International **M**ultisensory **R**esearch **F**orum

9th Annual Meeting

July 16 – 19, 2008
Hamburg, Germany

Meeting Program

IMRF 2008

Advisory Board

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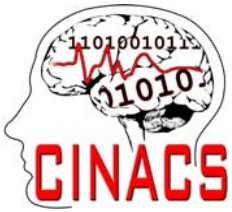

Acknowledgments

The local organization team consisted of Patrick Bruns, Christian Büchel, Thérèse Collins, Karin Deazle, Andreas K. Engel, Julia Föcker, Claudia K. Friedrich, Cordula Hagemann, Kathrin Holzschneider, Kirsten Hötting, Corinna Klinge, Monique Kügow, Anna Best, Mario Maiworm, Angelika Quade, Brigitte Röder, Sybille Röper, Tobias Schicke, Ulrike Schild, Till Schneider, Daniel Senkowski, Nils Skotara, Dagmar Tödter.
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General Information

Venue and meeting rooms

The conference will be held at Hotel Hafen Hamburg (Seewartenstr. 9, 20459 Hamburg, Germany, phone: +49 (0) 40 / 31 11 30, www.hotel-hafen-hamburg.de, near Landungsbrücken station). Oral presentations will be held in the Elbkuppel room and poster presentations will be held in the Foyer Elbkuppel. Both rooms are located in the 5th floor of Hotel Hafen Hamburg.

Registration and conference material pick-up

Conference delegates can register and pick up their conference materials at the opening reception in the Foyer West of the main building of the University of Hamburg on Tuesday, 15th July, 6.00 pm -7.00 pm, Edmund-Siemers-Allee 1, near Hamburg-Dammtor train station. There will also be a registration desk located in the Foyer Elbkuppel at Hotel Hafen Hamburg Wednesday till Friday, 16th - 18th July, 8.15 am - 4.00 pm.

Hospitality

Get-together / opening reception

The conference will open with an informal reception on Tuesday, 15th July between 6.00 pm and 7.00 pm in the Foyer West of the University of Hamburg main building, Edmund-Siemers-Allee 1, near Hamburg-Dammtor train station.

Conference dinner

The conference dinner will be held on Friday, 18th July on the steam boat Louisiana Star. The boat will depart at 8.00 pm sharp from the Landungsbrücken (Brücke 6-9), near Hotel Hafen Hamburg. The cruise will take 3 hours. Exact details of the departure will be announced during the meeting.

Coffee breaks and lunch

Coffee breaks and lunch are included with the registration. Breaks are scheduled between sessions (see program for further details). Lunch will be served in the restaurant of Hotel Hafen Hamburg from Wednesday, 16th July till Friday, 18th July. For security and access to the meeting and hospitality, please wear your name badge.

Internet access

Internet access will be provided at the Business Center of Hotel Hafen Hamburg or by Wireless LAN in designated areas.

Satellite symposium

There will be a satellite symposium titled “Multisensory processing in flavour perception” organized by John Prescott (James Cook University, Australia) on Tuesday, 15th of July 2008, 3.00 pm – 6.00 pm. The symposium will take place in the main building of the University of Hamburg, lecture hall B, Edmund-Siemers-Allee 1, near Hamburg-Dammtor train station. The registration desk will be opened from 2.00 pm until 6.00 pm.

Instructions for talk presenters

All talks (including Graduate Symposium) will be 15 minutes plus 5 minutes for discussion. The auditorium will be equipped with an LCD projector, loudspeakers, overhead projector and laptop computers (PCs). We ask that 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 on a CD or memory stick. If you must use your own laptop, please check your presentation before the session as well. We ask that presenters wishing to use any other kind of equipment during their talk to contact the organizers before the meeting.

Instructions for poster presenters

Maximum poster size is DIN-A0 (84,1cm x 119cm; portrait or landscape orientation). There will be four poster sessions of 2 hours each in the Foyer Elbkuppel of Hotel Hafen Hamburg (5th floor):

Wednesday, 5.00 pm - 7 pm
Thursday, 5.00 pm - 7 pm
Friday, 4.00 pm - 6.00 pm
Saturday, 9.00 am – 11.00 am

Posters can be placed during lunch time on the day of the poster session. Presenters of the Saturday session can place their posters from 8.30 am – 9.00 am. Please remove all posters after the poster sessions.

How to get there

From central station (Hauptbahnhof)

To get to the conference venue at Hotel Hafen Hamburg take the local train (S-Bahn, S1, direction Wedel) or the subway (U-Bahn, U3, direction Barmbek) to Landungsbrücken station. The Hotel Hafen Hamburg is located on a little hill just atop the Landungsbrücken (ship arrival buildings).

To get to the University of Hamburg (opening reception, satellite symposium) take the train (long-distance or local) or the bus to Hamburg-Dammtor train station. It is a three minutes walk from there.

From the airport

The airport is located in the north of Hamburg, ~ 12 km from the city center (by taxi ~ 20 €).

To get to the conference venue at Hotel Hafen Hamburg take bus 110 (Airport Shuttle) to Ohlsdorf station, then the local train (S-Bahn, S1, direction Wedel) to Landungsbrücken station.

To get to the University of Hamburg (opening reception, satellite symposium) take the subway U1 (direction Ohlstedt or Großhansdorf) and get off at Stephansplatz station. It is a ten minutes walk from there. Alternatively you can take an Airport Express bus (5 €) to the central station (Hauptbahnhof) and proceed from there.

Day trip tickets for the public transport system in Hamburg are available at tourist offices, vending machines in the stations or from the bus driver (6 € for one day, 15 € for three days).

Maps

A map showing the location of the Hotel Hafen Hamburg can be found here:
http://hotel-hafen-hamburg.de/anfahrt_route_lage_location.aspx?lang=en

A map of the University of Hamburg can be found here:
http://www.uni-hamburg.de/UHH/lageplan.pdf (building 20 and 21).

	Tuesday	Wednesday	Thursday	Friday	Saturday
9:00 – 9:30		Symposium I	Paper Session II	Keynote Speaker	Poster Session IV
9:30 – 10:00					
10:00 – 10:30				Coffee Break	
10:30 – 11:00		Coffee Break		Graduate Student Symposium	
11:00 – 11:30		Paper Session I	Coffee Break		Coffee Break
11:30 – 12:00			Symposium III		Keynote speaker
12:00 – 12:30					
12:30 – 13:00				Lunch time	Symposium IV
13:00 – 13:30		Lunch time			
13:30 – 14:00			Lunch time		
14:00 – 14:30				Paper Session IV	
14:30 – 15:00		Keynote speaker			
15:00 – 15:30	Satellite Symposium "Multisensory Processing in Flavour Perception"		Paper Session III		
15:30 – 16:00		Symposium II			
16:00 – 16:30				Coffee Break + Poster Session III	
16:30 – 17:00					
17:00 – 17:30		Coffee Break + Poster Session I	Coffee Break+ Poster Session II		
17:30 – 18:00					
18:00 – 18:30	Reception			IMRF Business Meeting	
18:30 – 19:00					
20:00				Conference Dinner	

Short Program

Tuesday, July 15th

Please notice: The satellite symposium and the reception on Tuesday take place at the University Hamburg, Main Building, Lecture Hall B, Edmund-Siemers-Allee 1

15:00 – 18:00 **Satellite Symposium**

Multisensory processing in flavour perception
Chair: John Prescott

15:00 – 15:10 John Prescott - Introduction
15:10 – 15:40 Fabian Grabenhorst – How cognition and attention modulate affective responses to taste and flavour: Top-down influences on the orbitofrontal and pregenual cingulate cortex
15:40 – 16:10 David Labbe – Olfactory-taste interactions and the role of familiarity and exposure strategy
16:10 – 16:40 Marga Veldhuizen – Neural encoding of the taste of odor
16:40 – 17:10 Garmt Dijksterhuis – Cross-modal capture within flavour
17:10 – 17:40 Charles Spence – Assessing the contribution of vision (colour) to multisensory flavour perception: Top-down vs. bottom-up influences
17:40 – 18:00 General discussion and closing remarks

18:00 – 19:00 **IMRF Reception**

Wednesday, July 16th

9:00 – 10:30 **Symposium "Multisensory integration of audition and vision using multimodal approaches: from neurophysiology and brain imaging to neural network modelling"**
Organized by Amir Amedi

Yoram Gutfreund - Visual-auditory integration in the barn owl: A neuroethological approach
Katharina von Kriegstein - A multisensory perspective on human auditory communication
Amir Amedi - Audio-visual integration for objects, location and low-level dynamic stimuli: novel insights from studying sensory substitution and topographical mapping
Ron Meir - Optimal multi-modal state estimation and prediction by neural networks based on dynamic spike train decoding

10:30 – 11:00 **Coffee Break**

11:00 – 13:00 **Paper Session I**
Chair: Erich Schröger

11:00 – 11:20 Mark T. Wallace - Spatial and spatio-temporal receptive fields of cortical and subcortical multisensory neurons
11:20 – 11:40 Benjamin Andrew Rowland - Multisensory integration in the superior colliculus: Inside the black box
11:40 – 12:00 Terrence R. Stanford - Distinct circuits support unisensory and multisensory integration in the cat superior colliculus

12:00 – 12:20 Thomas Thesen - The effects of task and attention on visual-tactile processing: Human intracranial data
12:20 – 12:40 Erik Van der Burg - Pip and pop: Non-spatial auditory signals improve spatial visual search
12:40 – 13:00 Erich Schröger - From visual symbols to sound representations: Event-related potentials and gamma-band responses

13:00 – 14:30 **Lunch Time**

14:30 – 15:30 **Keynote Address**
"Design and analysis strategies for multisensory fMRI research: Insights from letter-speech sound integration studies"
Rainer Goebel

15:30 – 17:00 **Symposium "Cross-modal reorganization in deafness"**
Organized by Pascal Barone and Andrej Kral

Stephen G. Lomber - Contributions of auditory cortex to the superior visual capabilities of congenitally deaf cats
Anu Sharma - Cortical re-organization and multimodal processing in children with cochlear implants
Pascal Barone - Cross-modal reorganization in cochlear implanted deaf patients: a brain imaging Pet study
Nils Skotara - Cross-modal reorganization in deafness: Neural correlates of semantic and syntactic processes in German Sign Language (DGS)

17:00 – 19:00 **Poster Session I**

Thursday, July 17th

9:00 – 11:00 **Paper Session II**
Chair: Charles Spence

9:00 – 9:20 Jeroen Smeets - An irrelevant tone can influence peri-saccadic mislocalisation
9:20 – 9:40 Anton L. Beer - Perceptual learning suggests crossmodal plasticity in adult humans at relatively early levels of processing
9:40 – 10:00 David Shore - Work better in the dark: Close your eyes
10:00 – 10:20 Malika Auvray - Sensory substitution and the taxonomy of our sensory modalities
10:20 – 10:40 Charles Spence - Multisensory integration promotes spatial attentional capture
10:40 – 11:00 Hsin-Ni Ho - Role of touch in referral of thermal sensations

11:00 – 11:30 **Coffee Break**

11:30 – 13:30 **Symposium " Role of neural synchrony for multisensory integrative processes"**
Organized by Andreas K. Engel

Andreas K. Engel - Searching for cross-modal synchrony – a testbed for the „temporal correlation“ hypothesis?
Christoph Kayser – Cross-modal influences on information processing in auditory cortex
Peter Lakatos - Attentional control of oscillatory phase reset in multisensory interactions
Daniel Senkowski - Friend or foe? Multisensory interactions between emotional face expressions and pain processing in neural gamma-band responses
Peter König – Integration of information in overt attention

13:30 – 15:00 **Lunch Time**

15:00 – 17:00 **Paper Session III**
Chair: Ladan Shams

15:00 – 15:20 Uta Noppeney - The prefrontal cortex accumulates object evidence through differential connectivity to the visual and auditory cortices
15:20 – 15:40 Micah M. Murray - The costs of crossing paths and switching tasks between audition and vision
15:40 – 16:00 Boukje Habets - Integration of speech and gesture: an ERP study
16:00 – 16:20 Ladan Shams - Bayesian priors and likelihoods are encoded independently in human multisensory perception
16:20 – 16:40 Nicholas Paul Holmes - The seemingly inviolable principle of inverse effectiveness: In search of a null hypothesis
16:40 – 17:00 Stefan Rach - On quantifying multisensory interaction effects in reaction time and detection rate

17:00 – 19:00 **Poster Session II**

Friday, July 18th

9:00 – 10:00 **Keynote Address**
"Early cortical control of the right and left arm reaching"
Larry Snyder

10:00 – 10:30 **Coffee Break**

10:30 – 12:30 **Graduate Student Symposium**
Chair: Brigitte Röder

- 10:30 – 10:50 Vera C. Blau - Bridging the gap between phonology and reading: Evidence from developmental neuroimaging
- 10:50 – 11:10 Keren Haroush - The visual attentional blink produces cross-modal effects that enhance concurrent involuntary auditory processing
- 11:10 – 11:30 Albert R. Powers - Perceptual training-induced narrowing of the multisensory temporal binding window
- 11:30 – 11:50 Alexandra Reichenbach - Neural correlates of sensory feedback loops in reaching

12:30 – 14:00 **Lunch Time**

14:00 – 16:00 **Paper Session IV**
Chair: Annabelle Blangero

- 14:00 – 14:20 Mark T. Elliott - Movement synchronisation to multisensory temporal cues
- 14:20 – 14:40 Claudio Brozzoli - Functional dynamic changes of peripersonal space induced by actions
- 14:40 – 15:00 John S. Butler - The role of stereo vision in visual and vestibular cue integration
- 15:00 – 15:20 Pascale Touzalin-Chretien - Must the hand be seen or only imagined for visuo-proprioceptive integration? Evidence from ERP
- 15:20 – 15:40 Annabelle Blangero - Optic ataxia is not only 'optic': Impaired spatial integration of proprioceptive information
- 15:40 – 16:00 Fabrice R. Sarlegna - Is visuo-proprioceptive integration advantageous to update internal models

16:00 – 18:00 **Poster Session III**

18:00 – 19:00 **IMRF Business Meeting**

20:00 **Social Dinner Louisiana Star**

Saturday, 19th

9:00 – 11:00 **Poster Session IV**

11:00 – 11:30 **Coffee Break**

11:30 – 12:30 **Keynote Address**
"Combining sight sound and touch, in mature and developing humans"
David Burr

12:30 – 14:00 **Symposium "Multisensory processing of visual and tactile information"**
Organized by Krish Sathian

Krish Sathian - Visuo-haptic processing of shape and location
Joshua Nelson Lucan - The spatio-temporal dynamics of somatosensory shape discrimination
Alberto Gallace - Similarities between the awareness of change in vision and touch: The role of spatial processing
Marc O. Ernst - Amodal multimodal integration

Poster Presentations

Poster Session I

Wednesday, July 16, 17.00 - 19.00

1. **Markus Bauer, Steffan Kennett, José van Velzen, Martin Eimer, Jon Driver**
Spatial attention operates simultaneously on ongoing activity in visual and somatosensory cortex - largely independent of the relevant modality

2. **Oliver Doehrmann, Christian F. Altmann, Sarah Weigelt, Jochen Kaiser, Marcus J. Naumer**
Audio-visual repetition suppression and enhancement in occipital and temporal cortices as revealed by fMRI-adaptation

3. **Abdelhafid Zeghbib, Antje Fillbrandt, Deliano Matthias, Frank Ohl**
Changes of oscillatory activity in the electrocorticogram from auditory cortex before and after adaptation to contingent, asynchronous audiovisual stimulation

4. **Jorge E. Esteves, John Geake, Charles Spence**
Investigating multisensory integration in an osteopathic clinical examination setting

5. **Anna Seemüller, Katja Fiehler, Frank Rösler**
Crossmodal discrimination of object shape

6. **Nicholas Myers, Anton L. Beer, Mark W. Greenlee**
Interaural time differences affect visual perception with high spatial precision

7. **Marco Bertamini, Luigi Masala, Georg Meyer, Nicola Bruno**
Vision, haptics, and attention: A further investigation of crossmodal interactions while exploring a 3D Necker cube

8. **Adele Diederich, Hans Colonius**
Multisensory integration in reaction time: Time-window-of-integration (TWIN) model for divided attention tasks

9. **Noriaki Kanayama, Luigi Tamè, Hideki Ohira, Francesco Pavani**
Top-down influences on the crossmodal gamma band oscillation

10. **Elena Nava, Davide Bottari, Francesca Bonfioli, Millo Achille Beltrame, Giovanna Portioli, Patrizia Formigoni, Francesco Pavani**
    Fast recovery of binaural spatial hearing in a bilateral cochlear implant recipient
11. **Vincenzo Romei, Micah M. Murray, Gregor Thut**
    Looming sounds selectively enhance visual excitability
12. **Jennifer Kate Steeves, Adria E.N. Hoover, Jean-François Démonet**
    Recognizing the voice but not the face: Cross-modal interactions in a patient with prosopagnosia
13. **Axel H. Winneke, Natalie A. Phillips**
    Investigation of event related brain potentials of audio-visual speech perception in background noise
14. **Isabel Cuevas, Paula Plaza, Philippe Rombaux, Jean Delbeke, Olivier Collignon, Anne G De Volder, Laurent Renier**
    Effect of early visual deprivation on olfactory perception: psychophysical and low resolution electromagnetic tomography (LORETA) investigation
15. **Maori Kobayashi, Shuichi Sakamoto, Yo-iti Suzuki**
    Effects of tonal organization on synchrony-asynchrony discrimination of cross-modal and within-modal stimuli
16. **Anne Kavounoudias, Jean-Pierre Roll, Régine Roll**
    Are brain areas assigned to proprio-tactile integration of one's own movement perception?
17. **Jeremy David Thorne, Stefan Debener**
    Effects of visual-auditory stimulus onset asynchrony on auditory event-related potentials in a speech identification task
18. **Fei Shao**
    Measurement for tactile sensation
19. **Martijn Baart, Jean Vroomen**
    Recalibration of phonetic categories by lipread ppeech: measuring aftereffects after a twenty-four hours delay
20. **Yoshinori Tanizawa, William R. Schafer**
    Multisensory processing in the nematode C. elegans

21. **James V. M. Hanson, James Heron, David Whitaker**
    Adaptive reversal of sensorimotor timing across the senses
22. **Vanessa Harrar, Laurence R. Harris**
    The perceptive location of a touch shifts with eye position
23. **Monica Gori, Alessandra Sciutti, Marco Jacono, Giulio Sandini, David Burr**
    Visual, tactile and visuo-tactile perception of acceleration and deceleration
24. **Satu Saalasti, Kaisa Tiippana, Mari Laine-Hernandez, Jari Kätsyri, Lennart von Wendt, Mikko Sams**
    Audiovisual speech perception in Asperger Syndrome
25. **Gloria Galloni, Franco Delogu, Carmela Morabito, Marta Olivetti Belardinelli**
    Voice, face and speech motion: interactions in person recognition
26. **Jennifer Campos, John Butler, Betty Mohler, Heinrich Buelthoff**
    Multimodal integration in the estimation of walked distances
27. **Christine Heinisch, Tobias Kalisch, Hubert R Dinse**
    Tactile and learning abilities in early and late-blind subjects
28. **Annerose Engel, Michael Burke, Katja Fiehler, Siegfried Bien, Frank Roesler**
    Motor learning affects neural processing of visual perception
29. **Jasper J. F. van den Bosch, Michael Wibral, Axel Kohler, Wolf Singer, Jochen Kaiser, Vincent van de Ven, Lars Muckli, Marcus J. Naumer**
    The cortical network for high-level audio-visual object processing mapped with sogICA
30. **Sascha Serwe, Konrad P. Koerding, Julia Trommershäuser**
    Are common consequences sufficient for visual-haptic integration?
31. **Fabrizio Leo, Caterina Bertini, Elisabetta Làdavas**
    Temporal-nasal asymmetry in multisensory integration mediated by the superior colliculus

32. **Wataru Teramoto, Souta Hidaka, Jiro Gyoba, Yoichi Suzuki**
Sound can enhance visual representational momentum

33. **Hanna Puharinen, Kaisa Tiippana, Riikka Möttönen, Mikko Sams**
Does sound location influence reaction times to audiovisual speech?

34. **Matthias Gamer, Heiko Hecht**
Visual information integration is not strictly additive: the influence of depth cue consistency

35. **Cesare Valerio Parise, Charles Spence**
Synaesthetic correspondence modulates audiovisual temporal integration

36. **Michael Schaefer, Hans-Jochen Heinze, Michael Rotte**
My third arm: shifts in topography of the somatosensory homunculus predict feeling of an artificial supernumerary arm

37. **Yael Zahar, Yoram Gutfreund**
Multisensory enhancement in the optic tectum of the barn owl: spike count and spike timing.

38. **Patricia Besson, Christophe Bourdin, Gabriel M. Gauthier, Lionel Bringoux, Daniel Mestre, Jona Richiardi, Jean-Louis Vercher**
Model of human's audiovisual perception using Bayesian networks

39. **Gregor Rafael Szycik, Jörg Stadler, Thomas F. Münte**
Audiovisual speech perception: Examining the McGurk illusion by fMRI at 7 Tesla

40. **Ross W. Deas, Neil W. Roach, Paul V. McGraw**
Adaptation to auditory motion produces direction-specific speed aftereffects

41. **Kentaroh Takagaki, Frank W. Ohl**
Cortical plasticity of audiovisual mass action

42. **A. Fillbrandt, M. Deliano, F. W. Ohl**
Audiovisual category transfer in rodents, an electrophysiological study of directional influences between auditory and visual cortex

43. **Felicitas Kroeger**
The relevance of multisensory learning in foreign language learning for adults

44. **Kirsten Hötting, Claudia K. Friedrich, Brigitte Röder**
Hearing cheats tactile deviant-detection: An event-related potential study

45. **Valerio Santangelo, Marta Olivetti Belardinelli, Charles Spence, Emiliano Macaluso**
Multisensory interactions between the endogenous and exogenous orienting of spatial attention

46. **Mirjam Keetels, Jean Vroomen**
Auditory-visual and tactile-visual temporal recalibration

47. **Ana Catarina Mendonça, Jorge Almeida Santos**
Auditory footsteps affect visual biological motion orientation detection

48. **Agnès Alsius, Salvador Soto-Faraco**
Searching for the talking head: The cocktail party revisited

Poster Session II

Thursday, July 17, 17.00 - 19.00

49. **Matthias Gondan**
Integration and segregation of auditory-visual signals

50. **Norimichi Kitagawa, Masaharu Kato, Makio Kashino**
Voluntary action improves auditory-somatosensory crossmodal temporal resolution.

51. **Jason Chan, T. Aisling Whitaker, Cristina Simoes-Franklin, Hugh Garavan, Fiona N Newell**
Investigating visuo-tactile recognition of unfamiliar moving objects: A combined behavioural and fMRI study

52. **Terry Elliott, Xutao Kuang, Nigel Richard Shadbolt, Klaus-Peter Zauner**
The impact of natural statistics on multisensory integration in Superior Colliculus

53. **Lars Torben Boenke, Matthias Deliano, Frank W. Ohl**
Temporal aspects of auditory and visual stimuli processing assessed by temporal order judgment and reaction times

54. **Inga Schepers, Daniel Senkowski, Joerg F. Hipp, Andreas K. Engel**
How vision can help audition: Speech recognition in noisy environments

55. **Andrea Serino, Francesca Pizzoferrato, Elisabetta Làdavas**
Viewing a face (especially one's own face) being touched enhances tactile perception on the face

56. **Chiara Francesca Sambo, Bettina Forster**
Projecting peripersonal space onto a mirror: ERP correlates of visual-tactile spatial interactions.

57. **Sepideh Sadaghiani, Joost X. Maier, Uta Noppeney**
Natural, metaphoric and linguistic auditory-visual interactions

58. **Hwee-Ling Lee, Johannes Tuennerhoff, Sebastian Werner, Chandrasekharan Pammi, Uta Noppeney**
Physical and perceptual factors determine the mode of audio-visual integration in distinct areas of the speech processing system

59. **Andy T. Woods, Garmt Dijksterhuis, Chantalle Groeneschild**
The contiguity principle – initial evidence for perceptual constancy in flavour

60. **James Heron, Neil W. Roach, David Whitaker, James V. M. Hanson**
Attention modulates adaptive temporal recalibration

61. **Holger Cramer, Brigitte Röder, Cordula Becker**
The role of brain lateralization and interhemispheric transfer for a multisensory reference frame of action control

62. **Helge Gillmeister, Monira Rahman, Bettina Forster**
Auditory-tactile and tactile-tactile enhancement: The role of task and overt visual attention

63. **Caterina Bertini, Fabrizio Leo, Alessio Avenanti, Elisabetta Làdavas**
TMS-based evidence for the independence of visual bias and audio-visual integration

64. **Matt Craddock, Rebecca Lawson**
Visual and haptic size constancy in object recognition

65. **Jordi Navarra, Agnès Alsius, Salvador Soto-Faraco, Charles Spence**
Prior linguistic experience modulates the temporal processing of audiovisual speech signals

66. **Claudia Passamonti, Ilja Frissen, Elisabetta Ladavas**
Neuropsychological evidence for different circuits subserving cross-modal recalibration of auditory spatial perception

67. **Shuichi Sakamoto, Maori Kobayashi, Mikio Seto, Kenzo Sakurai, Jiro Gyoba, Yo-iti Suzuki**
Effects of FM sounds on the perceived magnitude of self-motion induced by vestibular information

68. **Marie Montant, Daniele Schön, Jean-Luc Anton, Johannes Christoph Ziegler**
Speech perception is contaminated by visual words (orthography).

69. **Sascha Jockel**
Towards a multisensoric auto-associative memory to empower artificial agents with episodic memory capabilities

70. **Karin Petrini, Melanie Russell, Frank Pollick**
Obstructing the view degrades the audiovisual integration of drumming actions

71. **Jeremy Bluteau, Edouard Gentaz, Sabine Coquillart, Yohan Payan**
Haptic guidances increase the visuo-manual tracking of Japanese and Arabic letters

72. **Stephanie L. Simon-Dack, Margaret Baune, Malarie Deslauriers, Whitney Harchenko, Tyler Kurtz, Miller Ryan, Wahl Cassandra, Erin Wilkinson, Wolfgang A. Teder-Sälejärvi**
High-density EEG evidence of gender differences in processing of auditory and proprioceptive cues in peri-personal space.

