder1, Maryse Lassonde3, Franco Lepore3, Etienne Olivier2, Claude Veraart1.
1. Neural Rehabilitation Engineering Laboratory, Université catholique de Louvain, Brussels, Belgium; 2. Laboratory of Neurophysiology, Université catholique de Louvain, Brussels, Belgium; 3. Centre de Recherche en Neuropsychologie et Cognition, Université de Montréal, Canada

It has long been argued that the occipital cortex exclusively process visual information. However, recent studies have challenged this modality-specific view by showing that some occipital areas could also respond to auditory and tactile inputs in sighted subjects. Moreover, it has long been demonstrated that the occipital cortex of early blind subjects is extensively involved in non-visual perception suggesting a remarkable degree of plasticity in the developing human brain. In the present work, we investigated the functional involvement of the occipital cortex for auditory processing in early blind and sighted subjects. For this purpose, we used the technique of Transcranial Magnetic Stimulation (TMS) in order to induce a transient disruption of the activity in areas belonging to the occipito-parietal pathway. TMS was applied during various auditory tasks that consisted of sound pitch, intensity and spatial discriminations as well as the use of a prosthesis substituting vision by audition. Results demonstrated that early visual deprivation leads to functional cross-modal cerebral reorganization and also points to the specific involvement of the dorsal visual stream for auditory spatial processing.

(65)

TESTING MULTISENSORY INTERACTIONS WITH EVENT-RELATED POTENTIALS. HOW TO AVOID ARTIFACTS OF MODALITY SHIFTS.

Matthias Gondan & Mark W. Greenlee
Department of Experimental Psychology, University of Regensburg

A frequent approach to study interactions of the auditory and the visual system is to measure event-related potentials (ERPs) to auditory, visual, and auditory-visual stimuli (A, V, AV). If AV-(A+V) differs from zero, it is concluded that the senses interact at a specific processing stage. Usually, stimuli are presented in randomized order, and modality shifting effects (MSEs) have been ignored up to now: For example, the auditory N1 is increased if the auditory stimulus follows a visual stimulus (crossmodal stimulus), whereas it is decreased if the auditory stimulus follows another auditory stimulus (ipsimodal stimulus). Bimodal stimuli are not affected by modality shifts, because at least one stimulus component is always identical to the preceding stimulus. This fact might lead to an apparent multisensory interaction in the result of AV-(A+V), which manifests as a modulation of unisensory ERP components (e.g. a decrease of the auditory N1). We tested the influence of MSEs on auditory-visual interactions by

comparing the results of AV-(A+V) using the entire stimulus set (conventional analysis) and using only ipsimodal stimuli. Significant MSEs were observed. Unexpectedly, the results of the new analysis largely converge with those of the conventional analysis.

(66)
VISUAL MOTION WHICH EVOKES SELF-MOTION PERCEPTION ALTERS TEMPORAL ORDER JUDGMENT OF SOUNDS.
Wataru Teramoto1, Hiroshi Watanabe1, Hiroyuki Umemura1, Katsunori Matsuoka1, Shinichi Kita2.
1. National Institute of Advanced Industrial Science and Technology; 2. Kobe University

We examined the effect of visual motion which evoked self-motion perception on the perceived temporal-order of auditory events. Our previous study revealed the alteration of the perceived temporal-order of ?visual? events depending on the direction of apparent self-motion (Teramoto et al., 2004), but it was not clear whether the same phenomenon was observed with the events in a non-visual modality. In Experiment 1, a pair of white noise patterns was presented at various SOAs to different ears with headphones, while large-field visual motion was continuously presented and compelled observers to perceive self-motion (yaw-axis circular vection). The results revealed that the perceived order of auditory events was modulated by the direction of apparent self-motion in much the same way in our previous study. In Experiment 2, to reduce response bias (the observers might simply report the side to which they perceived self-motion), we used the method in which a pair of different pitched sounds was presented and observers were requested to judge which kind of sound was perceived first (high or low pitched sound), not its side (left or right). We discussed how the visual information on self-motion was used to reconstruct the temporal order of visual/auditory events in the brain.

(67)
EGOCENTRIC HAPTIC MATCHING IS NOT DOMINATED BY VISUAL INFORMATION
Amanda Kaas, Johan Lataster, Mirella Fingal, & Alex Sack.
Dept. Cognitive Neuroscience, Faculty of Psychology, University Maastricht

Systematic errors were found when blindfolded participants performed allocentric haptic tasks, in which they matched the orientations of two bars by making them parallel [1, 2]. In contrast, smaller errors were observed when the haptic matching instruction allowed both an egocentric and an allocentric strategy, e.g., when participants rotated a test bar to create the mirror image of a reference bar with respect to the body symmetry-plane [3,4]. It has been argued that mirror and parallel matching are performed in the same intermediate reference frame [3]. However, non-informative vision improved only haptic parallel matching, possibly facilitating the switch to more allocentric representations [5, 6]. The present study investigated the effect of adding congruent and incongruent visual information in allocentic and egocentric haptic orientation matching tasks. Thirty healthy right-handed participants performed bimanual haptic mirror symmetry matching and parallel matching. During haptic exploration participants received congruent, incongruent or no visual information. Results showed that visual congruent information significantly improved allocentric performance. However, visual information did not affect egocentric task performance. This suggests that visual representations are less important for egocentric haptic tasks, and indicates that the dominance of visual information depends on the appropriateness for the task at hand. [1] Kappers et al., 1999 [2] Kappers et al., 2003 [3] Kappers, 2004 [4] Kaas et al, submitted [5] Zuidhoek et al., 2004 [6] Newport et al., 2002

(68)
WHEN SOUNDS MAKE YOU SEE DOUBLE: BRAIN MECHANISMS OF ILLUSORY VERSUS VERIDICAL VISUAL PERCEPTIONS
Raphaël Meylan1, Micah M. Murray1, Eric Tardif1,2, Sandra Lehmann1.
1. The Functional Electrical Neuroimaging Laboratory Division de Neuropsychologie, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland, 2. Physiology Institute, University of Lausanne, Lausanne, Switzerland

Multisensory events can affect subsequent unisensory processing. An auditory stimulus presented shortly after an auditory-visual multisensory pair can result in illusory visual perceptions (Shams et al., 2000 Nature). The rate of seeing this illusion is modulated by the inter-stimulus-interval, making it possible for subjects to have two different perceptions of the same physical stimulus. We investigated if different brain mechanisms generate these two different perceptions and whether illusory and externally-driven perceptions engage similar brain mechanisms, using electrical neuroimaging methods. Subjects completed a 2-alternative forced-choice task, judging the number of visual flashes on each trial

where either 1 or 2 flashes (F) were presented with 0, 1, or 2 beeps (B). Subjects were accurate on all conditions, except the 2B1F condition. Here, two flashes were reported instead of one ~60% of the time. Electrical neuroimaging showed that at 90ms post-stimulus different electric field topographies (i.e. generator configurations) accounted for responses to the same stimulus when perceived as two flashes versus one flash. Moreover, this topography was indistinguishable from that elicited by retinally-driven visual perceptions. LAURA Source estimations further implicate both lower- and higher- level visual cortices in this illusion. Sound-induced visual perceptions thus modulate visual responses early in cortical processing.

(69)
ADAPTATION TO AUDITORY-VISUAL SPATIAL DISPARITY IN VIRTUAL REALITY
Ludivine Sarlat1, Olivier Warusfel2, & Isabelle Viaud-Delmon1.
1. CNRS - UPMC UMR 7593; 2. IRCAM - CNRS UMR 9912

After exposition to a consistent spatial disparity of auditory and visual stimuli, subjective localization of sound sources is usually shifted in the direction of visual stimuli, which is called a ventriloquism after-effect. The present study investigates if such ventriloquism after-effects can be observed after exposition to a conflicting bimodal stimulation in virtual reality (VR). Fourteen subjects participated to an experiment in which auditory localization was assessed in darkness. Subjects were then immersed in a virtual environment by means of a head-mounted display. They were asked to reproduce sequences of movements of virtual objects. However, a spatial discrepancy of 15° was introduced between the visual event and the concurrent auditory stimulation. After 20 minutes of exposure, subjects were tested again in total darkness in order to determine whether their auditory localization system had been modified by the conflicting visual signals. We observed that the association of virtual auditory and visual stimuli could lead to a 'complete' recalibration of the right auditory hemispace, including stimulus locations not presented during the VR immersion. It is therefore possible to induce a ventriloquism effect with VR, which can not be interpreted in terms of a simple visual biasing of auditory localization.

(70)
WITHIN THE SOMATOSENSORY SYSTEM: THE ROLE OF CUTANEOUS AND PROPRIOCEPTIVE INPUTS IN TEMPORAL DISCRIMINATION OF MOVEMENT
Mirta Fiorio, Clementina Stanzani, Giuseppe Moretto, Antonio Fiaschi, & Michele Tinazzi.
Dipartimento di Scienze Neurologiche e della Visione, Università di Verona

Timing is an important part of complex somatosensory functions. Normal temporal discrimination of cutaneous stimuli ranges from 30 to 40 ms. Timing information is also of importance to the CNS if it is to use proprioceptive inputs to provide information on position and movements of one body part with respect to another. Yet despite this, we know of no psychophysical studies on temporal discrimination of movement. We tried to address this question by stimulating the motor point of the first dorsal interosseous muscle (FDI) with different time intervals. This produced contractions of the muscle and movement of the index finger. The shortest inter-stimulus interval at which subjects reported the perception of two separate movements (temporal discrimination movement threshold, TDMT) was 75 ms. In order to assess the role of muscle and cutaneous afferents in TDMT, we also stimulated the radial nerve, which supplies the cutaneous territory overlying the muscle, and the ulnar nerve, which supplies muscle afferents. Stimulation of ulnar nerve increased TDMT by 40 ms. Stimulation of the radial nerve increased TDMT only by 16 ms, suggesting that this task may preferentially employ perception of input in muscle afferent fibres, although with a smaller contribution from other sources such as skin and joints.

(71)
CONTRAST-DEPENDENCY OF AUDIOVISUAL INTEGRATION
Sascha Tyll1, Jon Driver2, Hans-Jochen Heinze1, Toemme Noesselt1,2.
1. Department of Neurology II, Otto von Guericke University, Leipziger Strasse 44, 39120 Magdeburg, Germany; 2. Institute of Cognitive Neuroscience and Department of Psychology, UCL; 3.

Previous studies (e.g. Stein et al., 1994) have reported an increase of perceived brightness if a visual stimulus is paired with a sound. However, other studies (Odgaard et al., 2003) suggested that this could be due to a response bias. In the present study, we varied the contrast of a visual stimulus (high (80% hit rate)/low (60 %hit rate)) and orthogonally the presence of a sound (factor sound: present/absent). Subjects performed a visual detection task. A response bias might lead to a general increase in yes-responses independent of contrast, while a mechanism based on brightness enhancement should reveal

larger audiovisual effects at low contrast in accord with Weber-Fechner-Law. We found significantly higher accuracy (indicated by both hit rate and also d') and faster RTs for low contrast stimuli in the presence but not in the absence of sounds but not for high contrast visual stimuli (Brightness-Sound-interaction, $p<0.05$). These results accord with the Weber-Fechner-law and suggest that audiovisual integration does affect brightness enhancement. This finding is further corroborated by preliminary fMRI results suggesting that crossmodal brightness enhancement is modulated in unimodal visual cortex. Together, both behavioural and neurophysiological results point at contrast/brightness enhancement as one effect of audiovisual integration.