73. **Christine Heinisch, Hubert R. Dinse**
Blind subjects are unaware of changes in hand asymmetry

74. **Valeria Occelli, Charles Spence, Massimiliano Zampini**
The effect of sound intensity on the audiotactile crossmodal dynamic capture task

75. **Luigi Tamè, Alessandro Farnè, Francesco Pavani**
Tactile masking within and between hands:Insights for spatial coding of touch at the fingers

76. **Sonja Schall, Cliodhna Quigley, Selim Onat, Peter König**
EEG power in alpha and gamma bands follows the temporal profile of audiovisual stimuli

77. **Tamar R. Makin, Nicholas Paul Holmes, Claudio Brozzoli, Yves Rossetti, Alessandro Farne**
Coding of multisensory peripersonal space in hand-centred reference frames by human motor cortex

78. **Joerg F. Hipp**
Neuronal dynamics of bi-stable cross-modal binding

79. **Pascal Barone, Nikola Todorov Markov, Arnaud Falchier, Colette Dehay, Michel Berland, Pascale Giroud, Henry Kennedy**
Respecification of cortex following prenatal enucleation in the monkey leads to the development of projections from the temporal pole to early visual areas

80. **Krista Overvliet, Salvador Soto-Faraco**
Tactile and visual contributions to the perception of naturalness

81. **Joanna E. McHugh, Rachel McDonnell, Jason S. Chan, Fiona N. Newell**
The multisensory perception of emotion in real and virtual humans

82. **Lili Tcheang, Neil Burgess, Heinrich Buelthoff**
Effects of path length, visual and interoceptive information on path integration

83. **Holger F. Sperdin, Céline Cappe, John J. Foxe, Micah M. Murray**
The impact of reaction time speed on early auditory-somatosensory multisensory interactions

84. **Lucilla Cardinali, Alessandro Farnè, Claudio Brozzoli, Romeo Salemme, Francesca Frassinetti**
Visual-tactile perception of time

85. **Thomas Hoellinger, Malika Auvray, Agnes Roby-Brami, Sylvain Hanneton**
Localisation tasks with a three-dimensional audio-motor coupling based on an electromagnetic motion capture device

86. **Laetitia Perre, Chotiga Pattamadilok, Johannes Ziegler**
Orthographic effects on spoken language

87. **Vassilis Sevdalis, Peter Keller**
I act, hear and see, but is it really me? Cross-modal effects in the perception of biological motion

88. **Julie Vidal, Marie-Hélène Giard, Frédérique Bonnet-Brilhault, Catherine Barthélémy, Nicole Bruneau**
Auditory-visual interactions in autistic children: a topographic ERP study

89. **Aniket Shitalkumar Rali, Leslie Ellen Dowell, Christopher Tremone Edge, Laura Jenelle Stabin, Mark Thomas Wallace**
The effects of unattended multisensory stimuli on a visual pattern completion task

90. **Ferran Pons, David J. Lewkowicz, Salvador Soto-Faraco, Nuria Sebastian-Galles**
Perceptual narrowing of cross-modal perception of nonnative contrasts

91. **Annalisa Setti, Kate Elisabeth Burke, Fiona Newell**
Is auditory visual integration preserved in the elderly?

92. **José van Velzen, A. F. Eardley, Luke Mason, J. Mayas-Arrellano**
Visual and auditory selective attention in near and far space

93. **Michael Barnett-Cowan, Laurence R. Harris**
Perception of simultaneity and temporal order of active and passive head movements paired with visual, auditory and tactile stimuli

94. **Lauren Emberson, Rebecca J. Weiss, Adriano Barbosa, Eric Vatikiotis-Bateson, Michael Spivey**
Crossing hands can curve saccades: Multisensory dynamics in saccades trajectories

95. **Zhao Zhongxiang**
Management of the multi-sensor system and fault diagnosis Information fusion of mine main ventilator

96. **I-Fan Lin**
Where visually-guided auditory spatial adaptation occurs

Poster Session III

Friday, July 18, 16.00 - 18.00

97. **Nienke van Atteveldt, Vera Blau, Leo Blomert, Rainer Goebel**
fMR-adaptation reveals multisensory integration in human superior temporal cortex

98. **Thomas Koelewijn, Adelbert Bronkhorst, Jan Theeuwes**
Auditory capture during focused visual attention

99. **Jean Vroomen, Jeroen Stekelenburg**
Visual anticipatory information modulates audiovisual cross-modal interactions of artificial stimuli

100. **Fei Shao**
A Finite element fingertip model for simulating tactile sensation

101. **Till R. Schneider, Simone Lorenz, Daniel Senkowski, Andreas K. Engel**
Touching the sound: High-frequency oscillations in a distributed cortical network reflect cross-modal semantic matching in haptic-to-auditory priming

102. **Hans-Günther Nusseck, Harald Jürgen Teufel, Jennifer L. Campos, Heinrich H. Bülthoff**
The impact of gravitoinertial cues on the perception of lateral self-motion

103. **Dries Froyen, Milene Bonte, Nienke Van Atteveldt, Hanne Poelmans, Leo Blomert**
The long road to automation: Neurocognitive development of letter/speech-sound processing.

104. **Lisa Dopjans, Christian Wallraven, Heinrich H. Bülthoff**
Encoding differences in visual and haptic face recognition

105. **Michiteru Kitazaki, Atsushi Murata, Shinichi Onimaru, Takao Sato**
Vection during walking: effects of vision-action direction congruency and visual jitter

106. **Nina Gaißert, Christian Wallraven, Heinrich H. Bülthoff**
Analyzing haptic and visual object categorization of parametrically-defined shapes

107. **Cristina Simoes-Franklin, T. Aisling Whitaker, Fiona Newell**
Active touch vs. passive touch in roughness discrimination: an fMRI study.

108. **Yoshiyuki Ueda, Jun Saiki**
Different learning strategies in intra- and inter-modal 3-D object recognition tasks revealed by eye movements

109. **David McCormick, Pascal Mamassian**
Biasing saccades with sound

110. **Matthias Bischoff, Roman Pignanelli, Helge Gebhardt, Carlo Blecker, Dieter Vaitl, Gebhard Sammer**
EEG and fMRI during an unimodal and a crossmodal flanker task

111. **Jason S. Chan, Carol O'Sullivan, Fiona N Newell**
Audiovisual depth perception in real and virtual environments

112. **Kai Bronner, Herbert Bruhn, Rainer Hirt, Dag Piper**
Research on the interaction between the perception of music and flavour

113. **Lars Torben Boenke, Matthias Deliano, Frank W. Ohl**
Neuronal correlates of spatial audio-visual temporal order perception

114. **Christina M. Karns, Robert T. Knight**
Intermodal attention modulates early and late stages of multisensory processing

115. **Celine Cappe, Micah M. Murray**
Auditory-visual multisensory interactions in depth

116. **Cordula Hagemann, Corinna Klinge, Till R. Schneider, Brigitte Röder, Christian Büchel**
An fMRI study on crossmodal interactions during object processing

117. **Ana Tajadura-Jiménez, Norimichi Kitagawa, Aleksander Väljamäe, Massimiliano Zampini, Micah M. Murray, Charles Spence**
Spatial modulation of auditory-somatosensory interactions: effects of stimulated body surface and acoustic spectra

118. **Tobias Schicke, Brigitte Röder**
Interactions of different body parts in the peripersonal space and in the body schema

119. **Daniel K. Rogers, Jason S. Chan, Fiona N. Newell**
Investigating the role of audition in spatial perception of natural visual scenes

120. **Akira Gassho, Naoki Matsubara, Hidehiko Sakamoto**
The combined effect of color and temperature on thermal sensation and subject's gazing behavior

121. **Iwona Pomianowska, Jason S. Chan, Fiona N. Newell**
Action perception from audio-visual cues: the role of human voice and body orientation in determining locus of attention.

122. **Simon Lacey, Marisa Pappas, Kevin Lee, K. Sathian**
Is cross-modal transfer of perceptual learning and viewpoint-independence possible?

123. **Takuro Kayahara**
Indivisuality distinction judgment of the movie with scene shake by walking

124. **Ludovic Lacassagne, Andrej Kral, Pascal Barone**
Effect of a congenital deafness on the organization of the thalamo-cortical connections in the cat

125. **Ben Schouten, Elke Moyens, Anna Brooks, Rick van der Zwan, Karl Verfaillie**
The effect of looming and receding sounds on the in-depth perception of point-light figures

126. **Scott Love, James M. Hillis, Frank E. Pollick**
Does optimal integration of auditory and visual cues occur in a complex temporal task?

127. **Daniel Bergmann, Hans-Jochen Heinze, Toemme Noesselt**
Neural bases of phase shifted audiovisual stimuli

128. **Francesco Pavani, Patrick Haggard, GianLuigi Mansi, Alessandra Fumagalli, Massimiliano Zampini**
An indirect measure of body distortions in patients with eating disorders

129. **T. Aisling Whitaker, Cristina Simões-Franklin, Fiona N. Newell**
An fMRI investigation of the role of vision and touch in the perception of “Naturalness”

130. **Kensuke Oshima**
The way of touch affect the relationship between vision and touch

131. **Shinya Yamamoto, Makoto Miyazaki, Takayuki Iwano, Shigeru Kitazawa**
Bayesian calibration of simultaneity in audiovisual temporal order judgment

132. **Anja Kraft, Martina Kroeger, Rike Steenken, Hans Colonius, Adele Diederich**
The dual role of the non-target in visual-auditory saccadic integration

133. **David Whitaker, James V.M. Hanson, James Heron**
The effect of adaptation on tactile temporal order judgments

134. **Valeria Occelli, Jess Hartcher O'Brien, Charles Spence, Massimiliano Zampini**
Is the Colavita effect an exclusively visual phenomenon?

135. **Isadora Olive**
On the correlation between the spatial extension of touch pharmacological synaestesia and the plastic chategorization of the human body schema

136. **Yanzi Miao, Jianwei Zhang**
A novel method of dealing with the dynamic and fuzzy information from multi sensors

137. **Liang Chun**
The application of water environment monitoring based on the multisensory data fusion

138. **Andrea R. Hillock, Albert R. Powers, Juliane Krueger, Alexandra P.F. Key, Mark T. Wallace**
Analysis of multisensory simultaneity perception in adults using event related potentials.

139. **M. Luisa Dematte, Massimiliano Zampini, Francesco Pavani**
Time-to-Contact estimation for visual stimuli approaching the hand

140. **Elena Azañón, Salvador Soto-Faraco**
Changing representations during tactile encoding

141. **Leslie Ellen Dowell, Jennifer H Foss-Feig, Haleh Kadivar, Laura Jenelle Stabin, Courtney P Burnette, Eric A Esters, Tiffany G Woynaroski, Carissa Cascio, Wendy Stone, Mark Thomas Wallace**
An extended temporal window for multisensory integration in ASD

142. **Maria Mittag, Rika Takegata, Teija Kujala**
The neural network underlying letter and speech-sound integration

143. **Ryan Andrew Stevenson, Nicholas A. Altieri, Sunah Kim, Thomas W. James**
Anatomically and functionally distinct regions within multisensory superior temporal sulcus differentially integrate temporally-asynchronous speech

144. **Sunah Kim, Daniel Eylath, Ryan Andrew Stevenson, Thomas Wellington James**
Evidence for ventral and dorsal neural pathways for visuo-haptic object recognition

Poster Session IV

Saturday, July 19, 9.00 - 11.00

145. **Bjoern Bonath, Steven A. Hillyard, Sascha Tyll, Jyoti Mishra, Hans Jochen Heinze, Toemme Noesselt**
Spatial and temporal factors in audiovisual integration: An fMRI study

146. **Durk Talsma, Erik Van der Burg, Christiaan Olivers, Jan Theeuwes**
Multisensory integration causes non-informative auditory stimuli to facilitate visual search: An event-related potential investigation of the “Pip and Pop” phenomenon

147. **Yasuhito Nagai, Mayu Suzuki, Makoto Miyazaki, Shigeru Kitazawa**
Effects of visual cues on acquisition of multiple prior distributions in tactile temporal order judgments

148. **Tom Gijsbert Philippi, Jan B F van Erp, Peter J. Werkhoven**
Is bias and variance of multimodal temporal numerosity judgement consistent with Maximum Likelihood Estimation?

149. **Luc Tremblay, Thanh Nguyen**
Probing vision utilization using an audio-visual illusion: Evidence for modulation of visual afferent information processing during goal-directed movements

150. **Rike Steenken, Hans Colonius, Adele Diederich**
Spatial audio-visual integration without localizing the auditory stimulus?

151. **Ran Geva, Zohar Tal, Uri Hertz, Amir Amedi**
Mirror symmetry topographical mapping is a fundamental principle of cortex organization across sensory modalities: a whole brain fMRI study of body representation.

152. **Yuki Hongoh, Taku Konishi, Koichi Hioki, Hirokazu Nishio, Takaji Matsushima, Satoshi Maekawa**
Incongruent visual image impairs discrimination of tactile stimulus on a finger

153. **E. Courtenay Wilson, Charlotte M. Reed, Louis D. Braida**
Perceptual interactions between vibrotactile and auditory stimuli: Effects of frequency

154. **Georg F. Meyer, Sophie M. Wuerger, Roland M. Rutschmann, Mark W. Greenlee**
Neural correlates of audio-visual biological motion and speech processing

155. **Waka Fujisaki, Shin'ya Nishida**
Temporal limits of within- and cross-modal cross-attribute bindings

156. **Priyamvada Tripathi, Robert Gray, Mithra Vankipuram, Sethuraman Panchanathan**
Humans increasingly rely more on haptics in 3D shape perception with higher degrees of visual-haptic conflict

157. **Clara Suied, Isabelle Viaud-Delmon**
The role of object categories in auditory-visual object recognition

158. **Cornelia Kranczioch, Jeremy Thorne, Stefan Debener**
Audio-visual simultaneity judgments in rapid serial visual presentation

159. **Lars Arne Ross, Sophie Molholm, Manuel Gomez-Ramirez, Pejman Sehatpour, Alice Brown Brandwein, Natalie Russo, Hilary Gomes, Dave Saint-Amour, John James Foxe**
Audiovisual integration in word recognition in typically developing children and children with autistic spectrum disorder

160. **David Hartnagel, Alain Bichot, Corinne Roumes**
Effect of eye-position on auditory, visual or audio-visual target localization

161. **Toshiko Mochizuki**
Cognitive interactions between facial expression and vocal intonation in emotional judgment

162. **Francesco Campanella, Giulio Sandini**
Visual object recognition by prehension movement

163. **Valeria Occelli, Charles Spence, Massimiliano Zampini**
Assessing the effect of sound complexity on the audiotactile crossmodal dynamic capture task

164. **Ladan Shams, Ulrik R. Beierholm, David R. Wozny**
Human trimodal perception follows optimal statistical inference

165. **Marcus J. Naumer, Andrea Polony, Yavor Yalachkov, Leonie Ratz, Grit Hein, Oliver Doehrmann, Jochen Kaiser, Vincent G. van de Ven**
Audio-visual and visuo-tactile integration in the human thalamus

166. **Kohske Takahashi, Katsumi Watanabe**
Visual and auditory modulation of perceptual stability of ambiguous visual patterns

167. **Eugen Oetringer**
How the brain could make sense out of complex multi-sensory inputs

168. **Azra Nahid Ali**
Audiovisual fusion or just an illusion?

169. **Ian Ley, Patrick Haggard, Kielan Yarrow**
Optimal integration of auditory and vibrotactile information for judgements of temporal order

170. **Mikhail Zvyagintsev, Andrey Nikolaev, Heike Thoennessen, Klaus Mathiak**
Incoherent audio-visual motion reveals early multisensory integration in auditory cortex

171. **Janina Seubert, Frank Boers, Klaus Mathiak, James Loughead, Ute Habel**
Olfactory-visual interactions in emotional face processing

172. **Yuji Wada, Daisuke Tsuzuki, Tomohiro Masuda, Kaoru Kohyama, Ippeita Dan**
Tactile illusion induced by referred thermal sensation

173. **Joachim Lange, Robert Oostenveld, Pascal Fries**
Perception of the visual double-flash illusion correlates with changes of oscillatory activity in human sensory areas

174. **Katja Fiehler, Johanna Reuschel, Frank Rösler**
How vision and kinesthesia contribute to space perception: Evidence from blind and sighted humans

175. **Rebecca Lawson, Heinrich Bülthoff**
Cross-modal integration of visual and haptic information for object recognition: Effects of view changes and shape similarity

176. **Manuel Vidal, Alexandre Lehmann, Heinrich Bülthoff**
Combining sensory cues for spatial updating: The minimal sensory context to enhance mental rotation

177. **Monica Gori, Giulio Sandini, David Burr**
Motion discrimination of visual, tactile and bimodal stimuli

178. **Yavor Yalachkov, Jochen Kaiser, Marcus J. Naumer**
Activation of visuomotor brain areas reflects the individual smoking expertise: an fMRI study

179. **Ilja Frissen, Jan L. Souman, Marc O. Ernst**
Multisensory integration of non-visual sensory information for the perceptual estimation of walking speed

180. **Patrick Bruns, Brigitte Röder**
Tactile capture of auditory localization is modulated by hand posture

181. **Hans Colonius, Adele Diederich, Stefan Rach**
Measuring auditory-visual integration efficiency

182. **Birthe Pagel, Tobias Schicke, Brigitte Röder**
Developmental time course of the crossed hands effect for tactile temporal order judgements

183. **Zohar Eitan, Inbar Rothschild**
Musical parameters and audiotactile metaphorical mappings

184. **Ryan Remedios, Nikos K. Logothetis, Christoph Kayser**
Sensory interactions in the Claustrum and Insula Cortex.

185. **Oliver Alan Kannape, Tej Tadi, Lars Schwabe, Olaf Blanke**
Motor performance and motor awareness in a full body agency task using virtual reality

186. **Jess Hartcher-O'Brien, Charles J. Spence**
On and off the body: Extending the space for visual dominance of touch

187. **Julia Föcker, Anna Best, Brigitte Röder**
Plasticity of voice-processing: Evidence from event-related potentials in late-onset blind and sighted people

188. **Sebastian Werner, Uta Noppeney**
Audio-visual object integration in human STS: Determinants of stimulus efficacy and inverse effectiveness

189. **Lauren Emberson, Chris Conway, Morten Christiansen**
Timing is everything: Modality mediates effects of attention in implicit statistical learning

190. **Ella Striem, Uri Hertz, Amir Amedi**
Mirror symmetry topographical mapping is a fundamental principle of cortex organization across sensory modalities: a whole brain fMRI study of tonotopic mapping

191. **Davide Bottari**
Space and time modulate faster visual detection in the profound deaf

192. **Zhenzhu Yue, Xiaolin Zhou, Brigitte Röder**
Gradients of unimodal and crossmodal spatial attention under different processing load

Abstracts

In order of presentation.

Tuesday 15th

15:00 – 18:00 Satellite Symposium

Multisensory processing in flavour perception

Organized by John Prescott

School of Psychology, University of Newcastle, Australia

How cognition and attention modulate affective responses to taste and flavour: Top-down influences on the orbitofrontal and pregenual cingulatec cortices

Fabian Grabenhorst, Edmund T. Rolls

Department of Experimental Psychology, University of Oxford, UK

How cognition and attention influence the affective brain representations of taste, flavour, and smell is important not only for understanding top-down influences on multisensory representations in the brain, but also for understanding how taste and flavour can be influenced by these top-down signals. We found using functional magnetic resonance imaging that activations related to the affective value of umami taste and flavor (as shown by correlations with pleasantness ratings) in the orbitofrontal cortex were modulated by wordlevel descriptors, such as “rich delicious flavour”. Affect-related activations to taste were modulated in a region that receives from the orbitofrontal cortex, the pregenual cingulate cortex, and to taste and flavor in another region that receives from the orbitofrontal cortex, the ventral striatum. Affect-related cognitive modulations were not found in the insular taste cortex, where the intensity but not the pleasantness of the taste was represented. Moreover, in a different investigation, paying attention to affective value (pleasantness) increased activations to taste in the orbitofrontal and pregenual cingulate cortex, and to intensity in the insular taste cortex. We conclude that top-down language-level cognitive effects reach far down into the earliest cortical areas that represent the appetitive value of taste and flavor. This is an important way in which cognition influences the neural mechanisms of taste, flavour, and smell, that control appetite.

Olfactory-taste interactions and the role of familiarity and exposure strategy

David Labbe, Nathalie Martin

Nestle Research Centre, Switzerland

The role of familiarity and exposure strategy on sensory interactions between olfaction and taste has already been demonstrated in model solutions. The aim of our approach was to investigate the role of these two factors in real food products. First we investigated the impact of olfactory perception on taste in three bitter drinks varying in familiarity with, from the most to the least familiar, a black coffee, a cocoa drink and a caffeinated milk. A vanilla flavouring was added in the three beverages and each flavoured drinks as well as the related unflavoured drinks were characterized by sensory profiling. The vanilla olfactory stimulation led to an increase in sweetness and a decrease in bitterness for both coffee and cocoa drinks. But the effect was more powerful for the most familiar coffee drink. On the contrary when added in the least familiar caffeinated milk, vanilla flavouring did not influence sweetness, but unexpectedly enhanced bitterness. These results suggest the importance of the product familiarity on the expression of sensory interaction. Second, the impact of exposure strategy on coffee odour perception was explored comparing odour characterization of eight coffee drinks done by ten trained subjects according to QDA® and by forty coffee consumers using a sorting task (product grouping according to their similarities with a free description of each group). Results showed that consumers grouped the coffees consensually but differently from the trained panel. This gap may be explained by differences between consumers and sensory panel in terms of evaluation strategy, which may influence coffee perception and related description. Indeed consumers had a holistic approach considering product sensory properties as a whole which may promote the impact of previous food experience on perception, such as odour and taste association constructed during every day coffee exposure. On the contrary, trained panelists evaluated products with an analytical approach since they described individually and independently each attribute. This approach may reduce therefore the impact of food experience on perception andconsequently the role of interaction between sensory modalities. To conclude, findings of our study suggested that the impact of perceptual interactions between olfaction and taste was related to food familiarity and modulated by the applied exposure strategy.

Neural encoding of the taste of odor

Maria G. Veldhuizen, Dana M. Small

The John B. Pierce Laboratory and Yale University School of Medicine, New Haven, USA

Odors are often described as having taste-like qualities, and experiencing an odor in solution with a taste has been repeatedly demonstrated to enhance the intensity ratings of that tastelike quality in the odor [1, 2]. We have performed a series of fMRI studies investigating the possibility that neural processes in the insula encode the taste-like properties of odors. We chose to focus on the insula because neuroimaging studies consistently show that the insular cortex is activated by the perception of taste and the perception of smell [3, 4], and because damage to the insula leads to changes in both taste and smell perception [5, 6]. Collectively, the series of studies we have performed show that: 1) the anterior ventral insula, which receives projections from primary taste and primary olfactory cortex, responds supraadditively to taste-odor mixtures [7], suggesting that this region is important for flavor learning; 2) that several regions of insula and operculum respond more to food compared to equally pleasant and intense non-food odors; and 3) that attention to odors activates the piriform cortex and the ventral insula, and that the magnitude of the response in the ventral insula, but not the piriform cortex, correlates with the sweetness ratings of odors. Taken together, these findings suggest that the insula encodes the taste of odors. Supported by NIDCD grants R01 DC006706 and R03 DC006169.

1. Stevenson, R.J., R.A. Boakes, and J. Prescott, Learn. Motiv., 1998. 29(2), 113-132; 2. Stevenson, R.J., J. Prescott, and R.A. Boakes, Learn. Motiv., 1995. 26(4), 433-455; 3. Verhagen, J.V. and L. Engelen, Neurosci. Biobehav. Rev., 2006. 30(5), 613-50; 4. De Araujo, I.E., et al., Eur. J. Neurosci., 2003. 18(7), 2059-68; 5. Mak, Y.E., et al., Behav. Neurosci., 2005. 119(6), 1693-700; 6. Stevenson, R.J., L.A. Miller, & Z.C. Thayer, J. Exp. Psychol.: Hum Percep. Perform., 2008. In press; 7. Small, D.M., et al., J. Neurophysiol., 2004. 92(3), 1892-903.

Cross-modal capture within flavour

Garmt Dijksterhuis, Andy Woods

Unilever Food & Health Research Institute, Vlaardingen, The Netherlands

Food flavour often takes time to develop, varies over mouthfuls and indeed over inhalation and exhalation. Despite this, we rarely acknowledge or even perceive such variation. Somehow, a contiguous food flavour is experienced despite obvious variation in sensory signals. Related processes act in a similar fashion in other modalities (perceptual constancy, *e.g.* in vision) and across modalities (the unity assumption). It was hypothesised that a food which is *assumed* to be consistently flavoured will be tasted to be so, despite some variation in actual flavour. A cookie model-food-stimulus was developed, whose two halves sometimes differed in levels of sugar but were visually indistinguishable (to ensure the assumption of a contiguous cookie). Sweetness ratings for the different cookie halves were indistinguishable for early trials; for later trials the low sugar cookie halves were rated differently in terms of sweetness from each other. The high sugar cookie-halves were always rated differently in terms of sweetness. Our findings provide support for the existence for a contiguity effect which can mask some flavour variation, but whose effects seem to be modulated by increasing exposure to discrepant stimuli.

Assessing the contribution of vision (colour) to multisensory flavour perception: Topdown vs. bottom-up influences

Charles Spence, Maya U. Shankar, Carmel A. Levitan, Massimiliano Zampini,

Department of Experimental Psychology, University of Oxford. U.K.

Although researchers have known for more than 80 years that colour has the capacity to influence people's flavour perception (see 1 for early work in this area), surprisingly little is known about the specific conditions under which such crossmodal effects occur. Often, it seems as though researchers have assumed that they are always driven in a relatively 'bottom-up' manner. However, it is important to note that the crossmodal effect of colour on multisensory flavour perception has frequently been found to operate in a relatively top-down manner as well (as, for example, when specific food colours come to signify a brand or provide a semantic cue as to the identity of the food or beverage concerned - as when the red colouring of a drink reminds one participant of strawberries and another of watermelon).We review the experimental literature demonstrating top-down influences of vision (specifically colour) on multisensory flavour perception. We will also highlight the latest research from our own laboratory that has attempted to quantify the effect of colour on people's perception of both drinks and branded chocolate products (2). Finally, we show how findings from the laboratory relating to the colouring, labelling, and branding of foods are currently being used in commercial settings.