(72)
EYE-GAZE ORIENTING TO AUDITORY AND TACTILE TARGETS
Agnès Alsius1, Scott Sinnett1, Alan Kingstone2, & Salvador Soto-Faraco1.
1. GRNC, Parc científic de Barcelona, Universitat de Barcelona; 2. Psychology Department, University of British Columbia

Humans orient their visual attention reflexively in response to social cues such as the direction of someone else's gaze. However, the consequences of this kind of orienting have only been addressed using visual targets. We investigated whether covert orienting triggered by visible social cues may extend beyond the modality of vision, and induce shifts in tactile and auditory attention. A central non-informative eye-gaze cue (eyes looking laterally) was followed by auditory or vibrotactile targets at different stimulus onset asynchronies (SOAs). Targets appeared with equal probability at the cued side or at the opposite (uncued) side. Three different tasks were used to measure the target processing: Speeded detection, speeded discrimination and signal detection. Our results show that while there is no consistent evidence that eye-gaze cues trigger auditory attention shifts, eye-gaze based orienting do facilitate the processing of tactile targets at the gazed-at body location. This demonstrates, for the first time, that social attention cues have consequences that span beyond their own modality.

(73)
WHEN A CONSONANT EMERGES FROM VOWELS : THE CONDITIONS OF THE AUDIOVISUAL INTEGRATION
Christian Abry1, Séverine Gedzelman1, Marie-Agnes Cathiard1, Jean-Luc Schwartz2.
Institut de la Communication Parlée Université Stendhal BP 25 F-38040 Grenoble Cedex 9 France; 2. Institut de la Communication Parlée, INPG, 46 Av. Felix-Viallet F38031 Grenoble Cedex 1 FRANCE

We tested auditory and visual perception of the vowel-to-vowel [yi] gesture via the production of a [ÿ] epenthetic glide in-between. This epenthetic glide can gain in the course of linguistic change the status of a true represented segment, like v in French pouvoir, hence English power (from Old French t deletion of Latin potere): what we dubbed the power-effect. In experiment 1, we showed that the retraction movement in the off-gliding phase of the [y] vowel is misleading for the anticipation of the following [i] vowel, since [i] identification always comes after the minimal [ÿ] constriction event. Moreover the audio identification boundary is systematically ahead of the visual identification. In experiment 2, we tested if the epenthetic glide could give birth to a consonant, using an audiovisual McGurk paradigm. We evidenced that this glide needs to be sufficiently lengthened (i.e. maintained in a static phase) in order to be integrated with the sound and represented as a true consonant. These results are discussed in reference to the time-varying vs. stationary representational sound status, from recent computational modelling and neural data, especially the snapshot neuronal computation which fits with recent brain imaging data of stilled and moving speaking mouths.

(74)
INFANTS CAN PERCEIVE INTERSENSORY RHYTHM EQUIVALENCE
David Lewkowicz
Florida Atlantic University

Lewkowicz (2000) proposed a model of the development of temporally based intersensory perception in infancy. The model assumed that intersensory perception of rhythmic pattern equivalence emerges sometime in infancy. To test this possibility, groups of 4-, 6-, 8-, and 10-month-old infants were habituated either to one of two audible rhythmic patterns (2-1-3 or 2-3-1) or one of two visible rhythmic patterns and then tested with the familiar and novel patterns in the other modality. Regardless of age, infants responded more to the novel than to the familiar rhythmic pattern in the other modality, indicating that they perceived pattern equivalence across modalities. Interestingly, they only did so following auditory learning, indicating that the developmental emergence of intersensory perception of

rhythmic pattern information is driven by the auditory modality's early specialization for the processing of temporal information. The current findings are consistent with other evidence that newborn infants are sensitive to the rhythmical structure of their native language and that older infants can perceive audio-visual synchrony, duration, and tempo relations. They suggest that infants can generalize learning of auditory rhythmical information to other sensory modalities and that this may reflect the emergence of domain-general pattern perception skills early in life.

(75)
ERP/ERMF-CORRELATES OF ILLUSORY AND SUPPRESSED VISUAL FLASHES DUE TO SOUND.

Bjoern Bonath1, Jon Driver2, Ariel Schoenfeld1, Hans-Jochen Heinze1, & Toemme Noesselt1,2.
1. Department of Neurology II, Otto von Guericke University, Leipziger Strasse 44, 39120 Magdeburg, Germany; 2. Institute of Cognitive Neuroscience and Department of Psychology, University College London, 17 Queen Square, London WC1N 3AR, UK

Crossmodal temporal integration of events has considerable importance in daily life. Shams et al. (2000) showed that subjects perceive an extra illusory flash when a single visual flash is presented with two auditory beeps. Here we investigated this and also whether perception of auditory events can lead to the suppression of concurrently presented visual events. Event-related potentials (ERP) and magnetic fields (ERMF) were simultaneously recorded while subjects were presented with different combinations of auditory (beeps) and visual (flashes) stimuli. Sounds and flashes occurred either congruently (3Hzvis-3Hzaud, 5Hzvis-5Hzaud) or incongruently (3Hzvis-5Hzaud, 5Hzvis-3Hzaud) at 18° eccentricity. Subjects reported the number of perceived flashes (response options: 3-5, although 4 flashes were never presented). Consistent with previous studies, a 'positive' illusion occurred, with reports of more than three flashes during incongruent trials with 3 flashes and 5 beeps. Importantly, subjects also reported less than five flashes during incongruent trials with 5 flashes and 3 beeps. Both illusory precepts were driven by the auditory stimulus and associated with an early index of selection towards the auditory modality in electrophysiological data. The present findings provide a neurophysiological basis for auditory-visual interactions of both enhancement and suppression.

(76)
CROSSMODAL FACILITATION EFFECT IN SPATIAL ATTENTION AND MULTISENSORY DISPLAY OF SPATIAL INFORMATION USING HRTF

Ju Hwan Lee & Kwang Hee Han.
Department of Psychology, Yonsei University, SEOUL, KOREA

In everyday life, we pick up a valuable necessary input by paying selectively attention to it out of a great deal of information. For instance, we will usually turn our eyes to the information source if someone suddenly calls our name at a crowded cocktail party. In this and many other such situations, certain information that is initially processed in one sensory modality improves the sensory processing of stimuli presented in other modalities at the same spatial location. Such our sensory processing of the spatial information has the crossmodal consequences of spatial orienting. In the present study, we investigated empirically the feasibility of applying the crossmodal consequences of spatial orienting to the target detection systems such as RADAR of fighter planes by simultaneously or asynchronously presenting the visual and auditory display of the spatial information. In this paper, two experiments were conducted in a certain way that visual stimuli were presented alone or together with auditory cues (four SOAs) generated by Head-Related Transfer Function (HRTF) techniques that reflect some differences between two auditory signals delivered to two ears of listener from the sound source. Our data show that although the spatial information presented auditorily from non-real location is the virtual sound, the performance of the valid and simultaneous crossmodal display is faster than visual only, invalid, or non-spatial auditory cue with SOAs for the sensory processing of the spatial location. Finally, some of our experiments suggest that the valid and simultaneous crossmodal presentation of the spatial information based on the facilitation of crossmodal links is still effective in the stereo settings such as headphones pre-equipped in the existing systems by using the virtual sound generation techniques.

(77)
CROSS-MODAL MERE EXPOSURE EFFECTS BETWEEN VISUAL AND TACTILE MODALITIES
Miho Suzuki & Jiro Gyoba.
Tohoku University.

We investigated cross-modal mere exposure effects between the visual and tactile modalities using three dimensional novel objects. Participants were divided into four conditions including two experiment conditions (VT, TV) and two control conditions (V, T). In the VT condition, the participants were visually exposed to the target objects (exposure task), then 2 or 3 days later, they were asked to rate the preferences for the target objects mixed with distracter objects after touching them (rating task), and vice versa in the TV condition. The participants in the V or the T conditions were asked to rate preferences for all stimuli in either visual or tactile modalities. As a result, in the VT condition, it was found that participants significantly preferred the target objects to distracter ones. In contrast, in the TV condition, there were no significant differences in the preference ratings between the target and distracter objects, and those ratings were generally higher than the ratings in the V condition. In both of the control conditions, there are no significant differences in the preference ratings between the targets and distracters. These results suggested that cross-modal mere exposure effects occur depending on which modalities were used in the exposure and the rating tasks.

(78)
IRRELEVANT AUDITORY STIMULI CAN ENHANCE THE TEMPORAL RESOLUTION OF VISION
Daniel Bergmann1, Toemme Noesselt1,2, Hans-Jochen Heinze1, & Robert Fendrich1.
1. Department of Neurology II, Otto von Guericke University, Leipziger Strasse 44, 39120 Magdeburg, Germany; 2. Institute of Cognitive Neuroscience and Department of Psychology, University College London, 17 Queen Square, London WC1N 3AR, UK

Research on cross-modal processes has revealed that sounds can change the perceived temporal pattern of vision (e.g. Shipley, 1964; Scheier et al., 1999). Here, we investigated whether sounds can improve the temporal resolution of vision. In the present study, sounds were combined with a brief 'blink' of a visual stimulus in a 2-factorial design (visual blink present/absent; sound present/absent). Subjects (n=14) had to decide whether a blink occurred. A visual cue at the subject's fixation point specified the exact moment when the blink could occur, so the sounds yielded no new time of occurrence information. For each subject, the blink duration was adjusted so that with no auditory signal the blink detection rate was close to 75%. The visual stimuli (luminous outline circles) were presented with an X-Y display system which permitted blink durations accurate to 2 ms. When a non-predictive sound burst matching the duration of the blink was presented simultaneously with the blink, there was a significant improvement in subject's detection performance compared to trials with no sound. This result suggests that the temporal resolution of vision can be enhanced by the auditory system.

(79)
AN EVENT-RELATED POTENTIAL INVESTIGATION OF THE TIME-COURSE OF TEMPORAL VENTRILOQUISM
Jeroen J. Stekelenburg & Jean Vroomen.
Psychonomics Laboratory, Tilburg University, The Netherlands.

Temporal ventriloquism refers to the phenomenon that a sound presented in close temporal proximity of a visual stimulus attracts its perceived temporal occurrence. Here, we investigate the time-course of the neuronal processes underlying temporal ventriloquism, using event-related brain potentials. To measure shifts in perceived temporal visual occurrence, we used a paradigm in which a sound modulates the magnitude of a visual illusion called the flash-lag effect. A sound presented before the flash reduced both the size of the flash-lag effect and the amplitude of visual N1 compared to when the sound lagged the flash. We attribute the modulation of the flash-lag effect to a modulation of facilitation of visual processing. The time-course (190 ms) and localization (occipito-parietal cortex) of this particular auditory-visual interaction confirms the sensory nature of temporal ventriloquism.

(80)
TEMPORAL FACTORS INFLUENCE ON THE LOCATION OF AUDITORY-VISUAL INTEGRATIVE PROCESSING IN HUMAN CORTEX
Xilong Zhi1 & Huaying Jin2.
1. Kyushu Institute of Technology; 2. Ashikaga Institute of Technology

Although the recent studies found that the locations of auditory-visual integrative processing in human cortex, under synchronous bimodal stimulation condition, are different from that under bimodal stimuli onset asynchrony (SOA) condition, nothing is known about whether the different temporal gaps of auditory-visual SOA (SOA is unequal zero ms) may influence on the location. To detect this influence, we repeated the classic experiment of Giard and Peronnet's [J. Cogn. Neuroscience 11:5, 473-490], but visual stimulus onset was earlier 15 ms (experiment 1, SOA 15 ms) and 30 ms (experiment 2, SOA 30 ms) than the auditory stimulus onset. Comparing the interaction effects under SOA 15 ms condition with that under SOA 30 ms condition, the results showed that (1) in prefrontal cortex, the effects may be observed not only under SOA 15 ms condition but also under SOA 30 ms condition, suggest these multisensory cells do not process auditory-visual temporal information, it is consistent with previous study that prefrontal regions specialized in auditory and visual spatial processing; (2) left visual area and right parieto-occipital area were selectively activated under SOA 15 ms condition, right temporal-occipital area and right temporal were activated for SOA 30 ms, revealed that temporal factors of auditory-visual SOA may influence on the integrative processing location, and suggest that these regions are relative to 'compensation for sound delay in human perception', and furthermore, support the proposition that the different regions may be set-up to optimize audiovisual integration at different ranges of distance from the observer.

(81)
OSCILLATORY COMPONENTS OF SOMATOSENSORY-VISUAL-INTERACTIONS
Markus Bauer & Pascal Fries.
F.C.Donders Centre, University of Nijmegen

We investigated the neural correlates of visuo-tactile integration using MEG recordings. In a simple-reaction-time-task, visual checkerboard stimuli were presented to the left or right side of fixation and were accompanied, on half of the trials, by a tactile stimulus to the right index finger. Unimodal tactile and visual stimuli reliably induced gamma-band (60 -100 Hz) activity over somatosensory and visual areas, respectively. Bimodal stimulation reduced reaction times. Correspondingly, bimodal stimulation led to an earlier and enhanced gamma-band activity over visual areas and over motor cortex and to an enhanced short latency visual evoked response over parieto-occipital areas. Even though visual stimulation induced spectral pertubations in several frequency bands, the effect of intersensory interaction was concentrated in the early and high-frequency part of the gamma-band. Cross-modal enhancement of activity in early sensory areas as observed previously in BOLD measures might therefore be related to the observed enhancement of gamma-band activity. These findings may provide a basis for further studying the dynamic interactions between different sensory areas during multimodal integration.

(82)
A DIRECT MEASUREMENT OF AUDITORY-VISUAL TEMPORAL INTEGRATION
Philip Jaekl & Laurence Harris.
Psychology, York University

The perceived time of occurrence of a visual stimulus may be shifted towards an auditory stimulus that follows within 200ms: the so-called 'temporal ventriloquism' effect. However, this effect has only been demonstrated indirectly. Here we measure the perceived time shift directly by presenting subjects with sequences of three stimuli that could each be either lights (an LED switching on) or sounds (a 5ms burst of white noise) and asking them to indicate which of the two intervening intervals was shortest. The two intervals totaled either 600 or 125ms. The onset of the central member of the trio within the flanking stimuli was varied using the method of constant. stimuli. A psychometric function was obtained from which the perceived temporal midpoint of the sequence was deduced. When the total was 600ms, shifts in the perceived midpoint were consistent with the shorter neural processing time of sounds relative to lights. For the shorter intervals, when the central stimulus occurred within 100ms of the flanking stimuli, there were additional shifts in which the perceived timing of a visual stimulus shifted by 15-30ms towards a later auditory stimulus. These results show quantitative evidence for auditory-visual temporal integration.

(83)
AUDITORY-VISUAL FUSION SPACE IN DARKNESS
David Hartnagel1, Alain Bichot1, Martine Godfroy2, & Corinne Roumes1.
1.Sciences Cognitives - IMASSA - Université Paris 8; 2. NASA-Ames Research Center

As space perception implies egocentred, allocentred or even geocentred cues (Paillard, 1987), multisensory space perception requires these cues from each sensory modality. Effect of dissociation between auditory and visual egocentred reference frames on auditory-visual fusion has been investigated recently (Hartnagel et al., 2004). Datas supported that reference frame for visual-auditory space is neither visual, nor auditory, but results from cross-modal dynamic interaction. Experiments on Induced Roelofs Effect (Bridgeman et al., 1997) showed that visual localization depends on surrounding visual frame. Question arises about the relative effect of visual contextual cues (allocentred cues) on fusion perception in space. The current experiment investigates the effect of shift between egocentred auditory and visual reference frame on auditory-visual fusion in darkness. In an obscured room a broadband noise burst and a 1° spot of light, 500 ms duration, were simultaneously presented with a random spatial disparity. Participants had to judge about their unity. To ensure a spatial dissociation between the visual and the auditory referentials, subject's head was maintained, and the gaze, under eye-tracker control, oriented either straight ahead or 20° laterally shifted. Fusion limits varied according to the position of the gaze. Even in darkness auditory-visual fusion space results from cross-modal interaction.

(84)
MODULARITY OF IFE BY PREDICTABILITY OF THE TARGET LOCATION
Holle Kirchner1 & Hans Colonius2.
1. Centre de Recherche Cerveau et Cognition, CNRS Toulouse; 2. Department of Psychology, Oldenburg University

Intersensory facilitation of reaction time is usually considered a mandatory, bottom-up process. However, in several recent studies we showed that saccadic reaction time to a visual-auditory target can be modulated by the predictability of the target location. This only occurred in case of a response conflict between the natural predisposition of the oculomotor system for a visual target and a spatially disparate auditory cue that needed to be considered, either by instruction such as in an auditory prosaccade task [1], or which automatically attracts attention, such as in case of a short temporal offset between the cue and visual target in an antisaccade task [2]. In the present study, when participants were asked to saccade directly to a visual target when accompanied by an auditory cue, with different stimulus onset asynchronies, again reaction times were facilitated as compared to unimodal visual and auditory latencies. If the auditory cue was presented 40 ms after the visual target, bimodal reaction times violated Miller's race inequality, and this coactivation effect tended to be ordered by the predictability of the target location although no response conflict was involved in the task. We conclude that intersensory facilitation can be modulated by extremely fast top-down control on saccadic eye movements.

(85)
ROLE OF SUPERIOR COLLICULUS IN AUDIO-VISUAL REDUNDANCY GAIN
Angelo Maravita1, Silvia Savazzi2, Emanuela Bricolo1, Valentina Penati1, & Carlo Alberto Marzi2.
1. Dipartimento di Psicologia, Università degli Studi di Milano-Bicocca, Milano, Italy; 2. Dipartimento di Scienze Neurologiche e della visione, Università di Verona, Italy

The superior colliculus is known to be a critical structure for multimodal integration in lower species and may be an important candidate for multimodal integration in humans as well. In particular one could hypothesize that simple auditory and visual stimuli must be integrated in the superior colliculus in order to efficiently orient spatial attention in extrapersonal space. In this experiment we tested for the importance of the superior colliculus for audio-visual integration by using a simple reaction time task. Normal participants responded as fast as possible to either single (auditory or visual) or bimodal audio-visual stimuli presented at fixation. Response to bimodal stimuli was faster than that to single stimuli of either modality, a well-known phenomenon named Redundant Target Effect. Critically, however, the speed advantage for double bimodal stimuli (the so-called Redundancy Gain) could be explained by a neural co-activation mechanism when the visual stimulus was made of red monochromatic light, while it could be ascribed to probabilistic summation when a monochromatic purple colour was used. Since the superior colliculus cannot detect purple stimuli, this result suggests that it represents a crucial structure for multimodal integration between simple visual and acoustic stimuli in humans.

(86)
WEIGHTING OR SELECTING SENSORY INPUTS WHEN MEMORIZING BODY-TURNS: WHAT IS ACTUALLY BEING STORED?
Manuel Vidal, Daniel Berger, & Heinrich Bülthoff,
Max-Planck Institute for Biological Cybernetics.

Many previous studies focused on how humans integrate inputs provided by different modalities for the same physical property. Some claim that these are merged into a single amodal percept, others propose that we select the most relevant sensory input. We designed an experiment in order to study whether we select or merge senses, and we investigated what is actually being stored and recalled in a reproduction task. Participants experienced passive whole-body yaw rotations with a corresponding rotation of the visual scene (limited lifetime star field) turning 1.5 times faster. Then they actively reproduced the same rotation in the opposite direction, with body, visual or both cues available. When the gain was the same as during the presentation, reproduced angles with both cues were smaller than with visual cues only, larger than with body cues, and responses were more precise. This suggests that turns in both modalities (vision and body) are stored independently, and that the resulting fusion lies in between with a higher reliability. This provides evidence for near-optimal integration. Modifying the reproduction gain resulted in a larger change for body than for visual reproduced rotation, which indicates a visual dominance when a matching problem is introduced.

(87)
EFFECTS OF VIBRATORY STIMULATION ON AUDITORY INDUCED SELF-MOTION
Aleksander Väljamäe1, Pontus Larsson2, & Daniel Västfjäll2.
1. Dept. of Signals and Systems, Chalmers University of Technology; 2. Dept. of Applied Acoustics, Chalmers University of Technology

Creating a sense of illusory self-motion (vection) is crucial for many Virtual Reality (VR) applications, where optimized multi-modal stimulation is an essential, but often neglected, component. Extending our previous findings on auditory-induced vection (AIV), we investigated how additional stimulation of vestibular modality can enhance self-motion sensation. Our hypothesis was that a low level vibratory stimulation, which can be elicited either by mechanical shakers or low frequency sound, might affect vestibular system input and therefore reduce conflict between modalities and enhance AIV. In the first experiment on rotational AIV, we have found that both infrasound (15 Hz) and vibrations significantly increased AIV sensation intensity. In the second experiment on translational AIV, mechanic vibration but not low frequency sound (40 Hz) affected self-motion reports. Additionally, two vibratory stimulation levels revealed that the AIV ratings decreased for the high level vibrations, where instead of the desired auditory-vibrational combination two separate streams were perceived. Results suggest that the optimal level of cross-modal enhancement is important for VR applications with complex sensory stimulation.

(88)
EVENT-RELATED POTENTIAL STUDY OF AUDITORY-VISUAL INTERACTIONS DURING PASSIVE (NO-TASK) PERCEPTION
Julie Vidal1, Marie-Hélène Giard2, Sylvie Roux1, Catherine Barthélémy1, & Nicole Bruneau1.
1. INSERM U619, Tours, France; 2. INSERM U280, Lyon, France

The aim of this study was to investigate the time-course and scalp topography of auditory-visual interactions in adults using event-related potentials (ERPs) in a no-task paradigm. ERPs were recorded from 31 scalp electrodes while auditory and visual stimuli were presented separately (A and V) or simultaneously (AV) to the subject. Multisensory interactions were assessed by comparing the ERPs in response to bimodal stimulation with the sum of the ERPs in response to the unimodal stimulations. The analysis of [AV-(A+V)] difference displayed different significant spatio-temporal patterns that included: (1) an early effect occurring in the 55-95 ms latency range recorded over fronto-central sites, (2) an interaction pattern in the 150-195 ms latency range spreading over a wide central region - this was the most prominent effect observed - and (3) two late significant effects around 245-300 and 320-360 ms over occipital sites. Scalp current density mapping performed in these latency windows showed that different generators are involved in these auditory-visual interaction effects. These electrophysiological results indicate that crossmodal auditory-visual interactions occur even in passive situation, when no task is requested from the subject.

(89)
NON-ACOUSTIC EVENTS ACTIVATE AUDITORY CORTEX IN MONKEYS PERFORMING AN AUDITORY DISCRIMINATION
Michael Brosch, Elena Selezneva, & Henning Scheich.
Leibniz-Institut für Neurobiologie

Auditory cortex, similar to other sensory cortices, is generally considered to be unimodal, i.e., to be involved in processing and representing various aspects of sound. Here we report on extensive cross-modal activation in the auditory cortex of highly trained adult monkeys that was observed while the monkeys performed a demanding auditory categorization task: after a cue- light turns on monkeys could initiate a tone sequence by touching a bar and then earn a reward by releasing the bar upon occurrence of a falling pitch direction in the tone sequence. In the primary auditory cortex and posterior belt areas of these monkeys we found many neurons whose firing was synchronized to the cue-light and to the touch and the release of the bar. This suggests that auditory cortex can be active during visual and somatosensory stimulation as well as before and during movements. Our findings corroborate and extend recent findings on multi- modal activation in auditory cortex. We speculate that the multimodal corepresentation in auditory cortex has arisen from the intensive practice of the subjects with the behavioral procedure and that this corepresentation facilitates a subject's performance of audiomotor tasks.