1. Moir, H. C. (1936). *J. Soc. Chem. Indust.: Chem. Indust. Rev.*, 14, 145-148.

2. Levitan, C., Zampini, M., Li, R., & Spence, C. (2008). *Chemical Senses*.

Wednesday 16th

9:00 – 10:30 Symposium

Multisensory integration of audition and vision using multimodal approaches: from neurophysiology and brain imaging to neural network modelling

Organized by Amir Amedi,

The Hebrew University, Israel

In recent years, the role of multisensory integration in sensory processing and perception has attracted much scientific interest. However, the integration from neurophysiology, neuroimaging and especially neural network modeling on specific topics is still very much missing. Similar integration from development and clinical studies is also much needed. Here we propose to achieve such integration, in relation to auditory-visual interactions. The first speaker will present the specialization of the barn owl for hunting small prey in dimly lighted and acoustically noisy environments which advocates it as an excellent model for studying auditory-visual integration. The next two talks will build on this and will present neuroimaging and behavioral experiments of auditory-visual integration in humans. Similarly to the experiments in the barn owl these studies use natural dynamic stimuli. They will specifically focus on audio-visual aspects of human communication, sight restoration and brain development in health and disease (e.g. in congenital blindness and prosopagnosics). We will conclude by presenting a novel neural network model to achieve optimal multi- sensory integration.

Visual-auditory integration in the barn owl: A neuroethological approach

Yoram Gutfreund, Amit Reches, Yael Zahar

Faculty of Medicine, Technion

The barn owl (Tyto alba) evolved precise visual and auditory systems to detect small prey in acoustically noisy and dimly lit conditions. Consequently, this species provides us with an excellent model system for studying the physiology of visual-auditory integration. In recent years, my lab concentrated on studying visual-auditory integration in the barn owl. Our efforts led to the discovery of two previously unknown populations of multisensory neurons; in the thalamus and in the forebrain. These populations add to the well known multisensory neurons that exist in the midbrain (in the optic tectum or superior colliculus). In my talk I will present several examples of responses of multisensory neurons from the various brain sites, highlighting different principles of visual-auditory integration. The results so far point to a vast network of visual-auditory integration in the barn owl's brain. Comparisons with other species will be drawn.

A multisensory perspective on human auditory communication

Katharina von Kriegstein

University College of London, U.K.

Human face-to-face communication is essentially audio-visual. Typically, people talk to us face-to-face, providing concurrent auditory and visual input. Understanding someone is easier when there is visual input, because visual cues like mouth and tongue movements provide complementary information about speech content. I will present data which show that for auditory-only speech the human brain exploits previously encoded audio-visual correlations to optimize communication. The data are derived from behavioural and functional magnetic resonance imaging experiments in prosopagnosics (i.e. people with a face recognition deficit) and controls. The results show, that in the absence of visual input the brain optimizes both auditory-only speech and speaker recognition by harvesting speaker-specific predictions and constraints from distinct visual face-processing areas. These findings challenge current uni-sensory models of speech processing. They suggest that optimization of auditory speech processing is based on speaker-specific audio-visual internal models, which are used to simulate a talking face.

Audio-visual integration for objects, location and low-level dynamic stimuli: novel insights from studying sensory substitution and topographical mapping.

Amir Amedi, William Stern, Lotfi Merabet, Ella Striem, Uri Hertz, Peter Meijer, Alvaro Pascual-Leone

Hebrew University

The talk will present fMRI and behavioral experiments of auditory-visual integration in humans. It will focus on integration in sighted but also in sight restoration set-up, looking into the effects of learning, brain development and brain plasticity. New findings regarding the nature of sensory representations for dynamic stimuli ranging from pure tones to complex, natural object sounds will be presented. I will highlight the use of sensory substitution devices (SSDs) in the context of blindness. In SSDs, visual information captured by an artificial receptor is delivered to the brain using non-visual sensory information. Using an auditory-to-visual SSD called "The vOICe" we find that blind achieve successful performance on object recognition tasks, and specific recruitment of ventral and dorsal 'visual' structures. Comparable recruitment was observed also in sighted learning to use this device but not in sighted learning arbitrary associations between sounds and object identity. We also find using phase locking Fourier Techniques an array of topographic maps which can serve as a basis for such audio-visual integration. Finally, these results suggest "The vOICe" can be useful for blind individuals' daily activities but it also has a potential use to ‘guide’ visual cortex to interpret visual information arriving from prosthesis.

Optimal multi-modal state estimation and prediction by neural networks based on dynamic spike train decoding

Ron Meir

Technion

It is becoming increasingly evident that organisms acting in uncertain dynamical environments employ exact or approximate Bayesian statistical calculations in order to continuously estimate the environmental state and integrate information from multiple sensory modalities. What is less clear is how these putative computations are implemented by cortical neural networks. We show how optimal real-time state estimation based on noisy multi-modal sensory information may be effectively implemented by neural networks decoding sensory spikes. We demonstrate the efficacy of the approach on static decision problems as well as on dynamic tracking problems, and relate the properties of optimal tuning curves to the properties of the environment.

11:00 – 13:00 Paper Session

Chair: Erich Schröger

Spatial and spatiotemporal receptive fields of cortical and subcortical multisensory neurons

Mark T. Wallace, Brian N. Carriere, Matthew C. Fister, Juliane Krueger, David W. Royal

Vanderbilt University

Multisensory neurons throughout the neuraxis play an active role in transforming their different sensory inputs into an integrated output. These neurons have been shown to synthesize their inputs based on the spatial and temporal relationships of the combined stimuli, as well as on their relative effectiveness. Although these integrative principles have been extraordinarily useful as a foundation with which to assess the combinatorial operations carried out by multisensory neurons, they provide only a first-order approximation as to the results of any given multisensory combination. Although it has long been noted that the receptive fields of multisensory neurons are typically large and heterogeneous, the impact of receptive field architecture and the temporal dynamics of the evoked response on multisensory interactions has not been systematically evaluated. In the current study, we examined this issue by detailing the unisensory (i.e., visual, auditory) and multisensory (visual-auditory) spatial (SRFs) and spatiotemporal receptive fields (STRFs) of multisensory neurons in the cat anterior ectosylvian sulcus (AES) and superior colliculus (SC). In both structures, SRFs and STRFs revealed a strong interdependency between space, time and effectiveness in dictating the resultant interaction, and which provides a more dynamic description of the integrative profile of multisensory neurons.

Multisensory integration in the superior colliculus: Inside the black box

Benjamin Andrew Rowland

Wake Forest University School of Medicine

The multisensory neuron in the superior colliculus (SC) has proved to be an excellent model for understanding how the brain synthesizes information from different senses. Its responses to spatiotemporally concordant cross-modal stimulation are typically greater than that to the most effective of these alone. There is now a large body of information regarding the relationship between the magnitude of the SC neuron's multisensory response, the physical properties of the stimulus combination driving it, and the particular circuit in the CNS that is activated. The underlying multisensory computation that is engaged during this process appears to contain nonlinearities that are dependent on inputs from cortex. Here we present a neural network model based on simple anatomical and physiological principles that accounts for many of the empirical findings. In the model, spatiotemporally concordant cross-modal stimulation enhances the activity of multisensory SC output neurons by two mechanisms: the clustering of cortically-derived afferents on shared electrotonic compartments, and transient synchronization between the cortical afferents themselves. We review the anatomical and physiological principles upon which the model is founded, the data that it replicates, and offer empirical predictions of the model for future research.

Distinct circuits support unisensory and multisensory integration in the cat superior colliculus

Terrence R. Stanford, Juan Carlos Alvarado, J. William Vaughan, Barry E. Stein

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Multisensory neurons in the SC integrate within-modal cues quite differently from cross-modal cues; rather than additivity or superadditivity, simultaneous presentation of excitatory stimuli from the same modality typically yields a response that is subadditive (Alvarado et al., 2007). That the same SC neuron can integrate excitatory influences differently depending on their source is fortuitous from a functional perspective, however, details of the neural architecture underlying this dual capacity is not clear. A likely candidate is the projection to the SC from regions of the anterior ectosylvian cortex (AES) which has been shown to be necessary for promoting the additive and superadditive interactions typical of multisensory enhancement (Wallace and Stein, 1994; Jiang et al., 2001). The present study examines the degree to which the AES-derived cortico-collicular projection is multisensory-specific by evaluating the impact of cortical inactivation on both unisensory and multisensory integration in the same multisensory neurons. We found that cortical inactivation nearly abolished multisensory enhancement but had no impact on unisensory integration in the very same neurons. These findings suggest that this cortico-collicular circuit has evolved expressly for the purpose of combining information across multiple senses and, in doing so, highlight an essential distinction between within-modal and cross-modal processing architectures.

The effects of task and attention on visual-tactile processing: Human intracranial data

Thomas Thesen[1], Mark Blumberg[2], Charles Spence[3], Chad E Carlson[2], Sydney S Cash[4], Werner K Doyle[5], Ruben I Kuzniecky[2], Istvan Ulbert[6], Orrin Devinsky, Eric Halgren[7]

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We investigated the spatio-temporal profile of visual-tactile integration during crossmodal reaction time and congruency tasks. EEG activity was recorded from intracranial surface and depth electrodes in 8 patients. In a subset, we recorded responses from linear arrays of 24 laminar microelectrodes. Subjects were stimulated with brief tactile taps on the thumb and index finger with simultaneous LED flashes at the same locations. Each task employed eight stimulus conditions that consisted of bimodal congruent, bimodal incongruent or unimodal tactile or visual stimulation. The target modality varied between blocks. In Experiment I, subjects made speeded button responses to any stimulus in the target modality, irrespective of location. In Experiment II, subjects were instructed to make speeded elevation discrimination responses to stimuli in the target modality. Macro- and microelectrode data were analyzed in the time and frequency domains to compute ERPs and event-related power changes in broad frequency bands. Based on the microelectrode data we estimated population transmembrane currents and multi-unit activity in specific brain areas. We report the timing and laminar profile of multisensory interactions in the human brain and their modulation by task requirements and attention.

Pip and pop: Non-spatial auditory signals improve spatial visual search

Erik van der Burg[1], Christian Olivers[1,] Adelbert Bronkhorst[2], Jan Theeuwes[1]

[1]Vrije Universiteit, [2]TNO

Searching for an object within a cluttered, continuously changing environment can be a very time consuming process. Here we show that a simple auditory pip drastically decreases search times for a synchronized visual object that is normally very difficult to find. This effect occurs even though the pip contains no information on the location or identity of the visual object. The experiments also show that the effect is not due to general alerting (as it does not occur with visual cues), nor due to top-down cueing of the visual change (as it still occurs when the pip is synchronized with distractors on the majority of trials). Instead, we propose that the temporal information of the auditory signal is integrated with the visual signal, generating a relatively salient emergent feature that automatically draws attention. Phenomenally, the synchronous pip makes the visual object pop out from its complex environment, providing a direct demonstration of spatially non-specific sounds affecting competition in spatial visual processing.

From visual symbols to sound representations: Event-related potentials and gamma-band responses

Erich Schröger, Andreas Widmann, Thomas Gruber

University of Leipzig

We studied audio-visual integration with event-related potentials (ERPs) and gamma-band responses (GBRs). Human subjects performed symbol-to-sound-matching paradigm in which score-like visual stimuli had to be mapped to corresponding sound patterns. The sounds could be either congruent or occasionally incongruent with the corresponding symbol. In response to congruent sounds, a power increase of phase-locked (evoked) GBR in the 40-Hz band was observed peaking 42-ms post-stimulus onset. This suggests that the comparison process between an expected sound and the current sensory input is implemented at early levels of auditory processing. Subsequently, expected congruent sounds elicited a broadband power increase of non-phase-locked (induced) GBR peaking 152-ms post-stimulus onset, which might reflect the formation of a unitary event representation including both visual and auditory aspects of the stimulation. GBRs were not present for unexpected incongruent sounds. However, incongruent sounds elicited an ERP component starting at about 100 ms relative to their onset. It had a bilateral frontal distribution and a polarity inversion at the mastoids pointing at sources in auditory areas. Results can be explained by a model postulating the anticipatory activation of cortical auditory representations and the match of experience against this expectation. GBRs are sensitive to a match of the forward model, ERPs to a mismatch.

14:30 – 15:30 Keynote address

Design and analysis strategies for multisensory fMRI research: Insights from letter-speech sound integration studies

Rainer Goebel

Faculty of Psychology, Universiteit Maastricht

Multisensory research using fMRI presents specific challenges for appropriate experimental designs and analysis strategies. We report about a series of experiments investigating letter-speech sound integration using different experimental designs, paradigms and analysis methods, including block and event-related designs, adaptation paradigm, passive vs active performance, conjunction analysis as well as standard vs advanced brain alignment techniques for group analyses. While some results were rather consistent, some design and analysis choices lead to unexpected findings. We will discuss the implications of the obtained insights in the context of general multisensory fMRI research.

15:30 – 17:00 Symposium

Cross-modal reorganization in deafness

Organized by Pascal Barone[1] and Andrej Kral[2]

[1]Brain and Cognition Center, Université Paul Sabatier, Toulouse, France,
[2]University Medical Center Hamburg-Eppendorf, Germany

In congenital deafness the central auditory system is completely deprived of it's adequate input. That results in cross-modal reorganization of the auditory cortex both in animal models and in deaf humans. Deafness constitutes a unique opportunity to study the capacity of cortical plasticity within and between modalities, since hearing can be later restored through neuro-prostheses inserted at the peripheral level (even in humans). Speakers of the proposed symposium will elucidate the determinants of these reorganizations by contrasting their specificity at several levels, from anatomy to behavior in both animal models and humans.

Cross-modal reorganization is highly specific within the reorganized modality. Supranormal visual performance in deaf is demonstrated for particular functions and is not found in other ones. The reorganization at the cortical level is area-specific, some auditory areas are activated in processing of certain visual and somatosensory stimuli, some are not. Finally, the cortical network for multisensory processing is highly dependent on the onset and duration of recovery of the auditory function in cochlear-implanted deaf subjects. To understand these cross-modal reorganizations is of cardinal interest for basic science as well as for the therapy of profoundly deaf patients.

Contributions of auditory cortex to the superior visual capabilities of congenitally deaf cats

Stephen G. Lomber[1], Andrej Kral[2]

[1]Centre for Brain and Mind, University of Western Ontario, [2]Lab. of Auditory Neuroscience, University Medical Center Hamburg-Eppendorf, Hamburg

In the first part of this study we examined visual capabilities of adult congenitally deaf cats and adult hearing cats on a wide range of visual tasks in order to define which visual abilities are involved in cross-modal compensation. For tests of visual acuity, contrast sensitivity, direction of motion discrimination, velocity discrimination, and orientation discrimination performance in the deaf cats was not different from that of the hearing cats. However, for two tests of visual detection (movement detection and detection of a flashed stimulus) the deaf cats demonstrated superior performance to that of the hearing cats. For the deaf cats, movement detection thresholds were <0.5deg/sec, while for the hearing cats thresholds were above >0.5deg/sec. At the most peripherally tested positions (≥60 degs), detection of a 100 msec flashed red LED stimulus was significantly better for the deaf cats than for the hearing cats. The second part of this study was to examine if cross-modal reorganization in auditory cortex may be contributing to the superior visual capabilities of deaf cats. To accomplish this, we bilaterally placed cooling loops on AI, DZ, and PAF to permit their individual deactivation. Deactivation of neither AI, nor DZ, altered performance on the movement detection or visual detection tasks. However, bilateral deactivation of PAF resulted in the elimination of the superior visual detection capabilities of the deaf cats and resulted in performance not different from the hearing cats. During bilateral deactivation of PAF, the elimination of superior performance was specific to the visual detection task, deactivation as superior performance did not change on the movement detection task. Therefore, in this study we demonstrate specific superior visual detection abilities in congenitally deaf cats and that cross-modal reorganization in PAF is responsible for some of the superior abilities.

Cortical re-organization and multimodal processing in children with cochlear implants

Anu Sharma

University of Boulder, Co, USA

We are investigating the development and re-organization of the human central pathways in congenitally deaf children who regain hearing after being fitted with cochlear implants. Our measures of cortical development include cortical auditory evoked potentials (CAEP), high density electroencephalography (EEG), magnetoencephalography (MEG) and behavioral responses to auditory, visual, auditory-visual and somatosensory stimulation in the developing brain. In a series of experiments we have established the existence of, and time limits for, a sensitive period for normal development of auditory cortical pathways after cochlear implantation. Cochlear implantation within the sensitive period results in near-normal development of central auditory pathways. When children are implanted after the sensitive period, we find evidence of cortical re-organization. In late-implanted children, somatosensory and visual stimuli activate higher-order auditory areas and processing of auditory stimuli (like speech) involves multimodal areas such as parieto-temporal cortex. Late implanted children show significant deficits in unimodal (A-only & V-only) and multimodal (AV) behavioral processing compared to early-implanted and normal-hearing children. Overall, our results suggest that cortical re-organization occurs after a relatively brief period of deafness early in childhood. Cochlear implantation into a re-organized cortex does not appear to reverse the deficits in multimodal integrative processing caused by sensory deprivation.

Cross-modal reorganization in cochlear implanted deaf patients: A brain imaging PET study

J. Rouger[1], B. Fraysse[2], O. Deguine[1,2], Pascal Barone[3]

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Cochlear implants (CI) are neuroprostheses designed to restore speech perception in case of profound hearing loss. In a recent publication (Rouget et al PNAS 2007), we first demonstrated that deaf cochlear implant listeners developed high speech-reading skills during their period of deafness and maintained it several years after implantation, in spite of the progressive recovery of their auditory functions. Secondly, we showed that CI deaf patients present an over-normal ability to combine auditory and visual information synergistically, i.e. with a better performance than would be predicted by a simple probabilistic combination of the independent sensory streams. To investigate more precisely the neural mechanisms underlying these cross-modal compensations in CI patients, we performed a longitudinal PET study. Cochlear implant patients (n = 11) were scanned few days after the implant onset and less than one year later, at the time their auditory speech comprehension score was greater than 80%. Speech comprehension was screened in visual-only (speechreading) and audiovisual conditions. In cochlear-implant patients, visual speech induced activations of classical fusiform and occipital visual areas, as well as over-activations in associative auditory areas within the posterior STS (known to be involved in phonological processing), and in the right posterior inferior prefrontal region while showing deactivation of Broca's area. Audiovisual speech induced a potentiation of the associative auditory areas, showing an increase in observed activations. Remarkably, the leftward lateralization of speech and language processing observed in control subjects was not present in cochlear-implant patients, who showed a strong right lateralization in the first months following the implant onset. Moreover, as deaf people learn to use their cochlear implant, speech activations evolved to a more balanced lateralization. Taken together, our data show that CI users quickly develop specific strategies of speech comprehension in order to process the coarse information provided by the cochlear prosthesis while the cortical networks involved in audiovisual speech integration underwent a progressive reorganization within a short time period of few months after implantation.

Cross-modal reorganization in deafness: Neural correlates of semantic and syntactic processes in German Sign Language (DGS)

Nils Skotara[1,2], Barbara Hänel[1,3], Monique Kügow,[1,2], Brigitte Röder,[1]

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Sign languages contain the same structural properties as spoken languages (e.g. phonologic, syntactic and semantic elements). The present study investigated, to which extend visual-manual languages activate similar neural systems for both syntactic and semantic processes. Event-related potentials (ERPs) are known to show different patterns after semantic and syntactic violations in spoken languages. We investigated semantic and syntactic aspects of German Sign Language (DGS) with the ERPs. Congenitally deaf native signers of DGS watched movies of naturally signed sentences. Semantic violations (implausible nouns) and syntactic violations (verb-agreement violations) were embedded. Verb-agreement violations elicited a posterior negativity and a P600 whereas semantic violations are followed by a N400. The same participants were investigated with German written sentences with either a semantic (implausible noun) or a syntactic violation (number agreement violation at the verb). After syntactic violations a P600 was observed and semantic violations were followed by a N400. Thus, native signers of DGS display distinct ERP patterns for semantic and syntactic processing, comparable to those observed for spoken German. Moreover, the result pattern for their second language (German) is similar to that of hearing second language learners.

17:00 – 19:00 Poster Session I

Spatial attention operates simultaneously on ongoing activity in visual and somatosensory cortex - largely independent of the relevant modality

Markus Bauer, Steffan Kennett, José van Velzen, Martin Eimer, Jon Driver

Institute of Cognitive Neuroscience

Here we extended previous work on crossmodal spatial attention, using MEG in a visual-tactile paradigm. Covert attention was directed to one side on each trial, via a symbolic central cue, prior to judgement of either only visual or only tactile events on the cued side. In different blocks of trials, either vision or touch was task-relevant. Stimuli on the uncued side and/or in the currently irrelevant modality could be ignored. A single peripheral (tactile or visual) stimulus appeared 800 ms after the central symbolic spatial cue, equiprobably in vision or touch, and equiprobably on the left or right regardless of which side had been cued. In ongoing oscillatory activity we found lateralized effects of attention on activity in the 10-30 Hz range, attributed to somatosensory, parietal and occipital cortex, with enhanced suppression contralateral to the attended side, and less suppression ipsilaterally. These effects peaked shortly before anticipated peripheral stimulus-onset and were found for all regions both when attending vision and when attending touch, providing further information about the potentially supramodal nature of covert spatial attention.

Audio-visual repetition suppression and enhancement in occipital and temporal cortices as revealed by fMRI-adaptation

Oliver Doehrmann[1], Christian F. Altmann[1], Sarah Weigelt[2], Jochen Kaiser[1], Marcus J. Naumer[1]

[1]Institute of Medical Psychology, University Clinics Frankfurt, [2]Department of Neurophysiology, Max-Planck-Institute for Brain Research, Frankfurt

FMRI adaptation (fMRIa) is an experimental tool which provides complementary results compared to conventional neuroimaging paradigms. We combined fMRIa with sparse-sampling to investigate the processing of common audio-visual (AV) objects. Stimuli consisting of animal vocalizations and images were presented bimodally with an adapting stimulus S1 and a subsequent stimulus S2. Four experimental conditions involved in S1 and S2 either 1. the same image and vocalization, 2. the same image and a different vocalization, 3. a different image and the same vocalization, or 4. a different image and vocalization. S1 and S2 were always taken from the same basic-level category (e.g. cat). Auditory and visual repetitions compared to the respective stimulus changes reduced the fMRI signal in regions of the superior temporal gyrus (STG) and the ventral visual cortex, respectively. Additionally, auditory regions particularly in the right STG showed a response profile which suggested an enhanced response to the repetition of visual stimuli. Interestingly, a left lateral occipital region exhibited a similar enhancement for repeated auditory stimuli. These results suggest a complex interplay of human sensory cortices during the processing of repeated AV object stimuli as evidenced by the presence of both suppression and enhancement effects.

Changes of oscillatory activity in the electrocorticogram from auditory cortex before and after adaptation to contingent, asynchronous audiovisual stimulation

Abdelhafid Zeghbib, Antje Fillbrandt, Matthias Deliano, Frank Ohl

Leibniz-Institute for Neurobiology, Magdeburg, Germany

Psychophysical studies have shown that temporal contingencies between acoustic and visual stimuli can induce plastic changes in temporal audiovisual processing. Here we study electrocorticogram (ECoG) synchronization in response to single auditory and visual stimuli before and after adaptation to contingent audiovisual stimulation, consisting of pure-tones and light-flashes presented asynchronously (200ms delay). We applied two modelling approaches based on the assumption that the different elementary frequency signals carry sub-information about the stimuli and that only some of these oscillators respond with increasing energy to stimulation. In the first model the effect of energy attenuation between oscillators is considered, whereas in the second all oscillators are supposed to be equal energy under normalization. We observe that the evoked response is dominated by frequencies in a 7-18Hz band (12,5Hz mean frequency) in the pre-adaptation phase. This is different from the evoked response in the post-adaptation phase which is dominated by oscillations in a 32-43Hz band (37,5Hz mean frequency). Moreover these evoked signals are rather generated by a phase reset of ongoing oscillations. Changes of signal energy in response to the stimulus without phase locking are found in the 60-100Hz band in the pre-, and in the 70-120Hz band in the post-adaptation phase.

Investigating multisensory integration in an osteopathic clinical examination setting

Jorge E Esteves[1], John Geake[1], Charles Spence[2]

[1]Oxford Brookes University, [2]Oxford University

Osteopathic clinical examination is a multisensory experience that requires the integration of visual, tactile, and proprioceptive information regarding the assessment of tenderness, asymmetry, and the restriction of motion and tissue texture changes in the context of presenting symptoms and prior history. In this study, we investigated how osteopaths use their senses in the context of an osteopathic examination. Fifteen participants at different levels of expertise examined one subject with chronic back pain on two separate occasions. The osteopaths had to diagnose a somatic dysfunction in the spine and pelvis. All participants spent significantly more time using vision and touch simultaneously than vision or touch alone. Timecourse analysis revealed an obvious early emergence and subsequent prevalent simultaneous use of vision and touch observed for the expert clinicians. This contrasted with the behaviour displayed by the novices who at the beginning of their examinations seemed unable to focus on more than one sensory modality. The expert clinicians also demonstrated a higher degree of consistency in their diagnoses. These findings indicate that during the development of expertise in osteopathic practice, the integration of visuotactile information may become central to the diagnosis of somatic dysfunction thus contributing to increased diagnostic reliability.

Crossmodal discrimination of object shape

Anna Seemüller, Katja Fiehler, Frank Rösler

Experimental and Biological Psychology, Philipps-University Marburg

Object shape discrimination is dependent on information from visual and somatosensory (tactile and kinaesthetic) modalities. Whereas subjects show precise discrimination for geometric shapes presented visually or through active hand movements, the perception of shape through passively guided hand movements is still to be examined. Here, we investigated unimodal (visual – visual, kinaesthetic – kinaesthetic) and crossmodal (visual – kinaesthetic, kinaesthetic – visual) discrimination for different angles. In a delayed matching-to-sample task, participants compared two movement trajectories either presented visually as moving light point on a screen or kinaesthetically as passively guided hand movement via a manipulandum. Accuracy was measured by an adaptive psychophysical procedure. Shape discrimination was more accurate in the kinaesthetic condition compared to crossmodal conditions and did not significantly differ from the visual condition. Therefore, the kinaesthetic sense seems to be acute enough for sensorimotor control. Overall, crossmodal discrimination was less accurate than unimodal discrimination, independent of the presented angle, indicating an information loss due to the required transfer process.