(90)
VISUAL-TACTILE INTERACTIONS IN TOOL-USE: PERIPERSONAL SPACE OR MULTISENSORY SPATIAL ATTENTION?
Nicholas P Holmes1, Charles Spence1, & Gemma A. Calvert2.
1. Experimental Psychology, Oxford University, UK; 2. Psychology, Bath University, UK

Active and skilful tool-use has been claimed to extend the visual boundaries of multisensory peripersonal space. In macaque monkeys, it is thought that peripersonal space is represented in the ventral premotor cortex and the ventral intraparietal sulcus, primarily contralaterally to a given body part. Neurons representing peripersonal space show body-part centred visual receptive fields - representing visual stimuli with respect to a particular body part, regardless of the positions of the eyes, head, and of other body parts. This property allows clear predictions to be made regarding how tool-use affects peripersonal space representations in humans: If tool-use extends peripersonal space in humans, then visual stimuli presented at the end of an actively-used tool held in the right hand should always result in larger activations of 'peripersonal space' areas in the left hemisphere, regardless of the position of the tool in space (i.e., on the right or on the left). If, on the other hand, the effects of tool-use on visual-tactile interactions are due primarily to multisensory spatial attentional factors, then visual stimuli presented at the tip of a tool should always result in enhanced activations contralateral to the visual stimulus. These hypotheses were tested using functional magnetic resonance imaging.

(91)
PROPRIOCEPTIVE INFORMATION IMPROVES THE ACCURACY OF REACHING WHEN VISION IS LIMITED
Simona Monaco1, Greg Kroliczak2, Derek Quinlan, Patrizia Fattori3, Claudio Galletti3, Melvyn A. Goodale1, & Jody C. Culham1.
1. Department of Psychology, University of Western Ontario, London, ON, Canada, N6A5C2; 2. Neuroscience Program, University of Western Ontario, London, ON, Canada, N6A5C2; 3. Dipartimento di Fisiologia Umana e Generale, Universita` di Bologna, I-40127 Bologna, Italy

We investigated reaching accuracy given different degrees of visual and somatosensory information. Eight right-handed participants used their right index finger to quickly reach to either an external target or to the index fingertip of the left hand. Visual information could be absent (Somatosensation Only), available until movement onset (Brief Vision), or available throughout the movement (Full Vision). For external targets, somatosensory information was unavailable (Vision Only). For the fingertip targets, subjects began by either exploring the workspace to place the fingertip on the target (Active Somatosensation) or having the experimenter place the fingertip on the target (Passive Somatosensation). We measured accuracy of the end point (the average deviation of the reaching finger from the target). Increasing visual information improved participants' accuracy: accuracy was best during Full Vision, somewhat poorer with Brief Vision and considerably worse without vision (Somatosensation Only). In Brief Vision trials, accuracy was higher when somatosensory information was available (for both Active and Passive Somatosensation) than when it was not (Vision Only). In Full Vision Trials, accuracy was comparable regardless of the availability of somatosensory information. These results suggest that

somatosensory information can improve the accuracy of reaching but only when visual information is limited.

(92)
EXPOSURE TO ASYNCHRONOUS AUDIOVISUAL SPEECH EXTENDS THE TEMPORAL WINDOW FOR AUDIOVISUAL INTEGRATION
Jordi Navarra1, Argiro Vatakis2, Massimiliano Zampini3, Salvador Soto-Faraco1, & Charles Spence4.
1. Parc Científic de Barcelona, University of Barcelona; 2. Department of Experimental Psychology, University of Oxford; 3 Department of Cognitive Sciences and Education, University of Trento; 4 Department of Experimental Psychology, University of Oxford

We examined whether monitoring asynchronous audiovisual speech induces a general temporal recalibration of auditory and visual sensory processing. Participants monitored a videotape of a person pronouncing a list of words (Experiment 1) or of a hand playing a musical pattern on a piano (Experiment 2). The audio and video channels were presented either in synchrony, or else asynchronously (with the visual signal leading the auditory signal by 300 ms). Participants were asked to judge the temporal order of pairs of auditory (white noise bursts) and visual stimuli (flashes) that were presented at varying stimulus onset asynchronies (SOAs) during the experimental session. The results showed that, while monitoring desynchronized speech or music, participants required a longer interval between the auditory and visual stimuli in order to perceive their temporal order correctly, suggesting a widening of the temporal window for audiovisual integration. The fact that no such recalibration occurred when we used longer asynchronies (1000 ms) that exceeded the temporal window for the audiovisual integration (Experiment 3) supports this conclusion.

(93)
A COMBINED EEG, MEG AND FMRI INVESTIGATION OF AUDIO-VISUAL SPEECH
Gemma Calvert1, Thomas Thesen1, Krish Singh2, Peter Hansen3, & Ian Holliday4.
1. Psychology, University of Bath; 2. Neurosciences Research Institute, University of Aston; 3. University Laboratory of Physiology, University of Oxford; 4. Department of Psychology, University of Aston

Behavioural studies have shown that the audible and visible components of speech can be combined seamlessly to enhance speech comprehension. In a series of studies using fMRI, we previously reported multisensory interactions in auditory and visual cortex, as well as the STS, during bimodal speech perception that exceeded the summed response to each sensory channel alone. The temporal resolution of fMRI however precluded determination of the time course (and hence directional information flow) of these various interactions. By adopting a multi-technique approach (intracranial EEG, MEG and fMRI) using a single audio-visual speech paradigm, we have been able to exploit the superior temporal and spatial resolution of the different methods to reveal the time-course of these multisensory interactions with high spatial precision. In addition, we have characterised the changes in cortical oscillatory power associated with the perception of audio-visual speech.

(94)
ON THE AUTOMATICITY OF AUDIO-VISUAL LINKS IN SPATIAL ATTENTION CAPTURE
Veronica Mazza1, Massimo Turatto2, & Carlo Umiltà3.
1. Dipartimento di Psicologia dello Sviluppo e della Socializzazione, Università di Padova; 2. Dipartimento di Scienze della Cognizione e della Formazione, Università di Trento; 3. Dipartimento di Psicologia Generale, Università di Padova

Three experiments evaluated the degree of automaticity of crossmodal spatial attention shifts, by assessing the intentionality criterion. We used the orthogonal cueing paradigm, in which a lateralised stimulus in a given modality was followed (100 vs. 700 ms) by a target in the same or different modality. In all experiments, the first stimulus was always uninformative regarding the target location. In Experiment 1, where both the location and the modality of targets were unpredictable, we replicated Spence and Driver's (1997) basic results, with faster discrimination for visual targets following uninformative auditory stimuli on the same location at short intervals. By contrast, visual stimuli did not facilitate auditory target discrimination (but see Ward, McDonald & Lin, 2000). This result was replicated in Experiment 2, where the target location was blocked, and participants could orient their attention in advance, and in Experiment 3, where also the target modality was blocked. Our results suggest that this sort of crossmodal orienting is automatic, as it occurred even when participants were provided with all information about the target to prevent uninformative auditory stimuli from being processed. This, in

turn, is consistent with the notion that peripheral auditory stimuli are very powerful in attracting visual attention.

(95)
CROSSMODAL TEMPORAL INTEGRATION IN THE POSTERIOR MULTISENSORY SUPERIOR TEMPORAL SULCUS
Toemme Noesselt1,2, Claus Tempelmann2, Robert Fendrich2, Hans-Jochen Heinze2, & Jon Driver1.
1. ICN, UCL, London, UK; 2. Department of Neurology II, University of Magdeburg, Germany

We investigated the neural correlates of crossmodal temporal (a)synchrony using fMRI. Streams of uni- or bilateral visual stimuli (18o peripheral) were presented synchronous or asynchronous with a stream of sounds. In addition, we varied the spatial alignment of the sound source and visual stimuli. Regardless of whether the visual stimuli were presented unilaterally or bilaterally we found a modulation in the multimodal superior temporal sulcus contralateral to the visual stimuli synchronous with the sound. Further, this pattern was stable regardless of the location of the sound source (0 o vs. 18 o peripheral). Results from all single subjects scanned suggest that this pattern in posterior STS is highly stable and reliable. Finally, we presented the visual stimulus foveally while presenting sounds either synchronously or asynchronously. In the crossmodal synchronous trials this resulted in a bilateral modulation in the multimodal STS. However, this modulation was located anterior to the one found for peripheral stimuli. Together, these results strongly suggest that the posterior multimodal STS is affected by crossmodal synchrony, and these modulated areas within STS shift anteriorly with decreasing visual eccentricity.

(96)
SIMULATING OBJECT-BASED NEGLECT WITH "REAL POSITION" NEURONS.
Massimo Silvetti1, Eliano Pessa2, & Fabrizio Doricchi1.
1. Dep. of Psychology 39, University of Rome "La Sapienza"; 2. Dep. of Psychology, University of Pavia

The neglect syndrome is a frequent consequence of parietal-frontal right brain damage. (Mort et al., 2003; Doricchi & Tomaiuolo, 2003). Most frequently, neglect patients omit objects placed to the left of the head-body midline. More rarely, and curiously, neglect patients are able to detect all the objects around them though systematically neglecting the left side of the very same objects. This form of neglect is called "object-based" (Olson 2003). We describe a computational model simulating a pure object-based syndrome, in which neglect is anchored to eye centred coordinates and independent from head centred ones (i.e. the eye-centred frame of reference is damaged contralesionally while the head-centred one is intact). We demonstrate that pure object based coding of space is possible when the head centred position of objects is coded by units in which response amplitude is relatively independent from eye position signals, corresponding to functional and computational properties of real-position neurons located in the occipital parietal cortex of the monkey brain (Galletti, 1993). These neurons use eye position signals to explicitly code objects locations in head-centred coordinates: however, the amplitude of their response is not directly influenced by the eye position signal (Galletti, 1993). Doricchi, F. & Tomaiuolo, F. The anatomy of neglect without hemianopia: a key role of parietal-frontal disconnection? NeuroReport 14, 2239-2243 (2003). Galletti, C., Battaglini, P.P. & Fattori, P. Parietal neurons encoding spatial locations in craniotopic coordinates. Exp. Brain Res. 96, 221-229 (1993). Mort, D. J., Malhotra, P., Mannan, S. K., Rorden, C., Pambakian, A., Kennard, C., & Husain, M. The anatomy of visual neglect. Brain 126, 1-12 (2003). Olson, C.R. Brain representation of object-centred space in monkeys and humans. Annu. Rev. Neurosci. 26, 331-354 (2003).

(97)
CROSS-MODAL INTERACTIONS OF AUDIO-VISUAL INFORMATION DEFINED BY TIME AND SPACE: A FUNCTIONAL NEUROIMAGING STUDY
Shahin Zangenehpour & Robert J Zatorre.
Neuropsychology/Cognitive Neuroscience Unit

The principles underlying cross-modal integration of auditory-visual information have been ex-plored in several animal models using neurophysiological and behavioural approaches. However, cross-modal integration is poorly understood, particularly in the human nervous system. We used a speaker-LED array that fits inside a positron emission tomography (PET) scanner to study the be-havioural and functional aspects of audiovisual interactions in the human brain. We designed stim-uli that are composed of five noise bursts and five flashes of light, each lasting 2 seconds in total, with randomly variable duration of each of the five elements. We parametrically varied the tempo-ral asynchrony and

spatial disparity of the audio-visual components of these bimodal stimuli either independently or simultaneously. Here, we present results from an ongoing study of audio-visual interactions defined by spatiotemporal parameters at the behavioural and functional neuroimaging levels. We will discuss the neural correlates of audio-visual integration involved in the processing of these bimodal stimuli. We will also discuss the role of spatial and temporal congruity, and whether or not those aspects of signal processing depend on dissociable neural systems.