Interaural time differences affect visual perception with high spatial precision

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Interaural Time Differences Affect Visual Perception with High
The integration of sound and vision is an essential aspect of coherent perception. Salient peripheral free-field sounds improve processing of subsequent visual stimuli that appear at the same site as the sound. However, it is still unclear at what level of processing sounds affect visual perception. We investigated whether sound cues with interaural time differences are sufficient to modulate the perception of upcoming visual targets. Visual targets following sound cues were presented at several horizontal eccentricities. With a short cue-target onset asynchrony, subjects discriminated oriented visual stimuli more accurately at visual field locations that corresponded to the interaural time difference of the preceding sound. Interestingly, visual discrimination at nearby visual field locations remained unaffected by sounds. With long cue-target delays, visual discrimination performance decreased at the cued location but not at nearby locations. Our results suggest direct associations between auditory maps representing interaural time differences and corresponding sites in visual field maps.

Vision, haptics, and attention: A further investigation of crossmodal interactions while exploring a 3D Necker cube

Marco Bertamini[1], Luigi Masala[2], Georg Meyer[1], Nicola Bruno[3]

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To study the time course of the merging of visual and haptic information we recorded the changes over time of a three-dimentional Necker cube which participants explored with their hands. Touch reduces the likelihood of the illusory percept, consistent with a multisensory view of three-dimensional form perception. In addition, when stationary and haptic exploration alternate, transitions from stationary to moving (motion onset) play a crucial role in inhibiting illusory reversals. A temporal analysis of the probability of the illusion occurring after different types of transitions revealed a suppression lasting 2-4 seconds after motion onset (Bruno et al., 2007). In a new study we monitored eye movements and instructed participants about fixation. Although the percept does depend on which vertex is fixated, we ruled out a role of changes of fixation as a mediating factor for the effect of motion onset. In another study we introduced a change of position for the hand as a new type of transition. This type of change did not produce the same inhibition generated by the motion onset. We suggest that motion onset does not simply draw attention towards haptic information. Rather, the influence of haptics peaks briefly after new information becomes available.

Multisensory integration in reaction time: Time-window-of-integration (TWIN) model for divided attention tasks

Adele Diederich[1], Hans Colonius[2]

[1]Jacobs University Bremen,[2]University of Oldenburg

Both manual and saccadic reaction time tend to be facilitated when stimuli from two or more sensory modalities are presented in spatiotemporal proximity and subjects have to respond to the stimulus detected first (redundant target AKA divided attention paradigm). It is commonly accepted that this enhancement is typically larger than predicted by the probability summation effect of a race model. Retaining the notion of a race among stimulus-triggered peripheral activations, the time-window-of-integration (TWIN) model (Colonius & Diederich, JCogN 2004) postulates a first stage of parallel processing followed by second stage of (neural) coactivation and response preparation. A necessary condition for crossmodal enhancement to occur is that the peripheral processes terminate within a given time window. TWIN has been tested in a series of studies (Diederich & Colonius, ExpBrRes 2007, 2008; Perc&Psyphys 2007) where stimuli from one modality were designated as targets and stimuli from the other could be ignored (focused attention paradigm), and the model accounted for variations in spatial configuration, stimulus onset asynchrony, and intensities of targets and non-targets. Here we demonstrate how the TWIN model, within the redundant target paradigm, permits a separate assessment of reaction time enhancement due to probability summation and due to “true” multisensory integration.

Top-down influences on the crossmodal gamma band oscillation

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[1]Nagoya University, [2]Università di Trento

Visuotactile congruency effect has been considered as a behavioral index for the operation of bimodal (visuotactile) neurons in the human brain. Given that the visual receptive field in the bimodal neurons could share tactile receptive map onto the hand, the location information of visual stimulus could disturb localization of the tactile stimulus on the hand. If the bimodal neurons are sub-serving the visuotactile congruency effect and these neurons represent an early sensory representation, then it may be that the process producing the interference is immune from top-down strategic influences. In our study, participants hold a foamed cube in left hand, on which are mounted two tactile vibrators (on the top and bottom of the cube) along with two light emitting diodes (LEDs) adjacent to the vibrators. The task is to respond the elevation of the tactile stimulus (upper or lower) while ignoring the simultaneous visual stimulus. In order to investigate the top-down influence on the visuotactile congruency effect, the proportion of congruent trial was modulated across blocks. Our results suggest that the congruency effect on RT was modulated by the proportion of the congruent trial, also the gamma band activity was correspond to this modulation.

Fast recovery of binaural spatial hearing in a bilateral cochlear implant recipient

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[1]University of Trento, [2]Hospital "Santa Maria del Carmine", Rovereto, [3]Arcispedale "Santa Maria Nuova", Reggio Emilia

Although recent studies have documented that binaural cochlear implantation (CI) can restore spatial hearing, the time-course of such recovery and the role of previous binaural experience remain unclear. Here, we report, for the first time, a different time-course of spatial hearing recovery in two binaural CI recipients that substantially differ in terms of previous binaural experience. Both CI recipients had 5 years of monaural CI experience at the time of activation of the second implant. However, while recipient S.P. became deaf late in life, recipient P.A. became deaf in early childhood. At the time of binaural activation, P.A. was above chance at localizing sounds with both monaural and binaural hearing; on the contrary, S.P. was above chance with monaural hearing only. Strikingly, 1-month after activation, S.P. substantially improved his binaural localisation abilities (at the expenses of monaural ones), while P.A.'s performance remained stable regardless of hearing condition. Results show that recovery of binaural spatial abilities can occur rapidly after bilateral CI. However, deafness onset and duration of previous binaural experience may be critical for such fast plastic changes. Recovery of binaural hearing also conflicts with previously developed localisation abilities with monaural CI, suggesting competing auditory space representations in the brain.

Looming sounds selectively enhance visual excitability

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[1]University of Glasgow, [2]Centre Hospitalier Universitaire Vaudois and University of Lausanne

Approaching objects pose potential threats to an organism, making it advantageous for sensory systems to detect such events rapidly and efficiently. Evidence from nonhuman primates would further suggest that multisensory integration of looming auditory-visual stimuli is enhanced relative to those that recede (Maier et al., 2004). Whether such extends to humans and what brain mechanisms contribute to such effects remain largely unknown. We therefore studied the influence of looming, receding, and stationary sounds on visual cortex excitability; the latter of which was indexed by phosphene detection following single-pulse TMS over the occipital pole (Romei et al., 2007). The pulse was applied at auditory stimulus offset (the duration of which varied) and was fixed at a sub-phosphene threshold intensity (85%). Linear sound intensity changes led to the perception of looming or receding sounds (rising and falling changes, respectively), and control sounds were presented at constant intensity. Visual cortex excitability was dramatically increased by looming relative to either receding or stationary sounds (on average by about 80%), irrespective of the sound duration. This provides novel insight into modulatory, multisensory mechanisms within low-level visual cortex as a basis for efficient visual processing in the presence of auditory looming sounds.

Recognizing the voice but not the face: Cross-modal interactions in a patient with prosopagnosia

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[1]Centre for Vision Research, York University, [2]INSERM Centre for Vision Research, York University, [3]INSERM U455

We tested the interaction of face and voice information in identity recognition in both healthy controls and a patient (SB) who is unable to recognize faces (prosopagnosia). We asked whether bimodal information would facilitate identity recognition in patient SB. SB and controls learned the identities (face and voice) of individuals and were subsequently tested on two unimodal and one bimodal stimulus condition. SB's poor identity recognition with faces only information was contrasted by his excellent performance with voices only information. SB's performance was better in the bimodal conditions compared to that for visual faces alone, however, his performance was worse in the bimodal conditions compared to that for voices alone. Controls demonstrated the exact opposite pattern. For all participants, identity recognition was facilitated with 'new' stimuli from the participant's dominant modality but inhibited with 'new' stimuli from the non-preferred modality. These findings demonstrate perceptual interference from the non-dominant modality when vision and audition are combined for identity recognition suggesting interconnectivity of the visual and auditory identity pathways. Moreover, in spite of an inability to recognize faces due to damage to face identity pathways, residual interconnectivity between voice and face processing interferes with auditory identity recognition.

Investigation of event related brain potentials of audio-visual speech perception in background noise

Axel H. Winneke, Natalie A. Phillips

Concordia University, Montreal, Canada

We investigated event-related potentials (ERPs) to audio-visual (AV) speech in background babble noise. Participants (N=7) randomly perceived single spoken words presented in auditory-alone (A) and visual-alone (V) trials (i.e. lip-reading); and in a combined AV modality. ERPs were recorded to the onset of the mouth movement and/ or sound of spoken object names that participants categorized as natural (e.g., tree) or artificial (e.g., bike). Compared to A- and V-alone trials responses to AV trials were the fastest ($p<.01$) and most accurate ($p<.01$). This AV benefit was accompanied by a smaller amplitude of the auditory N1 ERP component at central sites relative to A-alone trials ($p= .045$) and also relative to the summed response of A and V-alone trials ($p=.033$). The data furthermore indicate a tendency of the N1 to peak slightly earlier during AV (~130ms) compared to A-alone trials (~145ms). The preliminary results imply that adding visual speech cues to auditory speech in a noisy environment enhances early auditory processing, possibly because the lips serve as a visual cue (i.e., attention and/ or complementary visemes) for the auditory system, which thus processes the speech signal more efficiently.

Effect of early visual deprivation on olfactory perception: psychophysical and low resolution electromagnetic tomography (LORETA) investigation.

Isabel Cuevas, Paula Plaza, Philippe Rombaux, Jean Delbeke, Olivier Collignon, Anne G. De Volder, Laurent Renier

Université Catholique de Louvain Paula Plaza

Several studies provided evidence of structural and functional reorganization of the occipital cortex in early blind (EB) people, associated with superior abilities in auditory and tactile tasks. However, little is known about odor perception in this population. The purpose of the present study was to investigate the olfactory capacities, as well as the brain areas recruited during olfactory stimulation, in EB subjects. Methods: Eight EB and eight sighted control participants were tested using the Sniffin's Sticks Test ® and a retronasal olfactory test. The cerebral cartography was obtained by Low Resolution Electromagnetic Tomography (LORETA®) through Event-Related Potentials recorded during olfactory (rose) and trigeminal (CO_2) passive stimulation using an olfactometer. Results: In the psychophysical tests, EB obtained better scores for "threshold perception" ($p=0.017$) and " odor discrimination" ($p > 0.05$). The cerebral cartography showed high activity in the precuneus (BA 7), cuneus (BA 19) and lingual gyrus (BA 18) in EB. Discussion: these findings indicate that EB subjects have an advantage in odor detection (but not in odor discrimination or identification). Furthermore, olfactory passive stimulation induced activation in EB occipital cortex, supporting the principle of functional reorganization of this cortex after visual deprivation, for the olfactory modality.

Effects of tonal organization on synchrony-asynchrony discrimination of cross-modal and within-modal stimuli

Maori Kobayashi, Shuichi Sakamoto, Yo-iti Suzuki

R.I.E.C., Tohoku University

We examined effects of auditory streaming on synchrony-asynchrony discrimination of audio-visual and audio-audio stimuli. Tone sequences were four repetitions of a triplet pattern comprising a low-frequency tone (L) and a high-frequency tone (H). The frequency difference (DF) between L and H was either approximately 0, 1/12, 1/6, 1/3, 1/2, or 1 octave, centered at 1 kHz. Each tone was 33.2 ms. The stimulus onset asynchrony of adjacent tones was randomized. The cross-modal stimulus was a luminance-modulated Gaussian blob. The intra-modal stimulus was white noise. Both stimuli were 8.3 ms. Experiment 1 measured synchrony-asynchrony discrimination limens of blob-tone stimulus onsets using the 2IFC paradigm with a 2-up 1-down method under six DF conditions. Results demonstrated that discrimination improved for flash-tone pulse trains at DF between L and H greater than 1/6 octave. Experiment 2 measured synchrony-asynchrony discrimination limens of noise-tone stimulus onsets using the method described for Experiment 1. Results showed that discrimination declined for noise-tone pulse trains at DF between L and H greater than 1/6 octave. Although the directions of the effects of streaming differed between cross-modal and intra-modal perception, these results suggest that the same system of auditory streaming influences synchrony perception within and across modalities.

Are brain areas assigned to proprio-tactile integration of one's own movement perception?

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Somesthetic messages from muscle and skin receptors contribute together to the perception of one's body movement. Here we investigated whether cerebral networks are involved in the integrative processing of these two sensory inputs for movement perception. For this, we designed an amagnetic device able to generate (clockwise) hand movement illusions from separate or combined tactile and muscle proprioceptive stimulations. Stimulations were delivered through a vibrator applied to the subjects' wrist adductors and a rotary disk set under the palm of their hand. Results show that, whether induced by a tactile or a proprioceptive stimulation, the kinesthetic illusion was accompanied by the activation of a very similar cerebral network including cortical and subcortical sensori-motor areas classically found in passive or imagined movement tasks. Moreover, as expected, the strongest kinesthetic illusions occurred under the combined stimulation condition. They were specifically associated to brain area activations in the inferior parietal lobule, the superior temporal sulcus, the insula-claustrum region, and the cerebellum. These findings support the hypothesis that heteromodal areas may subserve multisensory integrative mechanisms and suggest that the detection of the spatial coherence and of the temporal coincidence between these two kinesthetic messages might involve different cortical and subcortical brain zones.

Effects of visual-auditory stimulus onset asynchrony on auditory event-related potentials in a speech identification task

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In natural situations such as audio-visual speech, visual (V) events often precede auditory (A) events. With N=17 normal hearing individuals we systematically manipulated the V to A stimulus onset asynchrony (SOA) in a speech phoneme identification task. SOA varied from 0 to 100ms in 20ms steps, enabling us to assess the impact of SOA on task performance. We recorded EEG from 68 channels while subjects performed the task, and analyzed differences in auditory evoked potentials (AEPs) between AV and A+V conditions. Behavioral effects were broadly in line with our previous results (Thorne & Debener, in press, Neuroreport), showing an improvement in response times to audiovisual stimuli across a range of SOAs when compared to auditory alone controls ($F=2.2$, $p=.05$). Greatest improvement was found at SOA = 80ms ($F=5.5$, $p<.04$). ANOVA of the AEP P2 latencies revealed significant main effects of SOA ($F=13.7$, $p<.0001$) and condition (AV versus A+V; $F=14.9$, $p<.002$), and a significant SOA-by-condition interaction ($F=3.2$, $p<.02$). Largest AV-(A+V) difference (9ms) was found specifically at SOA = 80ms ($t=4.2$, $p<.001$). We conclude that audio-visual integration may be optimally facilitated at certain delays, which may be related to the perceived distance of an object.
measurements.

Measurement for tactile sensation

Fei Shao

The feel of films, wrapping paper, cardboards and other packaging materials are important to the commercial success of foods wrapped in them. It is known from people's self-report study that different surfaces do provoke different subjective responses. There are several mechanical parameters, including friction, vibration, compliance and thermal properties, which are important with respect to the sensory feel. This paper describes the design, construction and use of a novel measurement system for tactile sensation that can be used to evaluate the feel of different packaging materials. Experiments were conducted by sliding or pressing an artificial fingertip with embedded sensors against the surfaces of different samples which were fixed on a force table. The friction coefficients, frequencies of vibration, compliance and rates of change of temperature were obtained. Further, 30 volunteers were invited to touch the samples and complete questionnaires about how they felt about them. Strong correlations were found between the people feelings and the physical

Recalibration of ponetic categories by lipread speech: Measuring aftereffects after a twenty-four hours delay

Martijn Baart, Jean Vroomen

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Listeners hearing an ambiguous speech sound flexibly adjust their phonetic categories in accordance with lipread information telling what the phoneme should be (recalibration). Here, we tested the stability of lipread-induced recalibration over time. Listeners were exposed to an ambiguous sound halfway between /t/ and /p/ that was dubbed onto a face articulating either /t/ or /p/. When tested immediately, listeners exposed to lipread /t/ were more likely to categorize the ambiguous sound as /t/ than listeners exposed to /p/. This aftereffect dissipated quickly with prolonged testing and did not reappear after a 24 hours delay. Recalibration of phonetic categories is thus a fragile phenomenon.

Multisensory processing in the nematode C. elegans

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MRC-LMB

In natural world, it is necessary that animals can not only respond to various stimuli, but also change the way of response according to context. The nervous system of C.elegans consists of 302 neurons, and all the synaptic connections were described at EM resolution. Ease of genetic manipulation and the transparent body make it possible to control/monitor activity of specific neurons in vivo with genetically-encoded tools. Despite simplicity, its nervous system generates various behavior including taxis, avoidance and learning. All these characteristics make C.elegans a good model to study multisensory processing in its simple form, at multiple levels from gene to behavior. We are studying how sensory stimuli affect the nervous system of C.elegans, and how those changes affect sensory processing in other modalities. As input, we use ‘real’ sensory stimuli, and also light-induced direct activation of sensory neurons using channelrhodopsin-2, allowing precise control. To analyze effects of inputs, behavioral quantification and live-imaging with genetically-encoded calcium indicators are used. Preliminary results showed that sensory stimuli can transiently activate the nervous system, and during that period response of worms to other stimuli is promoted. In future we will characterize these changes further in cellular, behavioral and genetic levels.

Adaptive reversal of sensorimotor timing across the senses

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Recent work has shown that the perceived time of motor actions and subsequent visual events can be markedly influenced by recent experience. When observers become accustomed to a delay between motor action and visual event, subsequent events presented with a reduced delay appears to precede the causative motor action (an illusory reversal of perceived temporal order of motor action and related sensory event) (Stetson et al, 2006; Cunningham et al, 2001). However, it remains to be seen if such a fundamental error of temporal order perception also occurs if this effect occurs in the auditory-motor or tactile-motor domains. Here, we replicate earlier work in the visual domain, and extend this by measuring comparable misperceptions of sensorimotor time in the auditory and tactile domains. We demonstrate that the illusion exhibits similar temporal tuning characteristics in all three sensorimotor pairings, with comparable levels of sensitivity to sensorimotor temporal order in all conditions. In conclusion, we demonstrate that illusory reversal of perceived temporal order of motor action and subsequent sensory event is not peculiar to vision, and suggest that a single neural mechanism may mediate the observed effects in all three sensorimotor pairings. References Stetson et al. (2006). Motor-Sensory Recalibration Leads to an Illusory Reversal of Action and Sensation. Neuron 51, 671-679. Cunningham et al. (2001). Sensorimotor adaptation to violations of sensorimotor contiguity. Psychological Science 12 (6), 532-535.

The perceptive location of a touch shifts with eye position

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York University

Eye position is known to affect the perceived location of auditory and visual stimuli. Here, we tested for an effect of eye position on the perceived location of a touch on the forearm. Subjects fixated one of four target lights. Between 100 and 450 ms after the target light was turned off, subjects received a touch at one of four locations along the forearm. The forearm was arranged horizontal in front of the subject. Subjects indicated the location of the touch by pointing to its location with their other hand. They then identified the location of the point using illuminated rulers. When subjects fixated to one side of the midline, the perceived position of touches shifted to the same side (maximum displacement: elbow = 1.80 cm; mid-forearm = 3.79 cm; wrist = 3.40 cm). The amount of shift also correlated with variations in tactile acuity along the (variance: elbow = 13.5 cm; mid-forearm: 32.0 cm; wrist = 30.5 cm): locations with less tactile acuity were more affected by eye position. The effect of saccades on tactile localization was also tested. Unlike for visual stimuli, there was no systematic shift in the position of the touch around the time of a saccade.

Visual, tactile and visuo-tactile perception of acceleration and deceleration

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Psychophysical studies suggest that the human visual system is more sensitive to speed than acceleration (the temporal derivative of velocity). Although there exist some studies on visual perception of acceleration and deceleration, very few exist for tactile discrimination and none for visual-tactile perception of acceleration. In this study we investigated visual, tactile and bimodal perception of acceleration-deceleration by measuring speed discrimination over a wide range of transient speeds (from 6.8 to ~ 454 cm/sec²). The stimuli were physical wheels etched with a 10 c/deg sinewave profile that could be seen, felt or seen and felt at the same time. Subjects were presented in two separate intervals the standard stimulus, of fixed of 13 cm /sec and the comparison test which a stimulus which arrived at different final velocities with maximal acceleration (454 cm/sec²). Subjects were required to evaluate in 2AFC protocol which interval contained the faster movement, using only visual, only tactile or bimodal information. We found similar PSEs among visual, tactile and bimodal tasks considering all the different accelerations. Moreover we investigated the difference between deceleration and acceleration and the integration of bimodal signals characterized by opposite direction of motion. Our results suggest that transient velocity signals are analyzed in a similar way by visual and tactile systems.

Audiovisual speech perction in Asperger Syndrome

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Asperger syndrome (AS) is a lifelong developmental disorder of social interaction and behaviour. It belongs to the continuum of autism spectrum disorders (ASD). Individuals with ASD are reported to have difficulties in interpreting sensory information, but the research information on the topic, especially of multisensory perception, is still sparse. Speech is a good example of multisensory process. In the present study we studied audiovisual speech perception by utilising the McGurk effect in which conflicting visual articulation alters perception of heard speech. Furthermore, as atypical use of eye gaze is a feature in ASD, we registered eye gaze during speech perception (recognition of consonants /k/, /p/, /t/) in 16 adult individuals with AS. Results were compared with age, gender and IQ (WAIS-R) matched control group. The preliminary analysis suggests that it was more difficult for individuals with AS to read visual speech and especially, they were less influenced by visual speech in the audiovisual condition. Furthermore, according to the preliminary analysis, AS group focused less on the mouth area, during the speech recognition task.

Voice, face and speech motion: interactions in person recognition

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In this study we aimed at verifying the influence of face-voice association in personal identity recognition without familiarity. By means of two experiments, we assessed the effect of task-irrelevant stimuli in unimodal recognition of faces and voices and the influence of speech motion. In Experiment 1 participants memorized a list composed either of unimodal or bimodal items. During the presentation of a more extended test list, always unimodal (voices or faces, depending on the experimental group), they were asked to recall the items previously presented. Results indicate that voice recognition is negatively affected by bimodal encoding, while face recognition is not. When subjects are explicitly required to pay selective attention to a specific modality during the encoding phase, we found that also voice recognition is unaffected by bimodal encoding. In Experiment 2 participants memorized a list of dynamic stimuli (talking faces). They were required to recognize stimuli in more extended sequences of items crossing unimodal/bimodal and dynamic/static conditions. In dynamic conditions (unimodally and bimodally) performances are always higher than in static ones. Altogether, our results are consistent with a model of independent face and voice processing in person recognition without familiarity. Moreover, speech motion positively affects person recognition.

Multimodal integration in the estimation of walked distances

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When walking through space, both, dynamic visual information (i.e. optic flow), and body-based information (i.e., proprioceptive/efference copy and vestibular) jointly specify the magnitude of a distance travelled. While recent evidence has demonstrated the extent to which each of these cues can be used independently, relatively little is known about how they are integrated when simultaneously present. In this series of experiments, participants first travelled along a predefined distance and subsequently matched this distance by adjusting an egocentric, in-depth target. Visual information was presented via a head-mounted display and consisted of a long, richly textured, virtual hallway. Body-based cues were provided either by walking in a fully-tracked, free-walking space or by walking on a large, linear treadmill. Travelled distances were provided either through optic flow alone, body-based cues alone (i.e. blindfolded walking), or through both cues combined. In the combined condition, visually-specified distances were either congruent (1.0x) or incongruent (0.7x or 1.4x) with distances specified by body-based cues. The incongruencies were introduced either by changing the visual gain during natural walking or the proprioceptive gain during treadmill walking. Responses reflect a combined effect of both visual and body-based information, with an overall higher influence of body-based cues.

Tactile and learning abilities in early and late-blind subjects

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Over life-span tactile perception undergoes many changes either caused by altered use or by age. We here address the question how enhanced hand use in blind subjects affects tactile acuity and tactile learning abilities. We tested 4 groups of young and old early and late-blind subjects and compared them to age-matched control groups of sighted people. A static two-point discrimination task was used to measure tactile acuity on the index fingers of both hands. To induce learning processes we applied a tactile stimulation protocol to the tip of the Braille-reading finger. This so-called coactivation protocol is based on Hebbian Learning and has been shown to drive substantial improvement of tactile acuity in young and elderly subjects. Young blind and sighted subjects showed only little differences in their discrimination thresholds, whereas tactile acuity thresholds in elderly were much higher in sighted than in blind people. The improvement in tactile acuity induced by coactivation was largely confined to elderly late-blinds. The results are discussed in relation to preservation of high levels of tactile acuity at high age, and in respect to consequences of learning-induced improvement of tactile acuity in blind subjects.

Motor learning affects neural processing of visual perception

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We investigated whether motor experience with artificial movement trajectories of meaningless objects affects how these trajectories are later perceptually processed within the human brain. During observation of artificial object movements ten participants (experimental group) actively imitated the trajectories during motor training and ten participants (control group) solved a working-memory task without motor training. Using functional magnetic resonance imaging, hemodynamic responses were recorded before and after the intervention while participants observed the movements and either had to detect color changes of the objects (color task, motor-irrelevant) or had to judge whether the movement pattern could be imitated with human hands (simulation task, motor-relevant). The between group comparison of the post-intervention hemodynamic responses revealed stronger activity for the motor training than for the control group in motor-related areas (supplementary motor area, inferior parietal lobe) during the simulation but not during the color task. The control group did not reveal any stronger activity than the motor training group for either task. The results suggest that motor training has task specific effects on neural processes that are involved in perception of movements and indicate that motor-related areas can be triggered by observed artificial object movements but only if a motor-relevant task is pursued.

The cortical network for high-level audio-visual object processing mapped with sogICA

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In light of the ongoing debate on multisensory processing in the human brain, we employed spatial self-organizing group independent component analysis (sogICA) on an fMRI data set acquired during a passive audio-visual (AV) experiment with common object stimuli. Two independent components (ICs) were initially designated as unisensory auditory and visual, respectively, based on their spatial layout and their activation time course. However, in addition to their main clusters both ICs also comprised regions traditionally considered to belong to the other sensory modality. To explicitly test these regions-of-interest (ROIs) for their potential involvement in object-related AV processing, we conducted a second AV experiment. We found object-related AV integration effects (MAX-criterion: 0V>0) in left occipito-temporal cortex, right posterior superior temporal sulcus (pSTS), and bilateral inferior frontal cortex (IFC). The additional manipulation of crossmodal congruency in this experiment revealed a parametric preference for incongruency (congruent < incongruent within categories < incongruent between categories) in the same IFC ROIs as well as in bilateral posterior parietal cortex. This clearly demonstrates the particular value of IC maps in the context of crossmodal object processing, as they represent the underlying functional connectivity, which is of prime importance especially for higher-order processing along the multisensory hierarchy.