(98)
INTEGRATION OF VISION AND TOUCH IN THE CONTROL OF POSTURE
Åsa M. H. Pellijeff1, Kirsten J. McKenzie2, & Stephen R. Jackson1.
1. School of Psychology, University of Nottingham; 2. Institute of Neuroscience, University of Nottingham

We investigated the integration of vision and touch by testing TG, a 67-year-old man with congenital absence of the corpus callosum, and 15 healthy controls on a haptic matching task using three visual conditions; (1) vision, (2) non-informative vision and (3) no vision. In the vision condition participants had full view of the workspace, whereas in the non-informative vision condition an opaque wooden table and an opaque sheet were used to obscure the movements of either limb. Thus the participants could view the region of peripersonal space directly above the workspace, but were not provided with visual input in relation to the task. In the no vision condition participants were blindfolded. Two rotating bars, one reference and one test bar, were placed to the left and right of the participants' midline. At the start of each trial the experimenter positioned the bars in the appropriate locations and participants felt the reference bar before matching that orientation with the test bar. The reference bar angle and position (left or right side) were randomised. Participants were instructed to orient the test bar to either a parallel or mirror-symmetrical position in respect to the reference bar. Results are discussed.

(99)
AUDIOVISUAL FEATURE ASSOCIATION IN THE AUDITORY CORTEX
Julien Besle & Marie-Hélène Giard.
INSERM Unité 280

The Mismatch Negativity (MMN) is a component of the auditory event-related potentials that is automatically generated in the auditory cortex when incoming sounds are detected as deviating from a neural representation of acoustic regularities (e.g. when infrequent " deviant " tones are presented among frequent " standard " tones). It can thus be used as a probe to study the representation of sounds in the Auditory Sensory Memory. To study the influence of visual information on this representation, standard and deviant sounds were presented to 16 subjects in three conditions, while they were performing a distractive task: the auditory stimulus was associated with either always the same visual stimulus, or no visual stimulus, or several different equiprobable visual stimuli. Event related-potentials were recorded from 36 electrodes at the scalp surface. The results showed that the presence of visual information enhanced the amplitude of the MMN, but only when visual information was consistent across all standard trials (i.e. only when the visual stimulus was always the same). This suggests that relevant auditory and visual features may be associated in the auditory cortex to produce a representation of audiovisual events in the auditory sensory memory.

(100)
SENSORY SUBSTITUTION AND BALANCE
Achille Pasqualotto1, Aurelie Fouilleul1, Eliana Sampaio1, Patrice Rougier2, & Claude Liard1.
1. Conservatoire national des arts et métiers (Cnam); 2. Université de Savoie

Sensory information is known to play an unparalleled part in the control of upright undisturbed stance. The reduced motions of the body must be indeed detected throughout numerous receptors originating from the vestibular, proprioceptive, tactile and visual systems. However, when one of these cues becomes impaired (transitorily or permanently), some reorganisation of the control process can be observed at the central nervous system level. Along these lines, the pioneering techniques consisting to substitute one of these cues throughout the remaining systems constitutes a real and promising line of investigation. These feedback techniques have in common to allow the subjects to get spatio-temporal information from various origins through another sensory canal. In the present study, our aim was to compare several feedback techniques including visual, auditive, and tactile (through a monitor screen, a sound device and the tongue display unit, respectively) in both healthy and impaired (blind) individuals. The information given was relative to the centre-of-pressure displacements (indicative of the body motions) measured through a force platform on which the subjects stand. It visual feedback is a well

documented technique in both healthy and disabled subjects, the effects induced by furnishing additional information through tactile and auditory systems remained to be explored.

(101)
VISUAL AND PROPRIOCEPTIVE INTEGRATION IN REACHING MOVEMENTS.
Hendrikus J. (Dirk) Snijders1,2, Nicholas P. Holmes1, & Charles Spence1.
1. Department of Experimental Psychology, University of Oxford; 2. Department of Biomedical Sciences, University of Utrecht

According to an optimum integration model visual and proprioceptive information concerning hand position will be integrated depending on their accuracy in a given direction. A mirror was used to displace the apparent location of a hand and create a conflict between vision and proprioception ("mirror illusion"). When participants made forward or sideways reaching movements to a two-dimensional array of targets, the visual and proprioceptive information was expected to be weighted and integrated differentially and result in differing reaching errors varying with direction. It was found that reaching errors were generally greater in a left-right direction. This suggests a greater weighting of visual information in this direction than in the, more proprioceptively accurate, depth direction. The error was greater in a forwards reach than in a sideways movement. During motor planning a phase of movement vector formulation would require extensive visual input whereas the execution into motor commands would rely more on proprioceptive input. An additional experiment in which eye-movements were precluded showed no effect of multisensory conflict on reaching movements. Eye-movements appear to play a large role in establishing a movement vector and performing a reaching movement under a "mirror illusion".

(102)
LATENCY SHIFTS IN EARLY EVENT-RELATED POTENTIALS IN A CROSSMODAL ATTENTION TASK
Jonas Vibell1, Corinna Klinge1,2, Massimiliano Zampini1,3, Charles Spence1, & Anna C Nobre1.
Department of Experimental Psychology, Oxford University; 2. Goettingen University, Germany; 3. Department of Cognitive Sciences and Education, University of Trento, Italy

Behavioural studies have shown that attended stimuli are reported as occurring relatively earlier than unattended stimuli in temporal order judgement tasks. The nature of this effect, however, is not well characterised. The prior-entry effect could reflect modulation of early perceptual analysis of stimuli, as has been observed in spatial attention tasks, or it could reflect differential weighting of task relevant versus irrelevant information at decision-making or response stages. We used event-related potentials to test whether attention directed to the visual or tactile modality modulates perceptual and/or post-perceptual analysis during a temporal-order judgement task. During each trial visual and/or tactile stimuli were presented, one to each hand with different stimulus onset asynchronies. Trials could be unimodal (two stimuli in the same modality) or bimodal. The participant decided whether the stimulus presented on the left or on the right occurred first. During experimental blocks, attention was directed to either the visual or the tactile modality by a higher frequency of visual or tactile unimodal trials respectively. ERPs revealed that directing attention to vision significantly decreased the latency of the visual P1 component, showing that prior-entry during temporal-order judgement tasks is accompanied by changes in the timing of early perceptual analysis of stimuli.

(103)
MULTISENSORY OBJECT-PERCEPTION: AUDIO-VISUAL BINDING STUDIED WITH FMRI
Matthias Bischoff.
Bender Institute of Neuroimaging, University Giessen

Brain-physiological correlates of audio-visual object perception are examined under the aspect of crossmodal integration. fMRI is recorded in order to reveal activation in areas discussed to be involved in multisensory processing in the literature. Aiming at consciousness-related binding as subset of crossmodal integration, the study focuses on the comparison of a "bound" object with "unbound" object-features. Simple visual and auditory stimuli were presented simultaneously or with a time-delay. Simultaneous auditory-visual stimulation biases the perceived localization of the auditory stimulus towards the visual one. This is known as ventriloquism-effect. Trials, in which participants reported a ventriloquism-effect, were considered to represent consciousness-related object-binding. Asynchronously presented stimuli (no localization bias) refer to unbound object-features. Those trials formed the control (no-binding) condition. The contrast of binding vs no-binding condition (N=19

subjects) revealed activation in the insula, superior temporal sulcus and parieto-occipital sulcus (ROI-analysis, FWE-corrected at p = 0.05). Concluding, consciousness-related binding by synchronous audio-visual stimulation activates cortical areas, which have been suggested to serve as heteromodal areas in the recent literature. In contrast, these areas showed no activation in trials without a ventriloquism-effect (no-binding).

(104)
OPTIC AND TACTILE FLOW: DOES A SUPRAMODAL RESPONSE EXIST?
Enzo Pasquale Scilingo1, E. Ricciardi1, P. Pietrini2, & A. Bicchi1.
1. Interdepartmental Center E. Piaggio, University of Pisa, Italy; Laboratory of Clinical Biochemistry, University of Pisa, Italy

It is widely accepted [Morrone et al. Nature Neuroscience, 2000] that particular cortical areas like MT/V5 respond to optic flow stimuli. In order to test the hypothesis that the MT+ complex might also share a supramodal organization, we measured the neural response evoked during visual and tactile perception of coherently moving dot patterns (optic and tactile flows) in sighted and blind subjects by using functional magnetic resonance imaging. In particular a group of volunteers were asked to see and touch, during distinct trials, random distribution of dot patterns while moving in circular and translational direction. An ad hoc designed device made of nonmagnetic material was used. Both tactile and visual motion perception consistently activated MT+. In order to exclude the hypothesis that activation in visual cortical areas during tactile discrimination tasks might be attributed merely to visual imagery, tactile stimuli were presented to blind adults, confirming the activation of MT+ complex as well. Moreover, in order to assess the conjecture of supramodality of flow a magneto-compatible haptic display based on the contact area spread rate paradigm (specific aspect of tactile flow) was realized and used in fMRI experiment for investigating the neural activity elicited by tactile flow, providing satisfactory results.

(105)
PHYSIOLOGICAL BASES OF ALTERED MULTISENSORY TEMPORAL-ORDER-JUDGMENTS IN DYSLEXIA
W. David Hairston,1 Jonathan Burdette2, D. Lynn Flowers3, Frank Wood3, & Mark Wallace1.
1. Neurobiology and Anatomy, WFU School of Medicine; 2. Radiology, WFU School of Medicine; 3. Neuropsychology, WFU School of Medicine

Recent research in our lab suggests that dyslexia may be associated with abnormal multisensory temporal interactions, as shown by differences in the influence of a non-relevant auditory cue during the performance of a visual temporal-order-judgment (TOJ) task. To examine the physiological underpinnings of these altered multisensory interactions, fMRI is currently being done while subjects perform TOJ tasks. During initial testing, subjects perform both visual and auditory TOJ tasks in order to determine subject-specific thresholds (stimulus onset asynchronies - SOAs). Following this, subjects perform the visual TOJ with task-irrelevant auditory cues (multisensory TOJ). The first sound is always synchronous with the first light, and the second sound is either synchronous or lagged behind the second light by a variable delay. Although both control (i.e., normal reading) and dyslexic subjects show performance improvements (i.e., lower thresholds) with the addition of the auditory stimulus, dyslexic subjects show a larger gain over a wider range of temporal delays. To take advantage of these differences, during a subsequent event-related fMRI paradigm, subjects perform the multisensory TOJ task both with the visual SOA at their own subject-dependent visual threshold and at an SOA that is constant for all subjects, while sounds are presented with both short and long delays. Preliminary data suggests differences in activation between control and dyslexic subjects in multisensory cortical areas interposed between occipital, temporal and parietal cortices. Supported by NIH grant MH63861 and the WFU Center for Investigative Neuroscience

(106)
POSTURAL MODULATION OF VISUAL-TACTILE INTEGRATION IN THE NEGLECTED SPACE
Angelo Maravita1, Sabrina Longhi1, Charles Spence2, & Francesco Pavani3.
1. Dipartimento di Psicologia, Università degli Studi di Milano-Bicocca, Milano, Italy; 2. Department of Experimental Psychology, University of Oxford, UK; 3. Dipartimento di Scienze della Cognizione e della Formazione, Università di Trento, Rovereto, Italy

Both egocentric and body-centred frame of references are likely to determine visual-tactile integration. In this work we explore how crossmodal interference is affected by an impairment of contralesional egocentric space representation as that shown by patients with unilateral neglect. A modified version of

the Crossmodal Congruency Paradigm was used, in which unattended visual distractor produce large crossmodal interference on the localization of tactile targets, as shown by previous research. In three experimental groups, namely right brain-damaged patients with and without neglect and normal observers, tactile stimuli were delivered to the right hand, while visual distractors were presented at fixation. The right hand adopted one of four different postures (10 or 50° to the ipsi- or contralesional side) in separate blocks of trials. Normal observers and patients without neglect showed stronger interference at 10 than 50° in both hemifields, due to the well-known effect of spatial proximity on crossmodal interference. Neglect patients showed the same trend for ipsilesionale space but an opposite trend for contralesional space, with stronger interference at 50 than 10°. These results suggest that an altered representation of contralesional space in egocentric coordinates, due to neglect, may significantly alter crossmodal visual-tactile interference in that space.

(107)
THE DEVELOPMENT OF MULTISENSORY PROCESSES IN THE CEREBRAL CORTEX
Brian N. Carriere1, Jenna E. Schuster1, Thomas J. Perrault2, J. William Vaughan1, Barry E. Stein1, & Mark T. Wallace1.
1. Department of Neurobiology and Anatomy, Wafe Forest University Baptist Medical Center;
2. Neural and Behavioral Sciences, Penn State University Medical Center

Little is known about the maturation of multisensory processes that are likely to support perceptual functions. Therefore, we examined the development of multisensory neurons in a well-characterized multisensory cortical area, the anterior ectosylvian sulcus (AES) of the cat. Multisensory neurons are absent in AES at the earliest ages. At postnatal week 6, multisensory neurons first appear but are of very low incidence (< 5% of the population). The incidence of such neurons gradually rises over the ensuing 5 months, until adult-like values are achieved by 28 weeks postnatal. The earliest multisensory neurons are strikingly different from their adult counterparts, most notably in the large size of their receptive fields and their inability to integrate cross-modal cues. As development progresses, receptive fields consolidate, revealing excellent cross-modal register. However, most dramatic is the appearance of multisensory integration in these neurons, a capacity that appears to be tightly linked to receptive field maturation. Taken together, these results illustrate that the ability to integrate multisensory information is not an inherent characteristic of AES neurons, but rather requires a considerable period of postnatal development. Experiments are ongoing to examine whether a key feature in this developmental progression is the sensory experience gathered during this period. Supported by NIH grants NS36916 and MH63861

(108)
DISSOCIATING THE MULTIPLE PHASES OF SOMATOSENSORY-VISUAL INTEGRATIONS IN THE HUMAN EVENT-RELATED POTENTIAL: A HIGH-DENSITY ELECTRICAL MAPPING STUDY.
Jeannette Piesco, Sophie Molholm, Pejman Sehatpour, Walter Ritter, & John Foxe
Nathan Kline Institute

Correlated sensory inputs coursing along the individual sensory processing hierarchies arrive at multisensory convergence zones in cortex where research has shown that information is processed in an integrative manner. Here, using high-density electrical mapping (from a 168-channel array), source localization, and complementary psychophysical data, we examined visual and somatosensory interactions. We assessed 1) how early in sensory processing, visual-somatosensory (VS) interactions were seen in the event-related potential (ERP), 2) whether spatial alignment or misalignment had differential effects on these early multisensory interactions. Participants were randomly presented with unisensory-somatosensory, unisensory-visual and multisensory VS stimuli to both the left and right hemifields. Behavioral results indicate that RTs to all multisensory VS conditions were significantly faster than those elicited from the unisensory conditions, regardless of spatial alignment or misalignment. Electrophysiological results yielded significant differences between 'simultaneous' and 'summed' group-averaged ERPs for all four multisensory conditions at just 125 ms. Considering the nature of the stimuli, the timing and topographies of these early VS interactions is not surprising. Findings are in agreement with those of Murray et al. (2004); the earliest multisensory interactions seen in the ERP occur regardless of spatial register.

(109)
POSTURE EFFECTS ON MENTAL TRANSFORMATIONS OF BODY PART IMAGES
Bettina Forster.
City University, London, U.K.

To investigate the effect of one's own hand posture on left-right judgments of rotated hand images participants positioned their right and left hand either next to each other (standard posture), crossed so that the left hand was located in right hemispace and vice versa (location displacement), in a fist or oriented towards each other (90º posture). Images of a left and a right hand were presented in six different angular rotations (0º, 60º, 120º, 180º, 240º, 300º). In all conditions reaction times (RT) were fastest to images of an upward pointing hand (0º orientation) and increased monotonically with angular displacement of hand images from the upward pointing hand with the slowest RTs to images of a downward pointing hand (180º orientation). In the standard posture condition and in the location displacement condition RTs were faster to right than to left hand images regardless of their angular rotation. This difference in RT to left and right hand images was reduced when the participants' own hands were held in a fist, and in the 90 º posture condition, left-right RT differences varied dependent on the rotation of the hand images. It is proposed that mental transformations employed in left-right judgments of body part images are influenced by one's own posture.

(110)
HIGH-DENSITY ELECTRICAL MAPPING OF MISMATCH NEGATIVITY EVOKED BY THE MCGURK ILLUSION
Pierfilippo De Sanctis, Dave Saint-Amour, Sophie Molholm, Walter Ritter, & John James Foxe

Seeing a speaker's articulatory gestures can affect speech perception, as illustrated by the McGurk effect, where dubbing an incongruent articulatory movement onto an auditory phoneme leads to an illusory auditory perception. It has been shown that the event-related potential, the Mismatch Negativity (MMN), can be evoked by the McGurk illusion. Since the auditory stimuli are invariant, the deviant elicited MMN has been interpreted as phonetic in nature. Here we investigated the putative hemispheric dominance of McGurk-MMN by recording high-density ERPs using an oddball paradigm in two conditions: visual alone (/ba/ "standard" and /va/ "deviant") and audiovisual (audio /ba/ and visual /ba/ "standard" and /va/ "deviant", illusory percept /va/). If the McGurk-MMN represents phonetic processing, then one would predict left hemisphere dominance. A McGurk-MMN was indeed found, indicating that audiovisual integration gave rise to the auditory deviant percept. Surprisingly, the topography of the McGurk-MMN showed a right hemispheric dominance, suggesting that this effect may not be based on a phonological trace but might rely on acoustical processing which involves the right hemisphere. Source-analysis localized the generator of this right hemisphere dominant MMN response to the superior temporal gyrus, a region well-known for its multisensory integration properties from imaging studies.

(111)
BEHAVIORAL AND ELECTROPHYSIOLOGICAL INVESTIGATION OF CROSSMODAL INTERACTION IN OBJECT RECOGNITION
Shlomit Yuval-Greenberg & Leon Y Deouell.
Department of Psychology, The Hebrew University of Jerusalem

Recognition of objects in the world may depend on information from various modalities. We investigated the mutual effect of auditory and visual information in this process. In a stroop-like paradigm, fourteen subjects were required to identify animals from pictures or from vocalizations, while information from the other modality could be congruent, incongruent or neutral. Compared to congruent conditions, cross-modal incongruence affected auditory recognition significantly more than it affected visual recognition. Further exploration showed that relative to the neutral condition, cross-modal incongruence in fact hampered recognition similarly in both conditions, suggesting that information from the unattended modality is processed, despite its detrimental effect on performance. However, the cross modal facilitation effects were asymmetrical. Cross-modal congruency facilitated behavior significantly more during auditory than during visual recognition. Mirroring this, event related potential recording from 64 electrodes in these subjects showed that congruency affected the response to the stimuli when auditory recognition was required but significantly less so when visual recognition was required. The congruency effects were manifested as bimodal increased negativities with latencies around 200 and 500 ms after stimulus onset. In additional experiments, we investigate whether the asymmetrical effects result from different speeds of auditory and visual processing of complex information.

(112)
INTERINDIVIDUAL VARIABILITY IN VISUO-PROPRIOCEPTIVE INTEGRATION FOR THE MORPHOKINETIC CONTROL OF HAND MOVEMENTS
Joëlle Rouhana & Philippe Boulinguez.
LPMC, MSHS, 99 avenue du Recteur Pineau, 86000 Poitiers, France

This study deals with the idea that dominance effects (viewed as the privileged use of one source of information among others) vary both according to the processes under scrutiny (perceptual encoding, movement online control) and across subjects. Classical paradigms of addition/suppression of sensory information were adapted in the methods, handling all conditions of visual and proprioceptive feedbacks both for 1) stimulus encoding (movement trajectories to be reproduced: with or without passive movements, with or without vision) and for 2) execution control (with or without active movement, with or without vision). Kinematic analyses revealed that most subjects (60%) show visual dominance for encoding movement trajectory. Conversely, for execution control, subjects are largely distributed along a proprioceptive to visual dominance continuum. Dominance profiles for encoding of movement trajectory depend on the relative sensory resolution of visual and proprioceptive signals. Conversely, sensory dominance for online control is unrelated to sensory resolution. These results show that the central nervous system can select different combinations of sensory inputs on the basis of the computation in which the resulting estimate will be used. They are partly reminiscent of recent studies demonstrating that coding the position of the arm for movement vector planning would rely mostly on visual input, whereas the estimate used to compute the joint-based motor command would rather rely on proprioceptive signals (e.g., Sober & Sabes, 2003). However, we suggest that such various forms of dominance are subject to an important interindividual variability. Current neuromimetic models predict this variability could be linked to long term adaptive mechanisms varying with subjects' experience.

(113)
DO YOU SEE WHAT I'M SAYING? OPTIMAL VISUAL ENHANCEMENT OF SPEECH COMPREHENSION IN NOISY ENVIRONMENTS
Lars A. Ross1,2, Dave Saint-Amour2, Vicktoria Leavitt2,3, Daniel C. Javitt2, & John J. Foxe1,2.
1. Program in Cognitive Neuroscience, Department of Psychology at the City College of the City University New York; 2. Nathan Kline Institute for Psychiatric Research; 3. Program in Neuropsychology, Department of Psychology at the Queens College of the City University New York

Viewing a speaker's articulatory movements substantially improves a listener's ability to understand spoken words, especially under noisy environmental conditions. It has been claimed that this gain is most pronounced when auditory input is weakest, an effect that has been related to a well-known principle of multisensory integration - inverse effectiveness. In contrast, we show that this principle does not apply for audio-visual speech perception. Rather, the gain from viewing visual articulations is maximal at intermediate signal-to-noise ratios (SNRs) well above the lowest auditory SNR where the recognition of whole words is significantly different from zero. The multisensory speech system appears to be optimally tuned for SNRs between extremes, extremes where the system relies on either the visual (speech-reading) or the auditory modality alone, forming a window of maximal integration at intermediate SNR- levels. At these intermediate levels, the extent of multisensory enhancement of speech-recognition is considerable, amounting to more than a threefold performance improvement relative to an auditory-alone condition. Additional data collected from patients with schizophrenia show that the gain from additional visual stimulation in speech recognition in noise is not as pronounced as in controls, while unimodal auditory speech recognition remains intact.

(114)
THE EFFECTS OF AUDITORY SPATIAL ATTENTION ACROSS THE HIERARCHY OF EARLY VISUAL AREAS IN HUMAN OCCIPITAL CORTEX
Vivian Ciaramitaro & Geoffrey Boynton.
The Salk Institute

We examined how auditory spatial attention influences responses in visual areas by measuring fMRI responses to unattended visual information when attention was directed to auditory information on the same or the opposite side of space. Subjects simultaneously observed four stimuli: a drifting grating to the left and right of central fixation, and an auditory tone to the left and right ear. Auditory stimuli presented to the left ear were perceived on the left side of space, and vice versa. All stimuli were presented in two successive intervals at threshold. A central cue directed subjects to attend the left

versus right ear, where they performed an auditory frequency discrimination task. All early visual areas showed larger fMRI responses to unattended visual stimuli when auditory attention was directed to the same, compared to the opposite side of space. These results are consistent with previous ERP data (example, Eimer et al 2004) suggesting a crossmodal mechanism of spatial attention where attending a stimulus in one spatial region yields a processing advantage for other stimuli in the same spatial region, regardless of modality. Furthermore, our design allowed quantification of the separate contributions of visuo-spatial, audio-spatial and crossmodal attention across areas V1 to MT+.