Are common consequences sufficient for visual-haptic integration?

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Integration of information across sensory modalities helps to increase the accuracy of perceptual judgements. However, if two signals do not share a common cause, they should be recognized as independent signals and therefore be processed separately. The causal inference model (Körding & Tenenbaum, 2006) suggests a continuous transition from integration to separate processing which is influenced by the likelihood of a common cause. Here we asked whether subjects are able to integrate visual and haptic signals that do not share a common cause but a common consequence. We present an experiment where subjects performed goal-directed pointing movements. The position of the goal had to be inferred from both visual and haptic information, presented during movement execution. We varied the temporal distance between the signals to either facilitate or hinder the integration process. We expect an improvement in pointing accuracy if the information contained in both signals is integrated. In contrast to perceptual cue integration the signals are not intuitively belonging together but have to be integrated actively. Only 2 out of 6 subjects showed the expected increase in pointing accuracy under simultaneous presentation of visual and haptic information. Successive presentation performance was not worse than simultaneous presentation performance.

Temporal-nasal asymmetry in multisensory integration mediated by the superior colliculus

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Università degli Studi di Bologna

Temporo-nasal asymmetry in visual responses have been attributed to the anatomical asymmetry of fibres projecting to the Superior Colliculus (SC), even though this attribution is debated. The present study investigates temporo-nasal asymmetry in multisensory integration, and, by exploiting the absence of S-cone input to the SC, measures a behavioural response dependent strictly on the activity of the SC itself. We used a redundant signal paradigm for simple reaction times, with visual stimuli (red or purple) presented in either the temporal or the nasal hemifield. Participants responded quicker to concurrent audiovisual stimuli than to either an auditory or a visual stimulus alone, a phenomenon known as Redundant Target Effect (RTE). The nature of this effect was dependent on the colour of the visual stimuli, suggesting its modulation by collicular circuits. When spatially coincident audiovisual stimuli were visible to the SC (red stimuli), the RTE depended on a neural co-activation mechanism, suggesting an integration of multisensory information. When using stimuli invisible to the SC (purple stimuli), the RTE depended only on a simple statistical facilitation effect, in which the two sensory stimuli were processed by independent channels. Finally, we demonstrate that the multisensory integration effect was stronger for stimuli presented to the temporal than to the nasal hemifield.

Sound can enhance visual representational momentum

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Fellow Representational momentum is a phenomenon in which the remembered final position of a moving target is displaced in the direction of motion. This phenomenon has been reported in both the visual and auditory modalities. Here we investigated the crossmodal effect: the effect of concurrent sound on visual representational momentum. A visual target smoothly moved towards a center of the CRT display from left or right side, and disappeared at unpredictable positions. Participants judged whether a probe presented 500 ms after the target's offset was to the left or right of the target's final position. There were three sound conditions: no sound, constant noise, and "approaching noise" which had dynamic interaural time- and level-difference cues and whose overall intensity increased as the visual target approached the center of the display. Observed displacements were significantly larger for visual targets with approaching noise than those with no sound or constant noise. In the following experiment, we found that perceived velocity of the visual target was not correlated well with difference in displacement between the conditions. We speculate that relevant sound may enhance perceived fidelity of a moving visual object on the display, and consequently strengthen motion perception in the visual modality.

Does sound location influence reaction times to audiovisual speech?

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In IMRF2006 we showed that audiovisual speech perception can be influenced by sound location, depending on the direction of spatial attention. Auditory attention was manipulated by varying the probability of auditory stimulus presentations from different locations (centre, i.e. face location, and 45/90 deg left/right). Attention was directed spatially by presenting the majority (90%) of auditory stimuli from one location. In Experiment 1, the major location was in the centre, which resulted in an enhanced McGurk effect (i.e. conflicting visual speech altered the auditory speech percept) in the centre. In Experiment 2, the major location was 90 deg left, which resulted in a stronger McGurk effect on the left and centre relative to the right side. Now, we show that reaction times in this experiment are affected, too, so that for congruent audiovisual stimuli (matching visual and auditory speech) they are overall shorter than for McGurk stimuli, and specifically they tend to be shorter in the attended location. This suggests that processing speed of matching audiovisual information is faster, and more sensitive to the manipulation of spatial attention than that of conflicting audiovisual information.

Visual information integration is not strictly additive: The influence of depth cue consistency

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Additive reliability-based models have been successfully used to describe multisensory integration. More recently, these models which disregard potential influences of cue consistency were also applied to predict intrasensory integration of visual depth cues. The current study aimed at investigating whether interactions among visual cues affect their integration. Observers judged the depth of hemicylinders that were defined by stereoscopic disparity, shading, and texture gradients that could be manipulated independently. By using a novel multiple-observation task, single-cue weights and observer sensitivity were estimated for conditions with reduced reliability of single cues as well as for pairwise cue consistencies. Less reliable cues were found to be downweighted in the combined percept which is in accordance with reliability-based cue integration schemes. Moreover, a specific influence of cue consistency was revealed. When shading and disparity indicated a consistent depth of the stimulus, the weight of the texture cue was reduced while d' increased above the predictions of additive integration rules. Thus, shading and disparity seemed to be processed interactively. These results suggest that cue combination in visual depth perception is highly flexible and depends on single-cue properties as well as on interrelations among cues.

Synaesthetic correspondence modulates audiovisual temporal integration

Cesare Valerio Parise, Charles Spence

University of Oxford

The synaesthetic congruency between auditory and visual stimuli has been shown to modulate people's performance in speeded classification tasks, in which they have to classify stimuli in one modality whilst simultaneously trying to ignore concurrent stimuli presented in another (irrelevant) modality. In this study, we used psychophysical procedures to demonstrate that the association between auditory pitch and visual size can influence audiovisual integration in the temporal domain. In Experiment 1, the implicit association test (IAT) was used to verify the synaesthetic association between the proposed audiovisual dimensions. In Experiment 2, we investigated whether these synaesthetic associations would modulate the precision of participants' temporal order judgments (TOJs) in a temporal ventriloquism task. Participants judged the temporal order of the stimuli more accurately on those trials where the temporally proximate auditory and visual stimuli were synaesthetically congruent, than on those trials where there was no such congruency. These results provide the first empirical evidence that audiovisual temporal integration is modulated by the synaesthetic congruence between auditory and visual stimuli.

My third arm: Shifts in topography of the somatosensory homunculus predict feeling of an artificial supernumerary arm

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The classic understanding of the role of the primary somatosensory cortex (SI) is to be a first major unimodal area processing somatosensory input and reflecting the physical location of peripheral stimulation in the form of the famous homunculus. Whereas in the past this functional topography was believed to be fixed, recent studies challenge this view. The present study aims to further explore the role of SI by creating an illusion of feeling a supernumerary artificial limb. Using an artificial hand and arm that were connected to their body, subjects were given the visual impression that they had a supernumerary third arm. The topography in SI was examined with neuromagnetic source localization. Results revealed that the participants not only viewed the artificial arm but felt to have three arms. Furthermore, during the illusion the cortical representation of the thumb shifted to a more medial and superior position. Since this modulation in SI could predict the strength of the feeling that the third arm was belonging to the own body, the results suggest that the somatosensory homunculus is reflecting the perceived shape of the body rather than physical aspects of peripheral stimulation even when feeling an artificial third arm.

Multisensory enhancement in the optic tectum of the barn owl: Spike count and spike timing.

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The specialization of the barn owl in hunting small prey in dimly lighted and acoustically noisy environments provides us with an attractive model for studying cross-modal integration. In the present work we studied responses of multisensory neurons in the barn owl optic tectum (the avian homolog of the superior colliculus) to visual, auditory and bimodal stimuli. We specifically focused on responses to long sequences of repeated stimuli. We first report that bimodal stimulation tends to elicit more spikes than in the responses to its unimodal components (a phenomenon known as multisensory enhancement). However, this tendency was found to be history-dependent, multisensory enhancement was mostly apparent in the first stimulus of the sequence and to a much lesser extent in subsequent stimuli. Next, a vector strength analysis was applied to quantify the phase locking of the responses to the stimuli. We report that in a substantial number of multisensory neurons responses to sequences of bimodal stimuli elicited spike trains that were better phase locked to the stimulus than spike trains elicited by stimulating with the unimodal counterparts (visual or auditory). Therefore, multisensory enhancement can be manifested in phase locking to the stimulus rather than more spikes.

Model of human's audiovisual perception using Bayesian networks

Patricia Besson, Christophe Bourdin, Gabriel M. Gauthier, Lionel Bringoux, Daniel Mestre, Jonas Richiardi, Jean-Louis Vercher, Antje Fillbrandt

When exposed to acoustic and visual stimuli, human observers may perceive them as originating either from a common or from distinct sources. Audiovisual perception includes both integration and segregation effects whose importance in the final percept depends on the stimuli spatio-temporal synchrony. This phenomenon has been studied through perception tasks, where a stimulus in one modality may be perturbed by another stimulus in the other modality [1-2]. The authors have inferred some probabilistic relationships between the emitted and the reported stimulus location. We have performed a similar experiment to study and model these audiovisual integration and segregation phenomena. Subjects, seated in a dark room, were exposed to acoustic and visual stimuli presented either alone (unimodal case) or together (bimodal case). In the latter case, the stimuli co-occurred in time but not necessary in space. The subjects had to report the location of the visual or acoustic stimulus using a manual pointer connected to a potentiometer. The singularity of our work was to use Bayesian networks [3] to build a consistent model where a graph structure is learned from the data. This structure states the dependencies between random variables modeling the events (such as the emitted and perceived stimulus locations). The corresponding probabilistic relationships are then inferred. [1] Konrad P. Körding, Ulrich Beierholm, Wei Ji Ma, Steven Quartz, Joshua B. Tenebaum, and Ladan Shams. Causal inference in multisensory perception. PLoS ONE, 2(9):e943, September 2007. doi:10.1371/journal.pone.0000943. [2] Neil W. Roach, James Heron, and McGraw Paul V. Resolving multisensory conflict: a strategy for balancing the costs and benefits of audio-visual integration. In Proceedings of the Royal Society B: Biological Sciences, volume 273, pages 2159–2168, June 2006. doi: 10.1098/rspb.2006.3578. [3] Christopher M. Bishop. Pattern Recognition and Machine Learning. Springer, 2006.

Audiovisual speech perception: Examining the McGurk illusion by fMRI at 7 Tesla

Gregor Rafael Szycik[1], Jörg Stadler[2], Thomas F Münte[3]

[1]Medical School Hannover, [2]Leibniz Institute for Neurobiology, [3]Otto von Guericke University

In natural communication speech perception is profoundly influenced by observable mouth movements. This additional visual information facilitates considerable the intelligibility. Furthermore audiovisual (AV) incongruent (auditory stream does not match the articulatory movements) artificial speech may lead to novel percepts that neither match the auditory nor the visual information as evidenced by the McGurk effect. The recent "hypothesize-and-test" model of AV speech perception accentuates the role of both speech motor areas and the integrative brain sites in the vicinity of superior temporal sulcus (STS). In this event related 7 Tesla fMRI study we used three naturally spoken syllable pairs (BA, GA, DA) with matching AV information and one syllable pair designed to elicit the McGurk illusion (mcDA). The data were analysed by calculating linear contrasts including the comparison of mcDA vs. DA respectively BA and GA. Illusory syllables elicited grater brain activity than naturally spoken syllables. Furthermore, there were hemispheric differences in functional organisation of STS: the left STS showed two clusters processing auditory respective visual differences, whereas the right STS harboured both of these functions in one cluster. Our data supports and extends the model by showing hemispheric differences in processing AV speech.

Adaptation to auditory motion produces direction-specific speed aftereffects

Ross W. Deas, Neil W. Roach, Paul V. McGraw

The University of Nottingham

It is currently unclear whether the auditory system contains mechanisms dedicated to processing motion information, analogous to those known to exist in the visual system. If so, the auditory system should demonstrate selectivity to velocity, and its scalar components (direction and speed). In the visual domain, motion adaptation results in direction-specific changes in perceived speed. Here we investigated whether similar effects can be elicited using moving auditory stimuli. Auditory motion in the horizontal plane was simulated using individually measured head-related-transfer functions. Subjects adapted to unidirectional auditory motion (60s initially, 10s top-up between trials), after which they judged the relative speed of sequentially presented reference and test stimuli moving in opposite directions. Three interleaved reference speeds (8, 16 and 24 deg/s) were used for each adaptor speed (8, 16 and 24 deg/s). To obviate the use of spatial or temporal cues in isolation, the duration of each test stimulus was randomly jittered. Results revealed a systematic reduction in the perceived speed of stimuli moving in the adapted direction, the magnitude of which increased with adaptor speed. These results are compatible with the hypothesis that both the auditory and visual systems directly encode motion information.

Cortical plasticity of audiovisual mass action

Kentaroh Takagaki, Frank W.Ohl

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Many brain regions are now known to respond to input from multiple sensory modalities1. Even primary sensory areas, which were previously thought to respond almost exclusively to area-specific inputs, are now known to reflect multimodal sensory input. These multimodal responses manifest as either physiological response to non-area-specific stimulation alone, or as modulatory enhancement of the area-specific response by non-area-specific stimulation. However, it is unknown whether such multimodal responsivity is modulated by sensory experience. Here we show that multimodal population activity can be altered by patterned audiovisual input. By using voltage-sensitive dye imaging in the Mongolian gerbil (Meriones unguiculatus), we demonstrate that trains of patterned audiovisual stimulation can alter the spatial distribution, propagation patterns and magnitude of population mass action in the mammalian cortex. This modulation depends upon timing contingencies of the auditory and visual stimuli within the patterned stimulus trains. Our results demonstrate, for the first time, that sensory input can induce plasticity in the spatial organization of cortical mass action. These results further suggest that propagating patterns of population mass action may play a role in integrating information from multiple sensory modalities.

Audiovisual category transfer in rodents, an electrophysiological study of directional influences between auditory and visual cortex

Fillbrandt, A., Deliano, M., Ohl, F.W.

Leibniz-Institut für Neurobiologie

Audiovisual category transfer in rodents, an electrophysiological study of directional influences between auditory and visual cortex
A basic process in the build up of conceptual knowledge is the formation of categories by abstraction of shared features from specific sensory experiences. Here we investigate whether perceptual categories formed in the auditory modality can be transferred to the visual modality. We trained Mongolian Gerbils in a shuttle-box to discriminate two different rates of stimulus presentation first in the auditory, and then in the visual modality using a GO/NO-GO active avoidance paradigm. For one animal group (congruent group), the contingency of stimulus rates and responses was maintained from auditory to visual training, for a second group (incongruent group) contingency was reversed. After the modality switch, the congruent group had a higher acquisition rate of the conditioned responses than the incongruent group indicating a transfer of the rate-response contingency from auditory to visual training. During training local field potential activity was recorded from 20 depth electrodes chronically implanted in the primary auditory and visual cortices. Directional influences between auditory and visual cortex were analyzed by the Directed Transfer Function (Kaminski & Blinowska, Biological Cybernetics, 1991). Behavioral indications for a crossmodal transfer correlated with a higher rate of occurrence of peak values of the Directed Transfer Function in the gamma frequency range.

The relevance of multisensory learning in foreign language learning for adults

Felicitas Kroeger

There is a rising amount of publications which consider multisensory learning as an elementary and indispensable element of foreign language learning in primary classes and underline its positive effects on the learning process. Children are supposed to learn a new language far better by having 'all' their senses being addressed in class. However, there has only very little been published on multisensory language learning and respective methods in foreign language classes for grown-ups - especially if it comes to learning grammar. It lacks convincing empirical research in this field. Therefore, my thesis is going to aim at having a closer look at multisensory language learning in English classes for adults with an emphasis on grammar and tenses. The project that has been running in several classes of some German Volkshochschulen is meant to make clear in how far multisensory learning is relevant and helpful in foreign language classes in adult education.

Hearing cheats tactile deviant-detection: An event-related potential study

Kirsten Hötting, Claudia K. Friedrich, Brigitte Röder

Biological Psychology and Neuropsychology, University of Hamburg

When a single tactile stimulus is presented together with two tones, participants often report perceiving two touches. The present study used an oddball paradigm together with event-related brain potential (ERP) recordings to investigate the neural correlates of this multisensory illusion. ERPs were recorded while rare single tactile stimuli accompanied by two tones (1T2A) were presented amongst frequent tactile double stimuli accompanied by two tones (2T2A). Although participants were instructed to ignore the tones and to respond to single tactile stimuli only, they often failed to respond to 1T2A stimuli ("illusionary double touches", 1T2A(i)). ERPs to "illusory double touches" vs. "real double touches" (2T2A) differed 50 ms after the (missing) second touch. This indicates that at an early sensory stage, illusory and real touches are processed differently. On the other hand, although similar stimuli elicited a tactile mismatch response (MMN) between 100 and 200 ms in a unisensory tactile experiment, no MMN was observed for the 1T2A(i) stimuli in the multisensory experiment. “Tactile awareness” was associated with a negativity at 250 ms, which was enhanced in response to correctly identified deviants as compared to physically identical deviants that elicited an illusion. Thus, auditory stimuli seem to alter neural mechanisms associated with automatic tactile deviant-detection.

Multisensory interactions between the endogenous and exogenous orienting of spatial attention

Valerio Santangelo[1], Marta Olivetti Belardinelli[2], Charles Spence[3], Emiliano Macaluso[1]

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The neural basis of spatial attentional control have mostly been examined within a unimodal setting while presenting separate blocks of exogenous and endogenous trials. Here, we investigated this issue in a more ecological manner by using a spatial double-cuing paradigm in a multisensory setting. Participants discriminated the elevation (up/down) of a visual target equiproblably presented to either side of fixation. Targets were preceded by a central-symbolic, spatially-predictive visual cue voluntarily driving their attention to one side, followed by a peripheral, spatially-nonpredictive auditory signal designed to reflexively capture their attention. We found that the typical cost in responding to invalid as compared to valid exogenous and endogenous signals was associated with the activation of superior parietal and dorsal fronto-parietal cortical areas, respectively. However, greater activations within these separate neural systems were found when both cues required an attentional shift (i.e., they were both invalid). Furthermore, a greater contralateral extrastriate response to the target was observed in valid trials when both cues coherently indicated the side of target occurrence. Altogether, these results highlight the existence of separated-but-interacting neural circuits for the multisensory control of spatial attention, showing how endogenous/exogenous multisensory signals jointly interact to control the locus of our attention in space.

Auditory-Visual and Tactile-Visual Temporal Recalibration

Mirjam Keetels, Jean Vroomen

Tilburg University

It is known that the brain adapts to small (~100 ms) auditory-visual (AV) temporal asynchronies so as to maintain intersensory temporal coherence (Vroomen et al, 2004). Here we explored whether the effect also occurred for tactile-visual (TV) pairs and whether spatial disparity between A and V affects temporal recalibration. Participants were exposed to a train of asynchronous AV or TV stimulus pairs. Following a short exposure phase, participants were tested on an AV and TV temporal order judgement (TOJ) task. Temporal recalibration manifested itself as a shift of subjective simultaneity in the direction of the adapted lag. The shift was equally big for AV and TV stimulus pairs (Keetels and Vroomen, 2008), and for when exposure and test stimuli were presented from the same or different locations (Keetels and Vroomen, 2007). These results provide evidence for the idea that temporal recalibration is a more general phenomenon that maintains appropriate on timing between the senses. Moreover, spatial co-localisation is not necessary for intersensory pairing to occur.

Auditory footsteps affect visual biological motion orientation detection

Ana Catarina Mendonça, Jorge Almeida Santos

Universidade do Minho

This study investigated audiovisual interaction in the perception of the direction of biological motion using Point-Light-Walkers (PLW). It continues the work of Vanrie, Dekeyeser & Verfaillie (2004) about the bistable character and the perceptual bias of PLW, which has shown that ambiguous PLW are preferably interpreted as being oriented towards the viewer. Each participant made judgements about the direction of a PLW's motion in three conditions: visual, audiovisual and auditory. It was found that the auditory footsteps simultaneous and congruent with the visual representations diminished but didn't eliminate the visual bias. The reaction times reveal a strong bimodal facilitation effect, even when both stimuli could be interpreted as incongruent.

Searching for the talking head: The cocktail party revisited

Agnès Alsius[1], Salvador Soto-Faraco[2]

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Everyday life environments are characterized by a continuous flow of information arriving to our brains from different senses. A crucial question in multisensory research is how all these pieces of sensory information are organized, selected and integrated in a coherent representation of the world. Some authors have claimed that correlated multisensory information is bound pre-attentively, whereas other findings indicate that attention might play a crucial role during binding. Here, we used a visual (Experiments 1-4) and auditory (Experiments 5 & 6) search paradigm to explore whether audiovisual matching of natural stimuli (i.e., talking faces) occurs prior to the allocation of spatial selective attention. In Experiments 1-4, silent video-clips of four faces simultaneously speaking were presented along with one single auditory message. Participants were required to search for the face whose lips corresponded to the auditory sentence (we used both, a localization and a detection task). Our results showed that RT and error rates increased linearly with display size (the number of talking faces), thus indicating serial search and challenging the idea that audiovisual matching occurs prior to the allocation of visual spatial attention. In Experiments 5-6, we used an auditory search task with four different auditory sentences played from different spatial locations along with a single central talking face. Importantly, the results of this experiment showed that, while in the localization task RT increased linearly with the number of attended elements, the detection task showed a flat slope, consistent with a parallel search mechanism. On the basis of these findings, we suggest that spatial selective attention can play a crucial role in audiovisual binding in natural environments, and that it plays a differential role in vision and in audition.

Thursday 17th

9:00 – 11:00 Paper Session

Chair: Charles Spence

An irrelevant tone can influence peri-saccadic mislocalisation

Jeroen Smeets, Femke Maij, Eli Brenner

VU University Amsterdam

Flashes presented around the onset of a saccade are mislocalised in the direction of the saccade target. In order to evaluate whether uncertainty about the moment of the flash contributes to this peri-saccadic mislocalisation, we examined whether the mislocalisation is influenced by an irrelevant tone that was presented at different moments around the time of the flash. When a tone was presented before the flash, the time course of the mislocalisation was shifted, as if the flash had been presented earlier. The amplitude of the mislocalisation was not influenced by the tone. To explain the temporal shift, we used a model based on the following reasoning. If the flash and tone are judged to occur simultaneously, the perceived time of this event will be between the time of the flash and that of the tone. If we describe the chance of the flash and tone being regarded to occur simultaneously by a Gaussian with a temporal uncertainty (SD) of 43 ms, the resulting model could describe the data well if the tone is considered to contribute at least 25% to the estimated timing of the flash. We conclude that temporal uncertainty is indeed a factor in peri-saccadic mislocalisation.

Perceptual learning suggests crossmodal plasticity in adult humans at relatively early levels of processing

Anton L. Beer[1], Melissa A. Batson[2], Takeo Watanabe[2]

[1]Institut für Psychologie, Universität Regensburg, [2]Department of Psychology, Boston University

Sounds modulate the perception of spatially aligned visual patterns in normal humans and elicit neural activity in visual cortex of congenitally blind humans. However, the mechanisms underlying these crossmodal interactions are still unclear. We developed a novel perceptual learning paradigm that allowed us to detect crossmodal plasticity after repeated exposure to audio-visual stimuli. We found that peripheral sounds paired with spatially aligned moving dots induced persistent changes in visual motion discrimination. Auditory-guided visual plasticity was restricted to visual field locations that overlapped with the sound source and to the motion direction that was paired with the sound. This location- and feature-specificity suggests that crossmodal plasticity occured at relatively early levels of visual perception. We further tested whether the audio-visual maps underlying crossmodal interactions can be re-aligned in adult humans. Repeated exposure to mis-aligned audio-visual stimuli resulted in a shift of crossmodal maps. Crossmodal facilitation effects showed a relatively sharp spatial gradient whereas crossmodal inhibition effects had a relatively poor spatial resolution suggesting that facilitation involves earlier processing stages than crossmodal inhibition. Interestingly, facilitation effects were even more susceptible to perceptual learning than inhibition effects suggesting that multisensory plasticity in adults affects relatively early levels of multisensory integration.

Work better in the dark: Close your eyes.

David Shore, I.K. Dhanoah

McMaster University, Department of Psychology, Neuroscience & Behaviour

Visual deprivation for a short (e.g., 90 minutes), medium (e.g., 5 days) or long (e.g., blindness) duration increases the neural response to, and behavioural accuracy with, a tactile target. At the same time, simply closing the eyes can affect the cortical representation of a tactile stimulus. Using a novel active tactile search task, we explored the effect of closing the eyes in a completely dark room. Matching of mechanical nuts and bolts was both faster and more efficient when the eyes were closed compared to when they were open, despite equal amounts of visual information. Thus, the simple act of closing the eyes can modulate behavioural performance, and presumably the underlying neural processing. In a second experiment, observers were deprived on visual input for 90 minutes by blindfolding. Performance on the active search task was improved for the deprived group, but not for the non-deprived group.

Sensory substitution and the taxonomy of our sensory modalities

Malika Auvray, Thomas , Sylvain Hanneton

CNRS UMR 8119

Sensory substitution devices provide through an unusual sensory modality (the substituting modality, for example audition) the kind of information that is normally accessed through another sensory modality (the substituted modality, for example vision). Since their inception in the 60's various kinds of devices have been developed, tested, and shown to allow their users to behave to some degree as if they possessed the substituted sensory organ. These systems thus question the usual taxonomy of our sensory modalities and the characterisation of a perceptual experience. Through a set of behavioural studies involving localisation, recognition, and categorisation tasks with visual-to-auditory substitution devices, we addressed the question of which sensory modality the acquired perception belongs to. Though certain results might be taken to point to the conclusion that perception with a sensory substitution device belongs to the substituted modality, overall evidence leads to an alternative view on sensory substitution. According to it, the experience after sensory substitution is a transformation, extension, or augmentation of our perceptual capacities, rather than something equivalent or reducible to an already existing sensory modality.