(115)
NEURAL AND BEHAVIORAL CORRELATES OF DRAWING OBJECTS AND SCENES IN AN EARLY BLIND PAINTER.
Amir Amedi1, Joan Camprodon1, Lotfi Merabet1, Felix Bermpohl1, Erin Haligan1, Elif Ozdemir2, Itamar Ronen3, Dae-Shik Kim3, & Alvaro Pascual-Leone1.
1. Center for Non-Invasive Magnetic Brain Stimulation, Dept. of Neurology, BIDMC, Harvard Medical School; 2. Dept. of Neurology, BIDMC, Harvard Medical School; 3. Center for Biomedical Imaging and Department of Anatomy and Neurobiology, Boston University School of Medicine

Subject EA is a congenitally blind painter. He has an extraordinary ability to comprehend the shape of an object by touch and draw it from any vantage point so that it can be unequivocally identified visually. Given the fact that EA has never seen his drawings, he must possess internal representations of the objects and scenes consistent with visual frames of reference, not just tactile ones. Our aim was to study the neural basis for EA's drawing abilities, as compared with tactile exploration or imagery. We studied EA using an fMRI block design paradigm while he palpated objects, drew them, imagined their shape, scribbled on a piece of paper, or completed motor and verbal memory controls. EA shows prominent activation of early visual cortex (including V1) for drawing versus scribbling. Remarkably, he does not read Braille, so that recruitment of the visual cortex in EA has taken place independently of Braille or verbal representation. Contrary to other early blind subjects, EA does not activate visual areas during verbal memory. This might be because the resources of the 'visual' cortex are recruited for his remarkable drawing ability, thus being less available for verbal memory, which is EA is quite poor.

(116)
WHY ARE THE EXPERIENCES OF VISUAL PERCEPTION AND VISUAL IMAGERY DIFFERENT?
Amir Amedi1, Rafael Malach2, & Alvaro Pascual-Leone1.
1. Center for Non-Invasive Magnetic Brain Stimulation, Dept. of Neurology, BIDMC, Harvard Medical School; 2. Department of Neurobiology, Weizmann Institute of Science, Israel;

Seeing an object is clearly a different experience than imagining it. In fact, when experiential boundaries between perceiving and imagining blur, we speak of psychosis and hallucinations. Nevertheless, recent studies emphasize the large overlap in neural substrates supporting visual perception and visual imagery. So, why is our experience is so different? Here we demonstrate that deactivation of the auditory cortex unequivocally differentiates visual imagery from visual perception. In fact, the vividness of the visual imagery is stronger correlated with the magnitude of auditory cortex deactivation than with the activation of any visual cortical region. Finally we report of a patient with bilateral lesions in the auditory cortex, who shows supra-normal vividness visual imagery (5 S.D. above the average in the vividness of visual imagery questionnaire). Perception of the world requires merging of multi-sensory information so that seeing is inextricably associated with processing of other sensory modalities that modify visual cortical activity and shape experience. By contrast, we suggest that pure visual imagery is the isolated activation of visual cortical areas with concurrent suppression of sensory inputs that could disrupt the image created by our 'mind's eye'.

(117)
ENDOGENOUS AND EXOGENOUS ORIENTING OF SPATIAL ATTENTION IN INTRAMODAL AND CROSSMODAL DISPLAYS
Ana B. Chica1, Daniel Sanabria2, Juan Lupiáñez1, & Charles Spence2.
1. Universidad de Granada; 2. University of Oxford

The present experiments were designed to compare the endogenous and exogenous orienting of spatial attention using both intramodal and crossmodal displays. In Experiment 1, an informative peripheral cue, either visual or tactile, predicted (in each block of trials) either the same or opposite position of the appearance of a tactile target. Using this paradigm, both endogenously attended and unattended locations could either be cued or uncued, making it possible to dissociate endogenous and exogenous

orienting of spatial attention using the same set experimental of stimuli. In Experiment 2, an uninformative peripheral cue was used, in order to further study the cuing effects (independent of the orienting of attention) in the intramodal and crossmodal conditions. Two main results emerged from the present study: First, the effect of the voluntary orienting of spatial attention was larger when the cue and target were presented in the same modality than when they were presented in different modalities, but only at the short stimulus onset asynchrony (SOA). On the other hand, the cuing effects differed across SOA between crossmodal and intramodal conditions: In the intramodal condition both facilitation and Inhibition of Return (IOR) were observed, while in the crossmodal condition, a facilitatory effect was observed at the short SOA, but no evidence of IOR was observed at an 1000 ms SOA.

(118)

AUDITORY BUT NOT VISUAL ALERTING CUES PROVIDE RESPONSE FACILITATION IN SIMPLE VISUAL TARGET DETECTION

Magali Jaffard, Abdelrhani Benraïss, & Philippe Boulinguez.
LPMC, MSHS, 99 avenue du Recteur Pineau, 86000 Poitiers, France

Alerting mechanisms elicited by non-spatially informative cues are supposed to reduce reaction time (RT) in visual target detection tasks. It is generally reported that this automatic effect is attributed to a brief surge in arousal, and that auditory cues have a stronger effect than visual cues. In most studies, the method is based on the comparison of cued vs. non cued trials randomly presented in a unique bloc (mixed condition, e.g., Fan et al., 2005). In this study, we also tested the cueing effect when cued and non cued trials are presented in separate blocs. Several experiments adapted from a classical Posner like paradigm were performed. Reduced RT for cued compared with non cued trials were evidenced in the mixed condition, as previous studies already did. Conversely, an increase in RT for cued compared with non cued trials was found in separate blocs for short SOA (100 to 300ms). In other words, costs rather than benefits of peripheral visual alerting were observed. In fact, this difference was only due to the lengthening of non cued RT in the mixed condition with respect to non cued RT in the separate bloc condition (+80ms). Thanks to complementary Go/NoGo experiments, this effect was found to depend on inhibitory mechanisms elicited by cue presentation in the mixed condition. These experiments were reproduced with central visual alerting cues and similar patterns of results were found. Conversely, when using auditory alerting cues, alerting benefits are found for 300 to 900ms SOA. We suggest alerting effects (mechanisms?) could be specifically cross-modal whereas intra-modal cueing produces only interference at short cue-target delays.

Special issue

Call for papers: Advances in Multisensory Research

To be published in Neuropsychologia
Guest Editors:
Francesco Pavani, Micah Murray and Charles Schroeder

DEADLINE: August 29th, 2005

This special issue has been organized in collaboration with the scientific committee of the 6th Annual Meeting of the International Multisensory Research Forum. The present call is open to all potential submissions (i.e., IMRF attendants or not) dealing with research on multisensory processes that meet the aims and scope of Neuropsychologia (http://ees.elsevier.com/nsy/). All submitted paper will be peer reviewed according to the usual high standard of the journal.

This issue will feature research articles reporting empirical work. Space will be strictly limited and papers must be under 6000 words. Please include a word count in the title page.

Papers must be submitted electronically on the journal website (http://ees.elsevier.com/nsy). During the submission process choose "Special Issues" as article type. Please refer to the Guide for Authors of Neuropsychologia for manuscript formatting. Authors can suggest potential reviewers for the manuscript. Please provide contact details including e-mail address.

Author index

Delegates

Abry, Christian
abry@icp.inpg.fr
Alsius, Agnès
aalsius@ub.edu
Amedi, Amir
aamedi@bidmc.harvard.edu
Bach-y-Rita, Paul
pbachyri@wisc.edu
Balconi, Michela
michela.balconi@unicatt.it
Ballesteros, Soledad
mballesteros@psi.uned.es
Bargary, Gary
bargaryg@tcd.ie
Barnett, Kylie J.
Kylie.Barnett@tcd.ie
Barone, Pascal
pascal.barone@cerco.ups-tlse.fr
Bates, Helen
batesh@tcd.ie
Bauer, Markus
m.bauer@fcdonders.ru.nl
Baumann, Oliver
oliver.baumann@psychologie.uni-regensburg.de
Beierholm, Ulrik
beierh@caltech.edu
Benraiss, Abdel
abdel.benraiss@mshs.univ-poitiers.fr
Berger, Daniel R.
daniel.berger@tuebingen.mpg.de
Bergmann, Daniel
DanielB@gmx.li
Bernardis, Paolo
paolobernardis@mac.com
Bertelson, Paul
pbrtlsn@ulb.ac.be
Besle, Julien
besle@lyon.inserm.fr
Bischoff, Matthias
matthias.bischoff@psychol.uni-giessen.de
Blau, Vera
v.blau@psychology.unimaas.nl
Bolognini, Nadia
nbolognini@tiscali.it
Bonath, Bjoern
bonath@neuro2.med.uni-magdeburg.de
Bonfiglioli, Claudia
bonfiglioli@form.unitn.it
Boulinguez, Philippe
pbouling@univ-poitiers.fr
Brooks, Anna
annarayner.brooks@epfl.ch
Brosch, Michael
Brosch@ifn-magdeburg.de
Brozzoli, Claudio
claudiobrozzoli@gmail.com
Bruno, Nicola
dirpsicologia@units.it
Calvert, Gemma
g.calvert@bath.ac.uk
Campbell, Ruth
r.campbell@ucl.ac.uk
Cappe, Céline
celine.cappe@unifr.ch
Carrera, Alba
alba.carrera@rossoalice.it
Carriere, Brian N.
bcarrier@wfubmc.edu
Casey, Sarah J
caseys@tcd.ie
Chan, Jason
jchan@tcd.ie
Chica, Ana B.
anachica@ugr.es
Ciaramitaro, Vivian
vivian@salk.edu
Collignon, Olivier
olivier.collignon@gren.ucl.ac.be
Colonius, Hans
hans.colonius@uni-oldenburg.de
Cooke, Theresa
theresa.cooke@tuebingen.mpg.de
Crossbrown, Amelia
crossbra@tcd.ie
Culham, Jody
culham@uwo.ca
Dalton, Polly
polly.dalton@psy.ox.ac.uk
De Sanctis, Pierfilippo
pdesanctis@nki.rfmh.org
De Santis, Laura
laura.de-santis@laposte.net
Demattè, M. Luisa
dematte@form.unitn.it
Deouell, Leon
msleon@huji.ac.il
Diederich, Adele
a.diederich@iu-bremen.de
Doricchi, Fabrizio
fabrizio.doricchi@uniroma1.it
Dukewich, Kristie R.
dukewich@dal.ca
Ernst, Marc
marc.ernst@tuebingen.mpg.de
Falciati, Luca
falciati@med.unibs.it