Multisensory integration promotes spatial attentional capture

Charles Spence[1], Cristy Ho[1], Valerio Santangelo[2]

[1]Department of Experimental Psychology, University of Oxford
[2] Department of Psychology, University of Rome "La Sapienza"

We report a series of experiments designed to assess the influence of multisensory integration (MI) on the exogenous orienting of spatial attention. In Experiment 1, we compared the exogenous orienting elicited by auditory, visual, and audiovisual (bimodal) spatially-nonpredictive cues, while in Experiment 2, we used auditory, tactile, and audiotactile spatially-nonpredictive cues. In both experiments, participants had to discriminate the elevation (up/down) of visual targets preceded by either unimodal or bimodal cues under conditions of high perceptual load (in which they had to monitor a rapidly-presented central stream of visual letters for occasionally-presented target digits) or else no perceptual load (in which the central stream was replaced by a fixation point). The results of both experiments showed that all cues captured spatial attention in the no-load condition. By contrast, only the bimodal cues (i.e., audiovisual cues in Experiment 1, and audiotactile cues in Experiment 2) captured spatial attention in the high-load condition. The results of a third experiment demonstrated that the auditory and tactile cues need to be presented from the same direction in order for them to capture people's attention effectively. These results therefore suggest that MI facilitates the disengagement of spatial attention from a concurrent perceptually-demanding stimulus, thus playing a crucial role in the exogenous orienting of spatial attention. The application of these results to the design of multisensory collision avoidance warning signals for drivers will also be highlighted.

Role of touch in referral of thermal sensations

Hsin-Ni Ho[1], Junji Watanabe[2], Hideyuki Ando[1], Makio Kashino[1,3]

[1]NTT Communication Science Laboratories, NTT Corporation, [2] PRESTO, Japan Science and Technology Agency, [3]ERATO Shimojo Implicit Brain Function Project; Interdisciplinary Graduate School of Science and Engineering

When presenting simultaneous thermal and tactile stimulations on different skin sites, referral of thermal sensations occurs such that illusory thermal sensation is perceived at the site of tactile stimulation. Here, we investigated the role of touch in referral of thermal sensations with a psychophysical approach. One thermally neutral and two warm/cold stimulators were used to provide tactile and thermal stimulations. They were presented to three digits within one hand and the referred thermal sensation was induced on the digit in contact with the neutral stimulator. The location of the neutral stimulator varied from trial to trial and the magnitude of the referred thermal sensation was estimated based on participants' performance in discriminating the neutral stimulator from the warm/cold stimulators. The results indicate that warm referral occurred readily with simultaneous thermal and tactile stimulations regardless of the location of the tactile stimulation. As for cold referral, besides simultaneous thermal and tactile stimulations, it further required the tactile stimulation being surrounded by the thermal stimulation, which suggests the involvement of filling-in of cold sensation. Our findings indicate although cold and warm senses are sub-modalities of thermosensory system, their interactions with the tactile modality can be distinct.

11:30 – 13:30 Symposium

Role of neural synchrony for multisensory integrative processes

Organized by Andreas K. Engel

University Medical Center Hamburg-Eppendorf, Germany

Picture yourself on a crowded sideway with people moving around. The acoustic and visual signals generated by the people provide you with complementary information about their location and motion. Thus far, it is not well understood how such inputs from different sensory channels are integrated. In this symposium, we present recent studies on multisensory processing and neural synchrony using high-density EEG recordings in humans and local field potential and single unit recordings in primates. Data from these studies suggest that coupled oscillatory activity across a wide range of frequencies may serve to link neural signals across uni- and multisensory regions and to express the degree of crossmodal matching of stimulus-related information. The view that we advocate has several implications: we believe that the investigation of neural synchrony during crossmodal processing allows developing new research approaches and experimental strategies; furthermore, new accounts for abnormal variants like synesthesia and autism can be developed. Thus, we believe that the study of synchronization phenomena may lead to a new view on multisensory processing which considers the dynamic interplay of neural populations as a key to crossmodal integration.

Searching for cross-modal synchrony – a testbed for the „temporal correlation“ hypothesis?

Andreas K. Engel[1], Jörg F. Hipp[1], Till R. Schneider[1], Simone Lorenz[1], Markus Siegel[2], Stefan Debener[3], Daniel Senkowski[1]

[1]University Medical Center Hamburg-Eppendorf, [2]MIT, Cambridge, MA, [3]MRC Inst. of Hearing Res., Southampton

The temporal correlation hypothesis posits that coherent oscillations in neural populations, in particular at frequencies in the gamma-band, may play an important role in feature integration. For unisensory processing, oscillatory synchronization phenomena have been reported for all modalities, and available evidence suggests that synchrony does indeed play a key role in integrating perceptual information. This raises the possibility that coherent oscillations may also be involved in the cross-modal integration of signals. In this presentation, we describe evidence obtained in EEG studies supporting the notion of cross-modal interaction by neural coherence: (1) We have carried out cross-modal priming studies, involving both visual-to-auditory and haptic-to-auditory interactions, in which the semantic congruence between stimulus pairs representing natural objects was manipulated. For semantically matching stimuli, we observed an enhancement of gamma-band responses to the second, task-relevant stimulus. Source localization of this gamma-band effect using linear beamforming suggests an involvement of multisensory regions in the left temporal lobe. (2) In addition, we have studied visual-auditory binding using a bistable “bounce-pass”-paradigm where subjects perceive two moving visual objects, presented in conjunction with a collision sound, as either passing or bouncing off each other. Using beamforming analysis of the data, we find that cross-modal binding is associated with enhanced gamma-band activity and decreased alpha-band activity in visual and fronto-parietal regions. Remarkably, gamma-band activity in early visual areas was found to predict the quality of the bistable percept. Together, these data support the hypothesis that coherent oscillatory activity may play an important role in the formation of multisensory percepts.

Cross-modal influences on information processing in auditory cortex

Christoph Kayser

Max-Planck-Institute for Biological Cybernetics, Tübingen, Germany

Recent results from human imaging and electrophysiology promote the view that processing within auditory cortex can be influenced by cross-modal stimulation of other sensory modalities. Here we scrutinize the neuronal basis of these sensory interactions and ask whether they increase the information about the sensory environment available in neuronal responses. Recording field potentials and single unit responses in regions of the monkey auditory cortex we characterized the modulatory influence of visual stimuli on the responses to acoustic stimuli. While slow field potentials showed widespread visual modulations, only few individual neurons exhibited significant multisensory interactions, such as response enhancement or suppression. The visual modulation occurred only for a narrow time window of stimulus onset asynchronies and was independent of the particular kind of stimulus used. Using information theoretic analysis, we found that visual stimuli do not change the information in neuronal firing rates about the acoustic stimulus. However, visual modulation increased the information available in slow field potentials and in the phase of firing of individual neurons. Our results let us conclude that cross-modal input enhances the information available in auditory cortex about the environment and that this information is available not in the response strength of individual neurons but in a temporal neural code.

Attentional control of oscillatory phase reset in multisensory interactions

Peter Lakatos, Charles E. Schroeder

Nathan S. Kline Insitute, Orangeburg, NY, U.S.

To experience the multisensory world around us, our brain has the capability to integrate inputs from different sensory channels, while disregarding ones that do not belong to the same event. Timing of the inputs appears to be one of the key factors in this process. Neuronal oscillations have long been suspected as timekeepers in the brain. They are also ideal candidates for the dynamical coupling of distant cortical areas and thereby link inputs from different senses. The pre-requisite for both of these processes is the phase reset of neural oscillations by select events. We analyzed laminar profiles of field potentials and multiunit activity sampled during linear array multielectrode penetrations of primary auditory and visual cortices in awake macaques. We show that event related phase reset of neural oscillations in primary cortical areas occurs independent of their modality, and that attention plays a key role in this process. The phase reset of ambient neuronal oscillations by attended stimuli results in coherent neural oscillations across auditory and visual cortex in multiple frequency bands. These results suggest that attention plays the role of a conductor in orchestrating what type of inputs will re-set ongoing activity, which in turn can couple distant cortical areas and together with the structure of ambient oscillations determines the time window for possible multisensory interaction.

Friend or foe? Multisensory interactions between emotional face expressions and pain processing in neural gamma-band responses

Daniel Senkowski, Janine Kautz, Michael Hauck, Roger Zimmermann, Andreas K. Engel

Dept. of Neurophysiology and Pathophysiology, University Medical Center Hamburg-Eppendorf, Hamburg

The encoding of facial expressions of people surrounding us is highly relevant, especially if their actions can induce pain or bodily harm. Painful events automatically capture our attention, which enables us to rapidly evaluate the environmental conditions in social settings (e.g., was the painful event due to an accident or caused by an aggressive act). Given the relevance of both stimulus types, it is likely that processing of facial emotions can influence pain perception. We studied the crossmodal effects of emotional face expressions (fear, happy, anger) on the processing of painful events using magnetoencephalography (MEG). Pain ratings were enhanced when a painful stimulus was presented simultaneously with a face compared to when it was presented alone. This might result from a higher level of arousal when faces are presented compared to when they are absent. Importantly, pain ratings were larger when the faces expressed an emotion than when they were neutral. This finding was paralleled by modulations in gamma-band responses recorded with MEG, which will be reported in this talk. Our results suggest that gamma-band oscillations might play an important role for the integration of painful stimuli with socially relevant inputs from other sensory modalities, such as emotional face expressions.

Integration of information in overt attention

Peter König

University Osnabrück, Germany

How do different sources of information arising from different modalities interact to control where we look? To address this question with respect to real-world operational conditions we presented natural scenes to human subjects in a variety of conditions and measure subjects' eye-movements. Using quantitative measures we find that (1) the influence of top-down signals is systematically stronger than that of spatial biases, which in turn is stronger than bottom-up signals; (2) the information is optimally integrated along a scanning trajectory; (3) the empirical saliency is combined linearly; (4) the action of top-down information can not be explained by a modulation of bottom-up signals. (5) In spite of these constraints, a large scale combination of features in a bottom-up driven model can explain a significant part of the variability of eye movements as measures by an ROC analysis (AUC=0.75).

15:00 – 17:00 Paper Session

Chair: Ladan Shams

The prefrontal cortex accumulates object evidence through differential connectivity to the visual and auditory cortices

Uta Noppeney, Dirk Ostwald, Sebastian Werner, Mario Kleiner

Max Planck Institut for Biological Cybernetics

To form categorical decisions about objects in our environment, the human brain accumulates noisy sensory information over time till a decisional threshold is reached. Combining fMRI and Dynamic Causal Modelling (DCM), we investigated how the brain accumulates evidence from the auditory and visual senses through distinct interactions amongst brain regions. In a visual selective attention paradigm, subjects categorized visual action movies while ignoring their accompanying soundtracks that were semantically congruent or incongruent. Both, auditory and visual information could be intact or degraded. Reaction times as a marker for the time to decisional threshold accorded with random walk models of decision making. At the neural level, incongruent auditory sounds induced amplification of the task-relevant visual information in the occipito-temporal cortex. Importantly, only the left inferior frontal sulcus (IFS) showed an activation pattern of an accumulator region i.e. (i) positive reactiontime and (ii) incongruency effects that were increased for unreliable (=degraded) visual and interfering reliable (=intact) auditory information, which -based on our DCM analysis- were mediated by increased forward connectivity from visual regions. Thus, to form interpretations and decisions that guide behavioural responses, the IFS may accumulate multi-sensory evidence over time through dynamic weighting of its connectivity to auditory and visual regions.

The costs of crossing paths and switching tasks between audition and vision

Micah M. Murray[1], Laura De Santis[1], Gregor Thut[2], Glenn R. Wylie[3]

[1]University of Lausanne, [2]University of Glasgow, [3]Kessler Medical Rehabilitation Research and Education Corporation

Switching from one functional or cognitive operation to another is thought to rely on executive/control processes. The efficacy of these processes may depend on the extent of overlap between neural circuitry mediating the different tasks; more effective task preparation (and by extension smaller switch costs) is achieved when this overlap is small. We investigated the performance costs associated with switching tasks and/or switching sensory modalities. Participants discriminated either the identity or spatial location of objects that were presented either visually or acoustically. Switch costs between tasks were significantly smaller when the sensory modality of the task switched versus when it repeated. This was the case irrespective of whether the pre-trial cue informed participants only of the upcoming task, but not sensory modality (Experiment 1) or whether the pre-trial cue was informative about both the upcoming task and sensory modality (Experiment 2). In addition, in both experiments switch costs between the senses were positively correlated when the sensory modality of the task repeated across trials and not when it switched. The collective evidence supports the independence of control processes mediating task switching and modality switching and also the hypothesis that switch costs reflect competitive interference between neural circuits.

Integration of speech and gesture: an ERP study

Boukje Habets[1], Sotaro Kita[1], Asli Özyürek[2], Peter Hagoort

[1]University of Birmingham, [2]Radboud Universtiy

During face-to-face communication, one does not only hear speech but one also sees a speaker's hand movements and body language. In order to comprehend, listeners therefore have to integrate spoken language information with several forms of visual information, including hand gestures accompanying speech. ERPs have been successfully used to demonstrate that integration between gesture and speech takes place. The present ERP study investigated the optimal timing for this integration process. Videos of a person gesturing were combined with speech segments that had different timing onsets (0 ms (simultaneous with stroke onset), 160 ms or 360 ms after stroke onset) and that matched or mismatched the gesture meaning. We analyzed the negative ERP deflection around 400 ms (the N400), an indicator of semantic integration. When matching speech-gesture pairs with different asynchrony were compared, the N400 increased as speech-gesture asynchrony became bigger, an indicator for growing integration difficulties as the delay increased. For non-matching pairs the N400 was largest in the no-delay condition, decreasing with increase in asynchrony (not significant at 360 ms), implying a stronger disruption of integration when the asynchrony is smallest. Our results imply that speech and gesture are integrated best within a narrow time interval of 160 ms.

Bayesian priors and likelihoods are encoded independently in human multisensory perception

Ladan Shams[1], Ulrik Beierholm[2]

[1]UCLA, [2]Gatsby Computational Neuroscience Unit

We studied human auditory-visual perception using a spatial localization task. In this task, as in many other tasks, while zero or small discrepancies between the two modalities leads to fusion, large discrepancies result in segregation (no interaction between the modalities), and moderate discrepancies result in moderate interaction. We quantitatively show that this combination of crossmodal information is highly consistent with a normative Bayesian model performing causal inference. Because we have a method of estimating priors and likelihoods, we could also ask whether the priors and likelihoods are encoded independently of each other in this task. Intuitively, priors represent a priori information about the environment, i.e., information available prior to encountering the given stimuli, and are thus not dependent on the current stimuli. While this interpretation is considered as a defining characteristic of Bayesian computation by many, the Bayes rule per se does not require that priors remain constant despite significant changes in the stimulus, and therefore, the demonstration of Bayes-optimality of a task does not imply the invariance of priors to varying likelihoods. We empirically investigated the inter-dependence of priors and likelihoods by strongly manipulating the presumed likelihoods (testing subjects with two different stimulus parameters one week apart) and examining whether the estimated priors change or remain the same. The results suggest that the estimated prior probabilities are indeed independent of the immediate input (likelihood), which further supports the hypothesis that human auditory-visual perception is a Bayesian inference process combining a priori information with the sensory estimates.

The seemingly inviolable principle of inverse effectiveness: In search of a null hypothesis

Nicholas Paul Holmes

Hebrew University of Jerusalem

The Principle of Inverse Effectiveness (PoIE) was born 25 years ago next week (22/07/1983). In its youth, PoIE has been immensely influential in multisensory neuroscience, making regular IMRF appearances. PoIE describes an inverse relationship between multisensory integration and the maximal unisensory response. The PoIE is 'seemingly inviolable' (Alvarado et al., 2007): It is observed in most multisensory studies of the superior colliculus, auditory cortex, ventral intraparietal area, and in certain aspects of behaviour. Given this omnipresence, what is the alternative or null hypothesis? I describe a Matlab-based statistical search for the null hypothesis, asking: Under which numerical conditions is the PoIE *not* followed? I focus on three candidates: 1) Multisensory responses are uncorrelated with unisensory responses, 2) reflect their sum, or 3) their mean. The PoIE is almost always observed when unisensory and multisensory responses are uncorrelated, but the particular equation used to calculate multisensory integration can reduce the occurrence of PoIE, under uncorrelated conditions, from ubiquity to chance. The inviolability of the PoIE may therefore be due, in large part, to the particular equations used to calculate multisensory integration. The degree to which PoIE reflects the underlying neural processes of multisensory integration is yet to be determined.

On quantifying multisensory interaction effects in reaction time and detection rate

Stefan Rach[1], Adele Diederich[2], Hans Colonius[1]

[1]University of Oldenburg, [2]Jacobs University Bremen

Studies on multisensory interaction repeatedly demonstrated that reaction times [RT] to a stimulus from one sensory modality are altered when accompanied by a stimulus of a second modality in close spatial and/or temporal vicinity (intersensory facilitation effect, e.g., Hershenson, 1962, J Exp Psychol.). In order to quantify the observed changes in reaction time, different measures have been introduced and utilized in comparing different experimental conditions. Common to all these measures is that they relate RTs on unimodal stimulation to those on crossmodal stimulation on the level of mean RTs (e.g., difference between bimodal and unimodal RT [Bernstein et al., 1970, J.Exp.Psychol.], multisensory response enhancement [Diederich & Colonius, 2004, Percept.Psychophys.], multichannel diffusion model [Diederich, 1995, J. Math. Psych.]). However, as soon as stimuli with intensities near to detection threshold are employed it becomes obvious that not only RT can be influenced by multisensory interaction effects but also detection rate [DR] (e.g., Bolognini et al., 2005, Exp. Brain Res.). We introduce multisensory indices that combine RT and DR and thereby allow for a more accurate quantification of multisensory interaction effects for near-threshold stimuli. We report simulation results utilizing diffusion models to examine properties of these indices.

17:00 – 19:00 Poster Session II

Integration and segregation of auditory-visual signals

Matthias Gondan

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In a typical redundant target experiment, participants receive either unimodal of bimodal redundant signals from different modalities. A well known finding is that responses for bimodal stimuli are substantially faster than for unimodal stimuli (redundant signals effect, RSE). I present a stochastic model of the RSE (diffusion superposition model, DSM, Schwarz, 1994, 2006) which allows nearly perfect prediction of the mean and variance of response times in auditory-visual stimuli with different onset asynchrony. The basic integration mechanism in the DSM is a linear superposition of neural signals. In three experiments, the basic RSE paradigm was extended to include simple, go/nogo, and choice responses (Exp. 1), spatial attention (Exp. 2), and judgements of temporal order (Exp. 3). In all experiments, the model prediction was excellent, underlining the role of additive neural interactions in audiovisual integration.

Voluntary action improves auditory-somatosensory crossmodal temporal resolution.

Norimichi Kitagawa[1], Masaharu Kato[2], Makio Kashino[1]

[1]NTT Communication Science Laboratories, [2]Tokyo Women's Medical University

It has been reported that voluntary action captures a subsequent sensory event, causing perceptual shift of the event towards slightly earlier in time. This effect of sensorimotor binding could predict a larger temporal window of synchrony between voluntary action and a subsequent sensory event, and worse temporal resolution between them, compared with those observed without voluntary action. In the present study, we assessed this prediction by examining whether voluntary action affects performance of temporal order judgment (TOJ) to pairs of auditory and somatosensory events. Participants actively pressed a key, or their finger pad was passively stimulated, while trying to keep both tactile stimulations similar as much as possible. A noise burst was presented at various onset asynchronies relative to the touch. The participants made either 'sound-first' or 'touch-first' response to each pair of auditory and somatosensory events. The observed TOJ performance as indexed by just noticeable difference (JND) was better (i.e., smaller JNDs) when the participants actively pressed the key than when their finger was passively stimulated. The active touch shifted the point of subjective simultaneity towards the auditory delay. The results suggest that voluntary action improve auditory-somatosensory crossmodal temporal resolution, as opposed to the prediction from the previous findings.

Investigating visuo-tactile recognition of unfamiliar moving objects: A combined behavioural and fMRI study

Jason Chan, T. Aisling Whitaker, Cristina Simoes-Franklin Hugh Garavan, Fiona N. Newell

Trinity College Dublin

Previous research on haptic object recognition has focused mainly on static objects thus very little is understood about the role of dynamic information in haptic object recognition. In this study we examined if motion, particularly of dynamic object parts, is combined with shape information in the representation of an object in haptic processing. In our behavioural studies we found that target objects, previously learned as moving objects, were more easily recognized when presented dynamically, than when presented as static objects, even though, shape information alone was sufficient to recognize each object. Moreover, cross-modal, visuo-tactile object recognition was better for dynamic than static objects. We then explored, using fMRI, whether the same neural substrates underly the recognition of visual and haptic dynamic objects. Participants learned six shapes (3 static and 3 dynamic) through touch and another six (3 static and 3 dynamic) through vision. In the scanner, participants saw static greyscale images of the objects they had learned. We hypothesised that the moving objects previously learned would activate visual motion area compared to the learned static objects, across vision and touch. Our data shows that a wide array of brain areas are involved in this task, including area V5(MT).

The impact of natural statistics on multisensory integration in superior colliculus

Terry Elliott, Xutao Kuang, Nigel Richard Shadbolt, Klaus-Peter Zauner

School of Electronics and Computer Science, University of Southampton

The response of a multisensory neuron in the superior colliculus (SC) to a stimulation of one sensory modality is augmented by the presentation of a stimulus of another sensory modality. Furthermore, the percentage of augment is larger when the unimodal stimuli are weaker. This response property is generally known as multisensory enhancement associated with inverse effectiveness. Although multisensory enhancement has been widely studied experimentally, the mechanism underlying this response remains unclear. We suggest here that, adopting the same strategy as unimodal neurons earlier in sensory pathways, SC multisensory neurons adapt their responses according to the input statistics through processes such as gain control and firing threshold adjustment. We further propose an adaptation rule for the responses of SC multisensory neurons, based on which robust, testable predictions about the role that input statistics may play in multisensory enhancement are produced. Moreover, we suggest that the functional role of cortical afferents from the anterior ectosylvian sulcus (AES) and the rostral aspect of the lateral suprasylvian sulcus (rLS) is to control the overall gain of a SC multisensory neuron based on an estimation of the second-order correlation coefficients between two cross-modal inputs.

Temporal aspects of auditory and visual stimuli processing assessed by temporal order judgment and reaction times

Lars Torben Boenke, Matthias Deliano, Frank W. Ohl

Leibniz Institute for Neurobiology

It is currently debated which parameters of auditory and visual stimuli influence the perception of temporal order when such stimuli are presented in close temporal proximity. Previous research has demonstrated that the relative spatial locations and relative intensity relationships have an influence on the perceived temporal order. In a first experiment, using the method of constant stimuli, we examined the influence of stimulus duration and intensity on the temporal integration and temporal order perception for audio-visual stimuli by estimating the point of subjective simultaneity (PSS). Beyond the known effect of intensity, we found evidence that the stimulus duration plays an additional, and previously underestimated, role for the temporal perception of audio-visual stimuli. Another important debate in audio-visual integration is about in which way TOJ and reaction time (RT) measures tap same or different processes. To shed light on this relationship we collected also judgement times (JT) in the first experiment, and contrasted them with RTs derived from a second experiment in which participants were asked to give their speeded response with same stimulation like in the first experiment. Models for JTs and RTs will be proposed.

How vision can help audition: Speech recognition in noisy environments

Inga Schepers, Daniel Senkowski, Joerg F. Hipp, Andreas K. Engel

University Medical Center Hamburg-Eppendorf, Germany

The impact of visual inputs on multisensory audiovisual speech recognition is pronounced under noisy environmental conditions. Here, we explored influences of visual signals on audiovisual speech recognition under varying degrees of auditory stimulus degradation. Multisensory audiovisual (AV) and unisensory-auditory (A) speech signals with no-degradation, low-degradation and high-degradation of auditory inputs were presented. Speech stimuli consisted of simple syllables and a target syllable had to be detected by the subjects. Event-related potentials (ERPs) to unisensory-A stimuli were subtracted from ERPs to multisensory-AV stimuli for each degradation condition (i.e., AV – A) and the resulting difference waves were compared. Effects of auditory signal degradation were observed in the 90-140 ms and 460-520 ms time intervals after sound onset over anterior scalp. The local-autoregressive approach (LAURA) was applied to explore the neuronal sources underlying these effects. For the early time interval, effects of auditory stimulus degradation were linked to activity in superior parietal cortex. Effects of auditory stimulus degradation in the late time interval were projected to parieto-occipital and temporal regions. Our results suggest that a widespread cortical network, which is engaged during multiple stages of information processing, is the neurophysiological basis for the important role of visual speech signals under noisy environmental conditions.

Viewing a face (especially one's own face) being touched enhances tactile perception on the face

Andrea Serino, Francesca Pizzoferrato, Elisabetta Làdavas

University of Bologna

Observing touch on another person's body activates brain regions involved in tactile perception, even when the observer's body is not directly stimulated. Previous work has shown that in some synaesthetes, this effect induces a sensation of being touched. The present study shows that if perceptual thresholds are experimentally manipulated, viewing touch can modulate tactile experience in nonsynaesthetes as well. When observers saw a face being touched by hands, rather than a face being merely approached by hands, they demonstrated enhanced detection of subthreshold tactile stimuli on their own faces. This effect was specific to observing touch on a body part, and was not found for touch on a nonbodily stimulus, namely, a picture of a house. In addition, the effect was stronger when subjects viewed their own faces rather than another person's face. Thus, observing touch can activate the tactile system, and if perceptual thresholds are manipulated, such activation can result in a behavioral effect in nonsynaesthetes. The effect is maximum if the observed body matches the observer's body.

Projecting peripersonal space onto a mirror: ERP correlates of visual-tactile spatial interactions

Chiara Francesca Sambo, Bettina Forster

City University, London

Visual-tactile interaction occurs in a privileged way in peripersonal space, namely when visual and tactile stimuli are in spatial proximity. Here, we investigated whether the same principle (i.e. spatial rule) also holds when visual stimuli presented near the body are indirectly viewed in a mirror (i.e. although under this condition the visual image is consistent with stimuli in far space). Participants performed a tactile discrimination task while ignoring task-irrelevant visual stimuli presented simultaneously with tactile stimuli. Visual stimuli were delivered in peripersonal space either at congruent or incongruent locations as touch, and these were observed either directly (experiment 'near-space') or as indirect mirror reflections (experiment 'mirror'). Crossmodal spatial modulations on ERPs were found under both 'near-space' and 'mirror' conditions; that is ERPs were enhanced in response to tactile stimuli presented with spatially congruent versus incongruent visual stimuli. However, while in the 'near-space' condition congruence effects were present from 115 ms after the onset of tactile stimuli, in the 'mirror' condition crossmodal spatial modulations only emerged around 160 ms after stimuli onset. These findings suggest that visual stimuli observed in a mirror are recoded as peripersonal stimuli, and furthermore, that the remapping of mirror reflected visual stimuli as peripersonal ones may require an additional stage of processing.