Delegates

Farnè, Alessandro
farne@lyon.inserm.fr
Fiorio, Mirta
mirta.fiorio@medicina.univr.it
Forster, Bettina
b.forster@city.ac.uk
Fort, Alexandra
fort@lyon.inserm.fr
Frassinetti, Francesca
francesc.frassinetti@unibo.it
Fujisaki, Waka
fujisaki@avg.brl.ntt.co.jp
Galfano, Giovanni
giovanni.galfano@unipd.it
Gallace, Alberto
alberto.gallace@psy.ox.ac.uk
Gentilucci, Maurizio
gentiluc@unipr.it
Gillmeister, Helge
h.gillmeister@psychology.bbk.ac.uk
Gomez-Ramirez, Manuel
mramirez@nki.rfmh.org
Gondan, Matthias
matthias.gondan@psychologie.uni-regensburg.de
Gonzalo, Désirée
gonzalo@uke.uni-hamburg.de
Gray, Kellie
dshore@mcmaster.ca
Gyoba, Jiro
gyoba@sal.tohoku.ac.jp
Hairston, W. David
dhair@wfubmc.edu
Harrar, Vanessa
vharrar@yorku.ca
Harris, Laurence
harris@yorku.ca
Harrison, Neil
neilrh@liv.ac.uk
Hartnagel David
dhartnagel@imassa.fr
Hein, Grit
g.hein@med.uni-frankfurt.de
Heisz, Jennifer
heiszjj@mcmaster.ca
Helbig, Hannah
helbig@tuebingen.mpg.de
Ho, Cristy
cristy.ho@psy.ox.ac.uk
Holle, Kirchner
holle.kirchner@cerco.ups-tlse.fr
Holmes, Nicholas P
nicholas.holmes@psy.ox.ac.uk
Hongoh, Yuki
hongoh@lit.kobe-u.ac.jp
Igarashi, Yuka
igarasi-yuka@c.metro-u.ac.jp
Inoue, Yasuyuki
y-inoue@real.tutkie.tut.ac.jp
Jacomuzzi, Alessandra
jacomuzzi@psico.units.it
Jaekl, Philip
jaekl@yorku.ca
Jaffard, Magali
pbouling@univ-poitiers.fr
Jokiniemi, Jukka
satu.selvinen@kolumbus.fi
Kaas, Amanda
a.kaas@psychology.unimaas.nl
Kato, Masaharu
pieko@abmes.twmu.ac.jp
Keetels, Mirjam
m.n.keetels@uvt.nl
Kim, Robyn
robynkim@ucla.edu
Kirchner, Holle
holle.kirchner@cerco.ups-tlse.fr
Kita, Shinichi
kita@lit.kobe-u.ac.jp
Kitagawa, Norimichi
kitagawa-norimichi@c.metro-u.ac.jp
Kitazaki, Michiteru
mich@tutkie.tut.ac.jp
Konishi, Taku
konitaku@lit.kobe-u.ac.jp
Koppen, Camille
camille.koppen@psy.ox.ac.uk
Làdavas, Elisabetta
elisabetta.ladavas@unibo.it
Laasonen, Marja
Marja.Laasonen@helsinki.fi
Lacey, Simon
simon.lacey@solent.ac.uk
Lafargue, Antoine
antoine.lafargue@polytechnique.org
Lagleyre, Sebastien
sebastien.lagleyre@cerco.ups-tlse.fr
Lee, Ju Hwan
leejuhwan@yonsei.ac.kr
Lewkowicz, David
lewkowic@fau.edu
Ludden, Geke
G.D.S.Ludden@io.tudelft.nl
Macaluso, Emiliano
e.macaluso@hsantalucia.it
Maier, Joost
jmaier@tuebingen.mpg.de
Maravita, Angelo
angelo.maravita@unimib.it
Martuzzi, Roberto
Roberto.Martuzzi@chuv.ch
Mazza, Veronica
veronica.mazza@unipd.it
McKenzie, Kirsten
lpxkm@psychology.nottingham.ac.uk

Merabet, Lotfi
lmerabet@bidmc.harvard.edu
Meyer, Georg
georg@liv.ac.uk
Meylan, Raphaël
raphael.meylan@hospvd.ch
Molholm, Sophie
molholm@nki.rfmh.org
Monaco, Simona
anomis1978@yahoo.it
Munhall, Kevin G.
munhallk@post.queensu.ca
Murray, Micah M.
micah.murray@hospvd.ch
Naumer, Marcus Johannes
naumer@bic.uni-frankfurt.de
Navarra, Jordi
jordi.navarra@ub.edu
Newell, Fiona
fiona.newell@tcd.ie
Nicol, Jeffrey
nicoljr@mcmaster.ca
Noesselt, Toemme
toemme@neuro2.med.uni-magdeburg.de
Ojanen, Ville
viloja@lce.hut.fi
olivé, isadora
isadolive@yahoo.com
Omori, Keiko
keiko_omori@hotmail.com
Pascual-Leone, Alvaro
apleone@bidmc.harvard.edu
Pasqualotto, Achille
pasquala@tcd.ie
Pavani, Francesco
francesco.pavani@unitn.it
Pellegrini, John E.
jpellegrini@dplanet.ch
Pellijeff, Åsa M. H.
lpxamhp@psychology.nottingham.ac.uk
Phillips-Silver, Jessica
phillij@mcmaster.ca
Piesco, Jeannette
JPiesco@nki.rfmh.org
Poliakoff, Ellen
Ellen.Poliakoff@manchester.ac.uk
Reilly, Richard
richard.reilly@ucd.ie
Rizzolatti, Giacomo
giacomo.rizzolatti@unipr.it
Ross, Lars A.
lross@nki.rfmh.org
Rouger, Julien
julien.rouger@cerco.ups-tlse.fr
Rouhana, Joelle
joelle.rouhana@etu.univ-poitiers.fr
Sams, Mikko
Mikko.Sams@hut.fi
Sanabria, Daniel
daniel.sanabria@psy.ox.ac.uk
Sarlat, Ludivine
sarlat@ext.jussieu.fr
Sathian, Krish
krish.sathian@emory.edu
Schaefer, Michael
schaefem@ninds.nih.gov
Schifferstein, Hendrik
h.n.j.schifferstein@io.tudelft.nl
Schroeder, Charles E.
schrod@nki.rfmh.org
Schulz, Matthias
schumat@uni-muenster.de
Scilingo, Enzo Pasquale
e.scilingo@ing.unipi.it
Selvinen, Satu Paula
satu.selvinen@kolumbus.fi
Senkowski, Daniel
dsenkowski@nki.rfmh.org
Serino, Andrea
serino@cnc.psice.unibo.it
Sgambelluri, Nicola
n.sgambelluri@ing.unipi.it
Shams, Ladan
ladan@psych.ucla.edu
Shore, David
dshore@mcmaster.ca
Silvetti, Massimo
massimo.silvetti@uniroma1.it
Sinnett, Scott
ssinnett@ub.edu
Snijders, Hendrikus J.
H.J.Snijders@gmail.com
Soto-Faraco, Salvador
ssoto@ub.edu
Spence, Charles
charles.spence@psy.ox.ac.uk
Spierer, Lucas
lucas.spierer@hospvd.ch
Stanford, Terrence
stanford@wfubmc.edu
Stein, Barry
bestein@wfubmc.edu
Stein, Nancy
nstein@wfubmc.edu
Stekelenburg, Jeroen J.
J.J.Stekelenburg@uvt.nl
Suzuki, Miho
suzukim@sal.tohoku.ac.jp
Tajadura Jimenez, Ana
ana.tajadura@ta.chalmers.se
Taylor-Clarke, Marisa
marisa.taylor-clarke@spc.ox.ac.uk
Teramoto, Wataru
watatera@yahoo.co.jp
Tiippana, Kaisa
kaisa.tiippana@tkk.fi

Delegates

Turatto, Massimo
massimo.turatto@unitn.it
Tyll, Sascha
styll@helios.med.uni-magdeburg.de
Väljamäe, Aleksander
sasha@s2.chalmers.se
Van Atteveldt, Nienke
N.vantteveldt@psychology.unimaas.nl
van Eijk, Rob L.J.
R.L.J.v.Eijk@tm.tue.nl
van Linden, Sabine
S.vanLinden@uvt.nl
van Velzen, José
j.vanvelzen@psychology.bbk.ac.uk
van Wassenhove, Virginie
Virginie.van.Wassenhove@mrsc.ucsf.edu
Vatakis, Argiro
argiro.vatakis@psy.ox.ac.uk
Veraart, Claude
veraart@gren.ucl.ac.be
Viaud-Delmon, Isabelle
ivd@ext.jussieu.fr
Vibell, Jonas
jonas.vibell@psy.ox.ac.uk
Vidal, Julie
j.vidal@chu-tours.fr
Vidal, Manuel
manuel.vidal@tuebingen.mpg.de
Violentyev, Artem
artem@ucla.edu
von Kriegstein, Katharina
kkriegs@fil.ion.ucl.ac.uk
Vroomen, Jean
j.vroomen@uvt.nl
Wallace, Mark
mwallace@wfubmc.edu
Wang, Ye
ye.wang@cerco.ups-tlse.fr
Warusfel, Olivier
warusfel@ircam.fr
Watkins, Susanne
swatkins@fil.ion.ucl.ac.uk
Wylie, Glenn
wylie@nki.rfmh.org
Yuval-Greenberg, Shlomit
yuvalsh@mscc.huji.ac.il
Zampini, Massimiliano
zampini@psico.unitn.it
Zangenehpour, Shahin
shahin.zangenehpour@mcgill.ca
Zhi, Xilong
rtfqm365@ybb.ne.jp

Directions

Restaurants & bars listing

RESTAURANTS

1. **Al Trivio.** Campiello del Trivio, 11 - Closed on sunday evening and monday
2. **Antico Filatoio**. Via Tartarotti, 12 - Closed on tuesday
3. **Drago d'Oro.** Piazza Malfatti, 12 - Closed on monday
4. **Novecento.** Corso Rosmini, 82/D - Closed on sunday
5. **Bellavista.** Via Paganini, 17 - Closed on saturday
6. **Da Pierino.** Via Barattieri, 35 - Closed on saturday evening and sunday
7. **L'Osteria del Gusto.** Via Pasqui - Closed on monday
8. **Osteria del Pettirosso.** Corso Bettini, 24 - Closed on sunday
9. **Scala della Torre.** Via Scala della Torre, 7 - Closed on sunday

PIZZERIA

10. **Celeste.** Via Benacense, 18/A - Closed on friday evening and saturday noon
11. **Fucine.** Via Leonardo da Vinci, 5 - Closed on monday
12. **La Margherita.** Via Azzolini, 22 - Closed on wednesday evening
13. **La Terrazza sul Leno.** Via Setaioli, 2/A – Closed on monday
14. **Napoli.** Via Paoli, 20/E – Closed on sunday
15. **Piccolo Fiore.** Corso Rosmini, 22 – Closed on sunday and monday noon
16. **Stop and Go.** Via Lungo Leno Sinistro, 64 – Closed on sunday
17. **Vecchia Rovereto.** Piazza Malfatti, 9 – Closed on wednesday
18. **Villa Cristina.** Via Maioliche, 48 – Closed on monday

FAST FOOD

19. **Goloso.** Via Orefici, 18 – solo pranzo - Closed on saturday afternoon and sunday
20. **Osteria Perbacco**. Via. Roma, 18 – Closed on wednesday
21. **Pizza Pause.** Piazza Rosmini, 2 – Closed on sunday morning
22. **Stella d'Italia.** Piazza Erbe, 10 – lunch only, closed on wednesday

SELF SERVICE

23. **Gilda.** Via Matteo del Ben, 3/B – solo pranzo - Closed on sunday and saturday afternoon

BARS

24. **Al Teatro.** Corso Bettini, 37 – Closed on saturday afternoon and sunday
25. **Caffè de Min.** Via Dante, 6 – lunch only, closed on monday
26. **Caffè Ristretto.** Via Tartarotti, 60 – lunch only, closed on sunday
27. **Le Arti.** Corso Bettini, 43 (c/o Mart) – lunch only, closed on monday
28. **Christian.** Via Orefici, 17 – Closed on sunday
29. **Cristallo.** Angolo Via Paoli/Via Don Rossaro, 25 – Closed on sunday
30. **Caffè delle Rose.** Via Mercerie, 34 – Closed on sunday
31. **Meeting.** Via Fiume, 2 – Closed on monday
32. **Silver.** Via Paoli, 41/A – Closed on sunday
33. **Snack Bar Doll.** Piazza Leoni, 9 – lunch only, closed on saturday afternoon and sunday
34. **Stappomatto.** Corso Bettini, 56/A – Closed on monday