Natural, metaphoric and linguistic auditory-visual interactions

Sepideh Sadaghiani, Joost Maier, Uta Noppeney

Max Planck Institute for Biological Cybernetics, Tübingen, Germany

To form a coherent percept of our dynamic environment, the brain merges motion information from the auditory and visual senses. Yet, not only auditory motion, but also 'metaphoric' pitch has been shown to influence visual motion discrimination. Here, we systematically investigate the neural systems that mediate auditory influences on visual motion discrimination in natural, metaphoric and linguistic contexts. In a visual selective attention paradigm, subjects discriminated the direction of visual motion at several levels of ambiguity, while ignoring a simultaneous auditory stimulus that was 1) 'natural' MOTION: left vs. right moving white noise, 2) 'metaphoric' PITCH: rising vs. falling pitch or 3) 'linguistic' SPEECH: spoken German words denoting directions e.g. 'links' vs. 'rechts'. Behaviourally, all three classes of auditory stimuli induced a comparable directional bias. At the neural level, the interaction between visual ambiguity and audition revealed an auditory influence on visual motion processing for MOTION in left hMT/V5 and for SPEECH in right intraparietal sulcus. Direct comparisons across contexts confirmed this functional dissociation: The interaction effect gradually decreased in left hMT+/V5 for MOTION>PITCH>SPEECH and in right IPS for SPEECH>PITCH>MOTION. In conclusion, while natural audio-visual integration of motion signals emerges in motion processing areas, linguistic interactions are revealed primarily in higher level fronto-parietal regions.

Physical and perceptual factors determine the mode of audio-visual integration in distinct areas of the speech processing system

Hwee-Ling Lee, Johannes Tuennerhoff, Sebastian Werner, Chandrasekharan Pammi, Uta Noppeney

Max-Planck Institute for Biological Cybernetics

Speech and non-speech stimuli differ in their (i) physical (spectro-temporal structure) and (ii) perceptual (phonetic/linguistic representation) aspects. To dissociate these two levels in audio-visual integration, this fMRI study employed original spoken sentences and their sinewave analogues that were either trained and perceived as speech (group 1) or non-speech (group 2). In both groups, all stimuli were presented in visual, auditory or audiovisual modalities. AV-integration areas were identified by superadditive and subadditive interactions in a random effects analysis. While no superadditive interactions were observed, subadditive effects were found in right superior temporal sulci for both speech and sinewave stimuli. The left ventral premotor cortex showed increased subadditive interactions for speech relative to their sinewave analogues irrespective of whether they were perceived as speech or non-speech. More specifically, only familiar auditory speech signal suppressed premotor activation that was elicited by passive lipreading in the visual conditions, suggesting that acoustic rather than perceptual/linguistic features determine AV-integration in the mirror neuron system. In contrast, AV-integration modes differed between sinewave analogues perceived as speech and non-speech in bilateral anterior STS areas that have previously been implicated in speech comprehension. In conclusion, physical and perceptual factors determine the mode of AV-integration in distinct speech processing areas.

The contiguity principle – initial evidence for perceptual constancy in flavour

Andy T. Woods[1,2], Garmt Dijksterhuis[2], Chantalle Groeneschild[2]

[1]Manchester University, [2]Unilever R&D

Food flavour often takes time to develop, varies over mouthfuls and indeed over inhalation and exhalation. Despite this, we rarely acknowledge or even perceive such variation. Consider the last chocolate bar you consumed. You likely recall a contiguous chocolate flavour (i.e. non-changing over and even within mouthfuls) but have little or no recollection of any flavour variation. Somehow, a constant food flavour is experienced despite variation in sensory signal. Related processes act in a similar fashion in other modalities (perceptual constancy, e.g. in vision) and across modalities (the unity assumption; Welsh & Warren, 1980). It was hypothesised that a food which is assumed to be consistently flavoured will be tasted to be so, despite some variation in actual flavour. A cookie model-food-stimulus was developed, whose two halves sometimes differed in terms of sweetness (0%, 33% and 67% sugar quantity differences) but were visually indistinguishable (to ensure the assumption of a contiguous cookie). Sweetness ratings for 0% and 33% cookie halves were indistinguishable for early trials; for later trials the 33% cookie halves were rated differently in terms of sweetness from each other. The 67% cookie-halves were always rated differently in terms of sweetness. Our findings provide first support for the existence for a contiguity effect which can mask some flavour variation, but whose effects are modulated by increasing exposure to discrepant stimuli.

Attention modulates adaptive temporal recalibration

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Numerous studies have demonstrated that adaptation to fixed levels of audiovisual asynchrony recalibrates perceived simultaneity (Fujisaki et al., 2004; Heron, et al., 2007). However, the mechanism(s) underlying this phenomenon remain poorly understood. In particular, it is not known whether temporal recalibration is a mandatory, stimulus-driven process, or whether it is subject to cognitive control. Here, we address this issue by manipulating observers' attentional state during adaptation to audiovisual asynchrony. Within a given experimental session, observers were instructed to detect one of three different oddball stimuli (i) a change in the contrast polarity of the fixation cross: 'attend fixation condition', (ii) a change in the size/position of the auditory and visual stimuli: 'attend stimuli' condition, or (iii) a change in the temporal order of the adapting stimulus pairs: 'attend temporal order' condition. Critically, the sequence of adapting stimuli itself remained unchanged across conditions. Whilst some degree of adaptive temporal recalibration was found in all conditions, attending to temporal order proved by far the most effective manipulator of adaptive magnitude. Thus, in keeping with other adaptation phenomena such as the motion aftereffect (Mather, 1998), it appears that asynchrony adaptation can be substantially modulated by goal driven, top-down processes.

The role of brain lateralization and interhemispheric transfer for a multisensory reference frame of action control

Holger Cramer[1], Brigitte Röder[2], Cordula Becker[1]

[1]Biopsychology, Ruhr-University Bochum, [2]Biological Psychology and Neuropsychology, University of Hamburg

Multisensory information seems to be localized in a common external or eye-centered reference frame, possibly facilitating actions towards a perceived stimulus. There is evidence that the use of an external reference frame for multisensory localization requires an intact corpus callosum. We hypothesized that a highly efficient communication between the two hemispheres might be accompanied by a more efficient transformation of modality specific coordinates into external coordinates. We tested a group of sighted adults in the Banich Belger task, which requires stimulus matching within and across hemispheres. This task allows an estimation of interhemispheric transfer times, which we expect to correlate with the relative size of the crossing hands impairment in a Simon task performed by the same participants. Moreover, the cerebral asymmetries of each participant were assessed using a dichotic listening, a word recognition and figure recognition task and correlated with the crossing hands deficit of the same participants.

Auditory-tactile and tactile-tactile enhancement: The role of task and overt visual attention

Helge Gillmeister[1,2], Monira Rahman[1], Bettina Forster[1]

[1]City University, London, UK, [2] University College London, UK

Previous research has shown that the presence of auditory information can facilitate tactile processing, but it is not clear whether the information provided by sound enhances processing in the tactile system over and above that provided by an additional event within the tactile modality. Furthermore, it is not clear at what level of processing auditory-tactile enhancement occurs, and whether such enhancement is modulated by overt visual attention (looking at the stimulated body part). The present study addresses these issues by asking observers to rate the intensity of vibrotactile stimuli on their index finger in the presence or absence of synchronous co-located sounds or tactile events on an adjacent finger. Tactile intensities were rated either along a response scale or in a two-interval forced-choice task to test the level of processing at which enhancement occurs. To investigate the role of overt visual attention, observers either looked at or did not look at the stimulated hand. Results show that both sounds and additional tactile events can enhance perceived tactile intensity. Unlike tactile-tactile enhancement, auditory-tactile enhancement was found to occur at an early sensory stage (independently of task) when visual information of the stimulated hand was available. Precluding effects of response bias in the forced-choice task largely eliminated auditory-tactile enhancement when the hand was not looked at. Tactile-tactile enhancement occurred only when the stimulated hand was not looked at, and was abolished in the forced-choice task. Overt visual attention thus appears to affect crossmodal and intramodal enhancement in different ways. Looking at the stimulated body part may reinforce processing of the common spatial location of tactile and auditory events and increase auditory-tactile enhancement at early sensory stages. It may reduce tactile-tactile enhancement by reinforcing the spatially separate processing of tactile events on adjacent fingers.

TMS-based evidence for the independence of visual bias and audio-visual integration

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Previous studies show that visual stimuli can influence auditory localization. The present study investigates the role of primary visual cortex (V1) on multisensory-mediated auditory localization, using rTMS (inhibitory theta-burst stimulation, iTBS). Subjects were asked to localize an auditory stimulus alone or with a concurrent near-threshold visual stimulus presented at the same spatial position or at spatial disparity, in two counterbalanced sessions performed outside (baseline) or within the inhibitory effects created by iTBS of V1. Compared to baseline, after iTBS, visual capture (i.e. perceptual translocation of the auditory stimulus toward the visual one, when audio-visual stimuli are spatially disparate) disappeared into the visual field contralateral to the stimulated site, whereas no effect was found into the ipsilateral visual field. However, when audio-visual stimuli were spatially coincident, an acoustical localization enhancement of the same magnitude in the contralateral and in the ipsilateral field was found in both sessions, suggesting an audio-visual integration effect. These results suggest that visual capture and multisensory integration for spatially coincident audio-visual stimuli are functionally independent and mediated by different neural circuits: V1 activity is necessary in mediating visual capture, whereas audio-visual integration is unaffected by V1 inhibition and may be mediated by subcortical structures such as Superior Colliculus.

Visual and haptic size constancy in object recognition

Matt Craddock, Rebecca Lawson

University of Liverpool

Size changes from study to test affect subsequent old/new recognition of novel and familiar objects in the visual modality (e.g. Jolicouer, 1987; Biederman & Cooper, 1992; Uttl, Graf, & Siegenthaler, 2007). Size changes also disrupted haptic and visual old/new recognition of 2D, novel, symbolic stimuli (Srinivas, Green, & Easton, 1997). However, no experiments have examined how size changes might affect haptic recognition of real, 3D familiar objects. Size may be a more important cue for haptics than for vision, since it is not confounded with distance. Two experiments compared size effects on visual and haptic old/new recognition of familiar objects. The first experiment presented greyscale photographs of real 3D objects. The second experiment presented the real 3D objects haptically. In both experiments, participants first named one of three (standard, different size, and different shape) exemplars of 36 categories of object. Second, old/new recognition was assessed for the standard exemplars from each of the 36 old, studied categories and for 25 new object categories. Changes in size or shape disrupted both visual and haptic old/new object recognition to a similar extent, indicating similarity between the two modalities.

Prior linguistic experience modulates the temporal processing of audiovisual speech signals

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To what extent does our prior experience of particular combinations of audiovisual stimuli influence how we subsequently bind those stimuli? In the present study, we addressed this question by testing English and Spanish speakers (having little prior experience of Spanish and English, respectively) on a simultaneity judgment (SJ) task involving the presentation of visual and auditory channels of English or Spanish spoken sentences, that had been desynchronized by varying amounts. The results revealed that for English observers, the visual speech stream had to lead the auditory speech stream by a significantly larger interval in English than in Spanish for simultaneity to be perceived. By contrast, the Spanish observers showed the opposite pattern of results. We propose that this modulation of multisensory perception by the observer's prior experience is a consequence of the constraining role that visual information plays in the temporal alignment of audiovisual speech signals.

Neuropsychological evidence for different circuits subserving cross-modal recalibration of auditory spatial perception

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After a period of exposure to auditory-visual spatial disparity, sound localization is systematically shifted in the direction of the visual stimulus. In order to investigate the locus of the underlying processes, we asked patients with parietal (i.e.,neglect) and occipital lesion (i.e.,hemianopic) to localize weak sounds by laser pointing, before and after a 4 min adaptation to repetitive auditory-visual stimulation. During the adaptation phase, bimodal stimuli could be presented spatially displaced (8°) or spatially coincident (0°), in either hemifield. After adaptation to spatial disparity in the normal field, both groups showed significant shifts toward the visual stimulus. In contrast, after adaptation in the affected field, there was a significant shift in neglect patients, but not in the hemianopic patients. This reveals the importance of visual cortex for the remapping of auditory space: a lesion of this area prevents any form of visual bias. Interestingly, after exposure to coincident stimuli, all patients showed a reduction in localization error in both hemifields, with greater improvement for sounds presented at the adapted location. Such an effect may be explained by a covert processing of visual stimuli, possibly mediated by spared retino-tectal pathway. The present results suggest the independence of mechanisms underlying visual bias and audio-visual enhancement in the recalibration of auditory space.

Effects of FM sounds on the perceived magnitude of self-motion induced by vestibular information

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Frequency-modulated (FM) sounds impart significant effects on perceived self-motion because they convey information of a sound source's relative motion, as in the Doppler Effect. We examined whether FM sounds affect the perceived magnitude of backward-forward self-motion. The center frequency of one-octave band-pass noise was modulated smoothly between low frequency (LF) and high frequency (HF). The amount of modulation accorded with the velocity of motion in Exp. 1 and with its acceleration in Exp. 2. Experiment 1 examined three types of modulation: LF at the back dead center with HF at the front dead center (type 1-1), in the opposite direction to type 1-1 (type 1-2), and constant frequency (type REF as a reference). Experiment 2 examined three other types of modulation: LF at the front and back dead center with HF at the bottom dead center (type 2-1), in the opposite direction to type 2-1 (type 2-2), and type REF. The perceived magnitude of self-motion was significantly larger than that with the reference in Exp. 2; Exp. 1 yielded no significant result. These results suggest that auditory-vestibular integration depends on the type of frequency modulation of its auditory stimulus.

Speech perception is contaminated by visual words (orthography)

Marie Montant[1], Daniele Schön[2], Jean-Luc Anton[3], Johannes Christoph Ziegler[1]

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A growing number of studies suggest that speech perception is influenced by the consistency of the coupling between the auditory (phonological) and the visual (orthographic) forms of words (for a review, see Ziegler et al., 2008, J Exp Psych: Learn Mem Cog). Spoken words with inconsistent rimes (that can be spelled in multiple ways, e.g. the rime /-ANE/ is spelled differently in /BRAIN/ and in /SANE/) take more time to be processed than spoken words with consistent rimes (that can be spelled only one way, like /-ABE/). This auditory consistency effect could either be due to online activation of orthographic word forms in the left posterior cortex (BA 37 or 39/40) or to the direct contamination of the speech areas (BA 22, 44, 45) by orthographic knowledge, which would take place during reading and writing acquisition. To disentangle these two hypotheses, we conducted a bimodal fMRI experiment. Orthographic decisions on visual words involved left BA 22 and 45. Auditory lexical decisions on consistent and inconsistent words involved a wide left temporo-frontal network. The consistency effect (inconsistent minus consistent words) was located in left BA 45. These results suggest that orthographic knowledge contaminates speech perception during the process of learning how to read and write.

Towards a multisensoric auto-associative memory to empower artificial agents with episodic memory capabilities

Sascha Jockel

Current artificial memory mechanisms are not appropriate to mimic and handle learning like biological archtypes do (e.g. humans). Our artificial agent is a service robot that should be capable of memorizing episodic-autobiographical experiences of action and perception sequences based on multiple sensors. This kind of memory, in the field of psychology, refers to the so called episodic memory. A sparse distributed memory is a content addressable memory that - in many ways - is an ideal computational mechanism to be used as an episodic memory. Close memory items tend to be clustered together, with some abstraction and blurring of details. Items that are written to workspace cues evoke immediate retrieval from the memory, by returning prior activity associated with the current entry. This means that a memory is accessed as soon as information reaches the workspace and this concopts is related to episodic memory characteristics. At a certain time, workspace may contain perceptual events, spatial- and temporal relations as well as prior entrys and associations investigated by current perceptions. Such perceptions are information of high-level in nature (like "robot is in front of laboratory", "holding a cup") provided by information of a variety of sensors, e.g. laser range finder, vision, haptic and so forth. Executive events are main or partial goals the robot tries to solve, e.g. "switch on the light", "open the door", "bring some coffee". Thus, observing a percept should trigger previous behaviors into attention has been taken when similar percepts were observed in the past - quite like the human episodic memory does.

Obstructing the view degrades the audiovisual integration of drumming actions

Karin Petrini, Melanie Russell, Frank Pollick

Department of Psychology, University of Glasgow

Judgements of synchrony between a drummer's movements and produced sound have been shown to be very little affected by a variety of degradations of visual information. For example, observing drumming actions from different viewpoints was found to affect sensitivity to asynchrony very little (Arrighi, Alais & Burr, 2006). Here we demonstrate that occlusion of information concerning the contact between drumhead and drumstick strongly affects sensitivity to asynchrony. Six participants with no music experience gave audiovisual simultaneity judgements to three different drumming point-light displays. These included: 1) shoulder-elbow-wrist-hand-grip-tip of the drumstick and the drumhead as a line (SEWHGTD); 2) tip of the drumstick and drumhead as a line (TD); shoulder-elbow-wrist (SEW). The presentation of the three display conditions were counterbalanced across participants and each condition was run in a different day. Each one of the conditions consisted of 20 repetitions of the display played at 3 tempos X 9 Stimulus Onset Asynchrony. The results showed that sensitivity to asynchrony was the same when the contact between drumstick and drumhead was presented (SEWHGTD and TD), while was strongly reduced when only the arm information was presented (SEW).

Haptic guidances increase the visuo-manual tracking of Japanese and Arabic letters

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Haptic guidance by a force feedback device is a technology which provides additional proprioceptive cues during visuo-motor learning tasks. The effects of two types of haptic guidance - control in position (HGP) or in force (HGF) – on visuo-manual tracking ("following") of trajectories are still under debate. Three training techniques of haptic guidance (HGP, HGF or NHG control condition without haptic guidance) were evaluated. Movements produced by adults were assessed in terms of shapes (dynamic time warping) and kinematics criteria (number of velocity peaks and mean velocity) before and after the training sessions. Trajectories consisted of two Arabic and two Japanese-inspired letters. Results revealed both types of haptic guidance do not influence the shape quality, mainly guided by visual feedbacks. Moreover, the use of HGF globally improves the fluidity of the four movements while no significant improvement was found for HGP or NHG. These results suggest that learned information for this specific motor activity could be stored as internal inverse model and encoded in force coordinates.

High-density EEG evidence of gender differences in processing of auditory and proprioceptive cues in peri-personal space

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In a recent study by Simon-Dack & Teder-Sälejärvi (in press), human participants attended to noise bursts from either left or right sound sources in free-field in three experimental conditions and button-pressed to infrequent targets. The ERP grand-average signatures of two particular experimental conditions constituted the main finding of the study: further processing of auditory stimuli in free-field was significantly attenuated when participants held the speakers in their hands as opposed to resting their hands in their laps. However, a more detailed analysis of individual differences revealed differential effects between gender and the degree to which proprioceptive cues are utilized for further processing, corroborating well-established findings regarding gender-specific strategies of processing spatial information (Hugdahl, Thomsen, & Ersland, 2006). A follow-up study with equal numbers of female and male participants was designed to specifically test and replicate this observation. Beyond a successful replication, gender differences in behavior and ERP morphologies were statistically highly significant. Behaviorally, males responded more accurately than females to targets in the attended channels. Moreover, differences in ERP patterns confirmed existing predictions of female top-down and male bottom-up strategies in determining spatial locations. References: Simon-Dack, & Teder-Sälejärvi. Proprioceptive cues modulate further processing of spatially congruent auditory information. A high-density EEG study. Experimental Brain Research (in press). Hugdahl, Thomsen, & Ersland (2006). Sex differences in visuo-spatial processing: an fMRI study of mental rotation. Neuropsychologia, 44, 1575-1583.

Blind subjects are unaware of changes in hand asymmetry

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Here we addressed the question if impaired residual vision affects asymmetry in hand use in right-handed blind subjects. Getting blind requires finding new strategies for interaction with the environment. We therefore expected changes in hand use in subjects with impairer vision. We used three types of assessment of hand use: A modified Edinburgh questionnaire to detect the subjective hand preference, a tapping task to provide insight in how dexterity is affected, and an objective measure of the frequency of hand use during activities of daily living recorded with acceleration sensors. All subjects tested indicated that their preferred hand was right. The subjective rating was positively correlated with their performance in the motor task. In addition, we found a positive correlation between right hand superiority in the specific motor task and residual vision. The more residual vision the subject had, the more superiority was present in the right hand. Surprisingly, the hand usage during daily living was correlated neither with the subjective hand preference nor with the preference observed in the motor task. This discrepancy suggests that most blind subjects are unaware of the changes in hand dominance that occur during the process of impairment of vision.

The effect of sound intensity on the audiotactile crossmodal dynamic capture task

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We investigated the effect of the sound intensity on an audiotactile crossmodal dynamic capture task. Participants had to discriminate the direction of a target stream (tactile, Exp.1; auditory, Exp.2) while trying to ignore the direction of a distractor stream (auditory, Exp.1; tactile, Exp.2). The distractor streams could either be spatiotemporally congruent or incongruent with respect to the target stream. One group of participants was presented with 75dB auditory stimuli and another group with 82dB auditory stimuli. In Exp.1, the performance of the two groups was significantly affected by the intensity of the sounds, with high-intensity distractors inducing a stronger capture effect on tactile targets than the low-intensity distractors. In Exp.2, the interference induced by tactile distractors on the discrimination of the direction of the auditory target stream was comparable between the two groups. We also found that performance on both tasks was significantly modulated by the intensity of the auditory stimuli in a within-participants design. High-intensity distractors were more effective than low-intensity distractors in ‘capturing’ the perceived direction of tactile targets (Exp.3) and the interference induced by tactile distractors was greater on the low-intensity than on the high-intensity stimuli (Exp.4). The potential role of expectancy could account for the partially discordant results when comparing the between- and within-participants patterns of results.

Tactile masking within and between hands: Insights for spatial coding of touch at the fingers

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A tactile stimulus at the fingers can be encoded according to multiple reference frames (hand-, body- or space-specific). We examined the relative importance of these reference frames by adapting a tactile masking paradigm for stimuli at the index or middle fingers of either hand (unseen). In Exp.1, participants performed a go-no-go task to detect a vibrotactile target at a pre-specified finger (e.g., right index), when this was presented alone or with a concurrent distractor either on the same hand (right middle finger), or on the opposite hand (at homologous or non-homologous locations with respect to the target finger; e.g., left index or left middle finger, respectively). Tactile masking emerged under double stimulation, both for a distractor within the target-hand and for distractors at the non-homologous location on the opposite hand. This suggests use of hand-specific (than body- or space-specific) reference frames when solving this task. In Exp.2, one hand rotated by 180° around the wrist in half of the trials. Masking effects changed only between-hands. Intriguingly, masking from the non-homologous finger reduced only when the hand that changed posture contained the target. This suggests that spatial coding for touches at the fingers depend upon the behavioural relevance of tactile stimuli.

EEG power in alpha and gamma bands follows the temporal profile of audiovisual stimuli

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The temporal dynamics of input from different modalities provide important cues for the unified perception of multisensory events. Evidence from cat visual cortex indicates that LFP power locks to the temporal profile of visual stimuli. Does stimulus locking also occur in the human brain? How might multisensory processes profit from such a mechanism? To answer these questions, we employed dynamic, audiovisual stimuli consisting of a rotating Gabor patch and frequency-modulated tone that changed smoothly over time. EEG was recorded while bimodal stimuli were shown to human subjects in congruent (matching temporal profiles) and incongruent (temporally differing) conditions, and unimodal counterparts were also presented. To quantify stimulus locking we computed cross-correlations between induced EEG power over a trial, and the corresponding speed of stimulus modulation. At occipital sites, we found that the change in speed of the visual stimulus induces an analogous change in EEG power. In the low gamma band, a positive correlation was found, while the alpha and beta ranges showed an anticorrelation. Interestingly, these effects differed across congruent and incongruent conditions, suggesting distinct roles for alpha and low gamma oscillations in the processing of dynamical multisensory events.

Coding of multisensory peripersonal space in hand-centred reference frames by human motor cortex

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Certain neurons in macaque premotor cortex have hand-centered visual receptive fields selective for rapidly approaching 3D objects and may contribute to the multisensory guidance of avoidance movements. Here, we provide the first direct evidence of hand-centered coding of space in human motor cortex. We measured changes in corticospinal excitability following presentation of 3D visual distractor balls rapidly and unpredictably approaching near to or far from the subject's right hand. Simultaneously, subjects made speeded index finger movements in response to central targets. Between 40-120ms after distractor ball appearance, single TMS pulses were applied to the left primary motor cortex, eliciting motor evoked potentials (MEPs) in the index finger muscle. At 70-80ms, MEP amplitude was significantly smaller for distractors approaching near to as compared to far from the hand. Importantly, this hand-centred MEP suppression was observed across experiments, was independent of hand and fixation positions (left or right of the midline), and was specific to 3D moving objects (i.e., did not occur with static LEDs). Additional behavioural and skin conductance measurements provided converging evidence for hand-centred representation. Given both the rapidity and selectivity of this modulation of human corticospinal excitability, these effects likely reflect automatic, hand-centered avoidance mechanisms, homologous with those demonstrated in macaques

Neuronal dynamics of bi-stable cross-modal binding

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Most studies investigating the neuronal mechanisms of cross-modal sensory integration have compared neuronal activity during conditions of different sensory stimulation. Thus, it remains difficult to attribute effects to genuine changes in cross-modal binding rather than to changes in stimulation. We recorded EEG in human subjects using an audio-visual paradigm with bi-stable cross-modal binding (Sekuler et al., Nature 1997). This allowed us to study the neuronal mechanisms of cross-modal interaction under constant sensory stimulation. The use of spectral analysis and distributed source-reconstruction techniques provided a combination of exquisit temporal and good spatial resolution. We investigated: 1) The temporal sequence of regional neuronal activations during cross-modal binding 2) If these activations are reflected in changes in oscllatory population activity 3) The spatio-temporal pattern of inter-regional interactions during cross-modal binding

Respecification of cortex following prenatal enucleation in the monkey leads to the development of projections from the temporal pole to early visual areas

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To assess the functional reorganization observed in blindness we analyzed the connectivity of monkeys devoided of visual inputs following early prenatal enucleation. This induces a 70% reduction of the striate cortex and the cortex that was destined to become area V1 (default extrastriate cortex -DEC), acquires features indistinguishable from normal extrastriate cortex. Retrograde tracers injected in the DEC and area V2 shows that in the enucleate (i) no neurons were found in cortex subserving other sensory modalities (ii) An important increase in density (10-100 times that observed in normals) affects selectively the areas of the ventral stream (V4, TEO, TE, the parahippocampal cortex, area 36, parasubiculum). Some cells were found in the hippocampus (but never observed in normals) (iii) there was proportionally more labeled neurons in supragranular layers. We observed an essentially normal connectivity pattern of area V4 of the enucleate suggesting that early deafferentation does not influence the input to higher visual areas. While the results failed to reveal a crossmodal reorganization, they do show a large expansion of inputs from the ventral pathway and the temporal pole which could have a profound influence on the function of DEC and area V2 in the operated animals.

Tactile and visual contributions to the perception of naturalness

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Most people prefer natural over artificial things, and therefore "naturalness" is a highly appreciated material characteristic. For instance, a natural wooden floor is seen as more valuable than a fake replica, though they may be comparable in quality and durability. It is therefore surprising that the amount of research into which sensory modalities may influence the perception of naturalness is minimal. In the present study we investigated how vision and touch contribute to perception of naturalness in wood. Participants rated samples of wood or imitations thereof, such as vinyl and veneers. We used four measurement methods (labelled scaling, magnitude estimation, binary decision, ranked ordering) and three exploration modalities (vision only, touch only, bimodal). The results show a high degree of consistency across measurement methods. However, the estimations from the unimodal conditions, vision and touch, were not highly correlated; thus their contributions to this perception may be independent. Finally, the results of the bimodal condition can be approximated by a weighted average model, in which vision and touch have similar weighting.

The multisensory perception of emotion in real and virtual humans

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The perception of real and virtual humans activates different neural networks (Han et al., 2004; Mar et al., 2007). The current study investigates this difference on a behavioural level, focusing on the differences between the audiovisual perception of emotional cues when portrayed by real and virtual humans. Real and virtual correlates of the same actors portraying emotional body language (De Gelder, 2006) were created using Motion Capture technology. All stimuli were tested for recognisability in a series of pilot studies. Experiment 1 consisted of a six alternative forced choice task, in which participants had to accurately identify the emotion displayed, and it was found that virtual human portrayal is as effective as real human portrayal of emotional body language. Experiment 2 consisted of a crossmodal priming study with auditory primes (emotional utterances) and visual target stimuli (emotional body language). We expected that congruent audiovisual pairs would be recognised more efficiently than incongruent audiovisual pairs (see Van Den Stock et al., 2007), for both real and virtual humans. Results will help elucidate the processes involved in the perception of emotion in real humans and whether similar processes are involved in the perception of socially-relevant information from virtual humans.

Effects of path length, visual and interoceptive information on path integration

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A number of experiments have shown that path integration in darkness can be accomplished using interoceptive information. We examine the contribution of vision to the accumulation of translational information during path integration in a return to origin task, using a fully immersive cue-rich virtual environment. Nine paths with varying lengths and numbers of turns were tested. During walking the outward legs of a path, a mis-match was introduced between actual translation and the perceived translation of the virtual environment, which was either increased or decreased. The return leg of the path was performed without vision. The mis-match trials were interleaved with two control conditions; one where vision matched interoceptive information exactly on the outward paths, and one without any visual input. ANOVA analysis on sixteen subjects showed a significant effect of the visual manipulation. Return path lengths were consistent with the visual manipulation suggesting a strong visual component to 'path integration' in this task. A separate effect of path length, depending on path type suggests that distance is underestimated for longer paths with more turns.

The impact of reaction time speed on early auditory-somatosensory multisensory interactions

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Several lines of research have documented early-latency non-linear response interactions between audition and somatosensation in humans and non-human primates. The fact that these effects have been obtained under anesthesia, passive stimulation, as well as speeded reaction time tasks would suggest that early multisensory effects are not directly influencing behavioral outcome. To address this issue more specifically and empirically, we separately averaged trials leading to fast and slow reaction times (using a median split of individual subject data for each experimental condition) from a previously published study that required stimulus detection (Murray et al., 2005 Cereb Cortex 15:963-974). We show that non-linear neural response interactions between multisensory and constituent unisensory stimuli are present for both trials leading to fast and slow reaction times. However, these effects were also modulated within the initial ~100ms as a function of subjects' reaction times, with larger and earlier effects for trials leading to fast reaction times. These results suggest that early multisensory phenomena are indeed behaviorally relevant, even if also observable under varied subjective states and task demands.

Visual-tactile perception of time

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Time perception is fundamental for adaptive interaction in the environment. Although our experience of the world is basically multisensory, previous studies concentrated most on time perception either within vision or audition. Here we asked: 1) how precise is the processing of temporal durations in the tactile modality, as compared to the visual modality; 2) whether time perception is characterized by crossmodal visuo-tactile interaction, a visual (tactile) stimulus influencing time duration of a tactile (visual) stimulus. We asked healthy subjects to perform a time bisection task both with Visual and Tactile stimuli. After subjects learned to discriminate between long and short sample durations, they judged the duration of 5 intermediate different targets within a 2-forced-choice paradigm (short or long). Subjects performed the same bisection task both in unimodal (visual or tactile) stimulation conditions, and in bimodal conditions. Moreover, bimodal conditions could be congruent (same duration for each modality) or incongruent combinations (different durations across modalities). Results showed that tactile temporal processing is highly precise, being comparable to visual processing of time. Moreover, temporal processing in bimodal conditions is less precise when incongruent durations are presented as compared to congruent ones. These findings suggest a crossmodal visuo-tactile interaction in time perception.

Localisation tasks with a three-dimensional audio-motor coupling based on an electromagnetic motion capture device

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Understanding the adaptation processes through a new sensori-motor coupling with the environment is crucial for motor rehabilitation. In particular, through the learning of the new sensory consequences of body movements, adaptation allows an increase in the level of motor performance for particular tasks as well as an evolution of the characteristics of body movements. The aim of the study reported here was to investigate audio-motor adaptation thanks to localisation tasks. The participants had to localise and reach a virtual source thanks to its auditory rendering. An electromagnetic system (fastrack Polhemus) recorded the position and orientation of the participants' head and hand. This system was connected to a 3D audio rendering system (OpenAl) that provided auditory feedback of participants' position with respect to the virtual source target. The participants' position was computed either from their hand or from their head (with the sensors located near the ears). The results of this study revealed that in both conditions participants were able to localise a source within the 3D auditory environment. Performance was overall better when the sensors were located on the hand than on the head. The results also allowed an investigation of the movements' parameters correlated with the audio-motor learning.

Orthographic effects on spoken language

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Literacy changes the way the brain processes spoken language. Most psycholinguists believe that orthographic effects on spoken language are either strategic or restricted to meta-phonological tasks. In the present series of experiments, we used event-related brain potentials (ERPs) to investigate the locus and the time course of orthographic effects on spoken word recognition in a variety of tasks: lexical decision, semantic categorization and phonological priming. Overall, the ERP data showed a clear orthographic effect on spoken language that typically preceded lexical access and semantic effects. Moreover, the onset of the orthographic consistency effect was time-locked to the arrival of the inconsistency in a spoken word, which suggests that orthography influences spoken language in a time-dependent manner. In sum then, the existence of an orthographic effect on spoken language suggest that cross-modal integration of written and spoken language is a powerful mechanism even in tasks that do not explicitly require such integration to occur.

I act, hear and see, but is it really me? Cross-modal effects in the perception of biological motion

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Embodied experience affords essential information for action perception. Perception of environmental stimuli and action tendencies towards them are mediated by motor processes. The body acts as a link between perception and action. Intentions, emotions, and mental states are shared and communicated by corporeal movements and can be perceived by the observation of kinematic body cues in point-light displays. Perceptual sensitivity to human bodily movement tends to be higher if the observer is the agent of the action. Observers are able to discriminate between their own and others' actions when depicted as point-light displays. Such agency effects have been mainly investigated by focusing on either visual or auditory modalities. Nevertheless, the understanding and control of bodily actions requires integration of sensory information from many different channels. Specifically, can auditory cues about bodily actions influence the perception of point-light action patterns? The aim of this study is to investigate self recognition in point-light displays when actions and stimuli are presented in visual or audiovisual modalities. Participants are invited to execute different ecologically valid actions (i.e. dancing to musical stimuli) and subsequently identify the agent (self vs. other) from the point-light displays. Results are discussed in relation to common coding theory and embodied simulation theory.

Auditory-visual interactions in autistic children: A topographic ERP study

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The brain's ability to integrate auditory and visual information is essential for communication and social interactions, both of which are particularly impaired in individuals with autism. The aim of this study was to investigate the electrophysiological patterns of auditory–visual interactions during passive perception in autistic children. ERPs were recorded in response to auditory (A), visual (V) and auditory-visual (AV) stimuli in two age-groups of children with autism: 5- to 10-year-olds (n=9) and 11- to 15-year-olds (n=9). These were compared to the responses of 18 age-matched controls. Auditory-visual interactions were estimated using the additive model. The significance of [AV – (A+V)] amplitude was tested with Student's t tests, and topographical analyses were performed using scalp potential and current density mapping. Autistic children's unisensory responses were overall preserved and not modulated in the bimodal condition, contrary to those of controls. Moreover, interaction effects were observed in non-sensory-specific areas with the lateralization reversed in autistic compared to typically developing children. This pattern was found in both age groups, underlying the robustness of the effects. These findings provide evidence for anomalous cross-modal interactions in children with autism.

The effects of unattended multisensory stimuli on a visual pattern completion task

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Attention has been shown to strongly interact with both unisensory and multisensory processes. An emerging question of interest is whether unattended multisensory stimuli can be integrated in order to influence behavioral and/or perceptual performance. To investigate this question, we designed a paradigm to examine the impact of unattended information both within and across sensory modalities on a visual pattern completion task. Participants were asked to view a sequential pattern of shapes and to predict the next shape in the sequence. During the "learning" phase, the shapes were presented at fixation and were paired with an unattended visual (peripherally-presented color flash) and auditory (tone) stimulus. Each unattended stimulus was linked with a specific shape, and subjects were instructed to actively ignore them. During the test phase either the visual, auditory, or paired visual-auditory stimuli were presented, and subjects had to predict the next shape in the sequence. Participants' accuracy on each of the different trial types (including incongruent pairings) was assessed. Unattended unisensory stimuli and unattended congruent multisensory stimuli failed to significantly affect performance. In contrast, unattended incongruent multisensory stimuli significantly impaired performance, illustrating the capacity of unattended multisensory cues to interact with and shape behavior.

Perceptual narrowing of cross-modal perception of nonnative contrasts

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Lewkowicz and Ghazanfar (2006) tested cross-species intersensory integration in infancy by testing infants' ability to match monkey vocalizations and faces. They found that 4-6 month-old infants matched but that 8-10 month-old infants no longer did. More recently, Lewkowicz, Sowinski and Place (in press) found that this matching was mediated by temporal synchrony, that its developmental decline continues into the second year of life, and that it's not due to unisensory processing deficits. Considered together with prior findings of narrowing in responsiveness to nonnative stimulation in audition and vision, these findings suggest that perceptual narrowing in early development is a pan-sensory and fundamental feature of development. If so, intersensory perceptual narrowing also should occur in infants' response to nonnative but intra-species (human) faces and vocalizations. To test this prediction, we investigated 6- and 11-month-old Spanish-learning infants' integration of the audible and visible attributes of the nonnative contrast (/ba/-/va/). We first familiarized infants to an audible /ba/ or /va/ and then tested their preferences for one of two faces producing these two phonemes. Results revealed that 6-month-olds looked longer at the matching face but that 11-month-olds did not providing the first evidence of perceptual narrowing of intersensory integration of speech in infancy.

Is auditory visual integration preserved in the elderly?

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Little is known about the communication across the senses in the elderly. In three ongoing studies we investigate integration of auditory and visual stimuli in an elderly population using the Shams illusion (Shams et al., 2000) and the McGurk effect (McGurk & MacDonald, 1976). In Experiment 1, based on the Shams illusion, participants are presented with a variable number of beeps and 1 flash, in order to assess whether the elderly perceive the illusory multiple flashes. The stimulus onset asynchrony (SOA) is held constant (70ms). In Experiment 2, the SOA between the stimuli is varied. We hypothesize that, if the temporal window of integration in the elderly is similar to young adults', optimal integration should occur between a SOA of 70ms and 110ms. In Experiment 3, investigating the McGurk effect, participants are presented with a series of words. In the incongruent condition the auditory word differs from the visual word giving rise to the effect. In the congruent condition the both words are the same. If audio-visual integration is preserved we would expect that the elderly will perceive the illusory words in the incongruent condition.

Visual and auditory selective attention in near and far space

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Two experiments, one in the visual domain, one in the auditory domain, aimed to investigate the distribution of spatial attention in the radial plane. In both experiments, participants detected infrequent targets at one of four locations, two in near space, two in far space. In one experimental half, participants were instructed to detect infrequent target stimuli on the left or right in near space. In the remaining experimental half, targets detected targets on the same peripheral planes but in far space. The relevant side (left/right) was indicated by a central cue on a trial-by-trial basis. The cue was followed by either a target stimulus or a nontarget stimulus, presented from one of the four stimulus locations (cued or uncued). The ERPs elicited by the cue stimuli and nontarget stimuli were collected, as well as behavioural measures.
In both modalities, behavioural results showed that participants were successful in efficiently selecting stimuli in one depth plane. It was also the case that shifting attention within far space resulted in similar cue-related lateralised effects as in near space. Unexpectedly, in the visual domain the ERPs elicited by nontarget stimuli suggested that initially stimuli from the unattended depth plane attract attention, as reflected by larger N1 amplitudes in comparison to stimuli presented at the relevant depth. This was true for near and far stimuli. In the auditory domain, attentional modulations were stronger if attention was focussed on near space. In both modalities later attention effects (SN) were consistent with behavioural findings and largest for stimuli at the relevant side and at the relevant depth. These results indicate that attention can selectively be employed to a location in depth in both visual and auditory modalities. However, attention may initially be attracted by irrelevant-depth stimuli.

Perception of simultaneity and temporal order of active and passive head movements paired with visual, auditory and tactile stimuli

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Different senses have different processing times. The consequences of this have been explored in the perceived timing of visual, auditory and tactile stimuli. However the perceived timing of vestibular stimulation, one of the fastest senses to be transduced, has not been systematically investigated. We measured the perceived timing of vestibular stimulation induced passively (head rotated by experimenter in response to 'go' stimulus) or under active control (head moved by participant in response to go stimulus). Visual, auditory and tactile stimuli were delivered at various delays from the go stimulus. Participants judged, in separate runs, whether the onset of head movement was simultaneous with the other stimulus (synchronicity judgements) or which stimulus came first (temporal order judgements). Most comparisons required head movements to occur first by between 50-90ms to be perceived as simultaneous, implying that head movements, both passive and active, were perceived after a longer latency than visual, auditory or tactile stimuli. Active movements generally needed a longer lead than passive, suggesting that they had the longest latency, which is consistent with vestibular sensitivity being reduced during active movement. These results will be discussed in terms of the perceived timing of active and passive head movement.

Crossing hands can curve saccades: Multisensory dynamics in saccades trajectories

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Crossing one's hands across the midline can interfere with multisensory processing in both spatial and non-spatial tasks. The current experiment examines the crossed hand effect in a dynamic framework. Participants were asked to saccade to visual targets during concurrent manual vibro-tactile distraction. This tactile stimulation was presented on either the same or opposite side from the target and with hands crossed or uncrossed. Trajectories of the resulting saccades were analyzed for curvature. Consistent with previous findings, spatially incongruent trials in an uncrossed position resulted in a marginal saccade curvature compared to control trials. By contrast, the crossed hand condition resulted in significant curvature when compared to control trials regardless of spatial configuration. In other words, even when tactile stimulation of a crossed hand is spatially congruent with the visual target, the resulting saccades are significantly more curved than spatially congruent controls. Thus, the current study demonstrates that the role of sensory integration in eye movement dynamics is modulated by relative positions of the hands. These results create a link between known multisensory phenomena resulting from crossed hand positions and saccade trajectories. Findings are discussed in the context of the role of perception-action loops in real-time sensory integration.

Management of the multi-sensor system and fault diagnosis information fusion of mine main ventilator

Zhao Zhongxiang

The ventilator for colliery appears kinds of malfunctions, only carry on by single information examination hard to avoid the leak diagnosis. Therefore, the status monitoring and failure diagnosis of ventilator for colliery is an important problem that needs to research urgently.The main work of this thesis is the systematically research of data fusion that studies the equipments failure to diagnosis method and realize of failure diagnosis fusion of ventilator for colliery. The research work is as below mainly: Put forward the function model that the data fusion of failure diagnosis.Aim at the request of failure diagnosis of equipments failure to data fusion, according to its characteristic and the data characteristics. With the survey data come from many ways, to these transducers put forward management thought, and put forward a frame of transducer system management function.

Where visually-guided auditory spatial adaptation occurs

I-Fan Lin

Boston University

Acoustic spatial information is processed in several stages along the auditory pathway. Different spatial cues are extracted within a limited frequency range and then integrated both across cue type and across frequency to determine perceived location. In mammals, little is known about where in the pathway this integration occurs or where visually-guided auditory spatial adaptation occurs. Two experiments were performed to explore how listeners adapt to a novel mapping between acoustic spatial cues and exocentric locations in space. Listeners were trained with visual feedback to adjust their perceptual localization of acoustic stimuli. The experiments tested the degree to which the perceptual adaptation elicited by such training generalized to sounds with untrained frequency content or in untrained regions of space, respectively. Results show that adaptation generalizes across frequency only for stimuli with the same dominant spatial cue, suggesting that 1) spatial information is integrated across frequency before being integrated across cue type, and 2) adaptation takes at a stage intermediate between these two processing stages. Spatial generalization is limited to locations in space near the locations presented during training. This result hints that auditory spatial adaptation occurs when auditory spatial information is encoded in a way that preserves spatial topology.

Friday 18th

9:00 – 10:00 Keynote address

Early cortical control of the right and left arm reaching

Larry Snyder

Washington University School of Medicine

The parietal reach region, in the posterior parietal cortex, has been characterized as coding targets for reaching in an eye-centered frame of reference. We now show that in fact, a substantial minority of PRR neurons are arm-centered, and other PRR neurons are intermdiate between eye- and arm-centered. We also find that these cells are gain-field modulated by the distance between starting arm and starting gaze position.
This gain field modulation could directly contribute to a reference frame transformation.
In the second half of the talk, we will show that both single unit recording in monkey PRR, as well as BOLD activations in human posterior parietal cortex, show that the parietal cortex represents reach targets for both limbs, with a bias for the contralateral limb. Three additional lines of evidence strongly suggest, however, that the posterior parietal cortex controls only the contralateral limb. We will discuss the significance of these findings, both in terms of parietal control of reaching and in understanding the limitations of single unit and BOLD data.

10:30 – 12:30 Graduate Student Symposium

Chair: Brigitte Röder

Bridging the gap between phonology and reading: Evidence from developmental neuroimaging

Vera C. Blau, Nienke van Atteveldt, Jochen Seitz, Rainer Goebel, Leo Blomert

Maastricht University

Learning to associate letters and speech sounds is an important milestone in literacy acquisition. We used pediatric functional magnetic resonance imaging (fMRI) to investigate letter-speech sound integration in 8-12 year old children with and without reading impairment. Dyslexic and control children (N=20) were scanned at 3T while viewing and/or listening to letters and speech sounds and performing a simple attention control task. Speech sounds and letters were presented in isolation or in congruent or incongruent combinations. Dyslexic readers activated early auditory cortex (Heschl Sulcus/Planum Temporale) less than fluent readers in response to congruent versus incongruent letter-speech sound pairs. Moreover, dyslexic readers show less pronounced activation for speech sounds in isolation. Finally, dyslexic readers but not fluent readers activate left-hemispheric pre-central motor regions in response to visual and bimodal stimuli. These findings suggest that during reading acquisition fluent readers but not dyslexic readers sufficiently automate letter-speech sound associations. Moreover, the data suggest that the cause of this insufficient letter-speech sound binding reside in the phonological domain. On the basis of the present findings, we propose that the impaired neural binding of letters and speech sounds might act as mediator between phonological processing deficits and reading problems in developmental dyslexia.

The visual attentional blink produces cross-modal effects that enhance concurrent involuntary auditory processing

Keren Haroush, Leon Deouell, Shaul Hochstein

Hebrew University, Jerusalem

When looking for two targets embedded in a rapid sequence of visual presentations (RSVP), subjects often accurately report the first target (T1) but not the second (T2), perhaps due to preoccupation with T1 consolidation. This is known as 'Attentional Blink' (AB). We ask if the AB is multimodal, but avoid using a dual task paradigm, which may confuse AB and task switching effects. We record auditory Event Related Potentials (ERPs) to unattended frequent standard and rare deviant tones, while participants performed only a two-target visual RSVP task. The dependent measure is the mismatch negativity (MMN), a signature of involuntary change detection, the difference between the ERP responses to auditory standards and deviants. Surprisingly, we find that when conditional identification of visual T2 fails (for a T1-to-T2 lag of 3 stimuli), the auditory MMN is significantly increased compared to trials (with the same lag) where both visual targets are correctly reported. Thus, when visual attention falters, auditory processing gains. This could be due either to release of sensory attentional resources by the "blinking" visual system, allowing more resources to be devoted to audition, or to a failure to inhibit the processing of irrelevant auditory information during the blink period.

Perceptual training-induced narrowing of the multisensory temporal binding window

Albert R. Powers, Andrea R. Hillock Mark T. Wallace

Vanderbilt University

The brain's ability to bind incoming multisensory stimuli depends critically on their temporal structure. Specifically, there exists a window of time wherein multisensory stimuli are bound together, affecting perception and performance. Although recent evidence suggests that multisensory temporal processing is malleable in adults, no study has looked at whether this temporal window of integration can be narrowed. We used an audiovisual simultaneity task to determine the malleability of the temporal window's boundaries, subjecting 24 participants to a perceptual learning paradigm wherein feedback was given as to the correctness of their audiovisual simultaneity judgments. Results show that the temporal window was narrowed by 29% (from 291 to 177ms), the effect was stable for one week after training, and a similar effect was seen in subjects' susceptibility to the Flash-Beep illusion. Furthermore, the effects were specific to active training: subjects passively exposed to the identical stimulus set without feedback showed no performance improvements. This generalization indicates alteration of a common multisensory pathway and has strong implications for future manipulation of performance on more complex tasks. Given recent evidence for an expanded temporal window in neurodevelopmental disabilities such as dyslexia and autism, these efforts may lead to more effective diagnostic and remediation tools.

Neural correlates of sensory feedback loops in reaching

Alexandra Reichenbach[1], Axel Thielscher[1], Angelika Peer[2], Heinrich H. Bülthoff[1], Jean-Pierre Bresciani[1]

[1]Max-Planck-Institute for Biological Cybernetics, [2]Technische Universitaet Muenchen

When reaching for a target, the information provided by different sensory channels is continuously processed to supervise the ongoing movement. If a discrepancy between predicted end-point of movement and target location is detected, the arm trajectory is modulated to preserve reaching accuracy. Desmurget et al. (1999) showed that the left posterior parietal cortex (lPPC) is crucial for this online control when the visual target is displaced. We investigate further the localization of involved brain areas in the lPPC and expand the paradigm to other visual and proprioceptive perturbations (visual hand feedback displacement and force impulse application to the reaching arm). An fMRI study served as localizer task. All subjects showed strong activation in the lPPC when correcting for any visual perturbation. Using event-related TMS, we subsequently tested the site of strongest fMRI activation on the lPPC and some adjacent control sites. The goal was to disrupt online corrections occurring with a target displacement. Despite huge inter-individual differences in the location of the strongest BOLD activation, we could demonstrate spatial localized TMS effects in congruence with the site of each participant's individual fMRI activation in the lPPC. The next goal is to find the dedicated cortical sites for the other perturbations.

14:00 – 16:00 Paper Session

Chair: Annabelle Blangero

Movement synchronisation to multisensory temporal cues

Mark T Elliott[1], Andrew E Welchman[1], Michail Doumas[2], Alan M Wing[1]

[1]University of Birmingham, [2]K. U. Leuven

Responding and synchronising movements to external events is a task we perform on a daily basis, whether it be tapping our foot along to a song or keeping in step with a dance partner. Often the brain has access to multiple sensory cues useful for timing actions (e.g., the auditory beat, flashing lights and touch of a dance partner), yet when presented independently, previous studies have shown that auditory cues dominate other modalities when controlling movement timing. Here we test a Maximum Likelihood Model (MLE) of multisensory combination for the temporal control of action. We asked participants to tap their index finger in time with a beat provided by a combinatory pair of auditory, haptic or visual metronomes. Furthermore, differing levels of noise were added to manipulate the reliability of individual metronomes. Synchronisation performance in multimodal settings was predominantly in accordance with that of an MLE combination of the component signals: metronome-tap asynchronies were intermediate between the components and variability was lower. Our results suggest that when timing actions coincident with an external event the brain combines all the available sensory information in a quasi-optimal way to minimise the synchronisation variability.

Functional dynamic changes of peripersonal space induced by actions

Claudio Brozzoli[1], Francesco Pavani[2], Lucilla Cardinali[1], Christian Urquizar[1], Olivier Sillan[1], Alessandro Farnè[1]

[1]INSERM U864 "Espace et Action"; Université Claude Bernard, Lyon; Hospices Civils de Lyon, Hôpital Neurologique, Mouvement et Handicap, Lyon, [2]Dep. Cognitive Science and Education, University of Trento, Italy; Center for Mind/Brain Sciences, University of Trento, Italy

Single cell recording in monkeys' parietal and frontal cortex showed that visuo-tactile neurons contribute to represent space near to the body. Neuropsychological studies suggested a similar coding of the multisensory peripersonal space (pps) in humans. We have recently shown that action dependent modifications of multisensory coding of pps arise in humans during action execution. Here we asked whether different modulations of multisensory coding of pps may arise on-line during different kinds of action. Healthy subjects were involved in two concurrent tasks: 1) They discriminated the elevation of tactile stimulations delivered on their right hand (up-index finger, down-thumb), while ignoring visual distractors embedded on the upper and lower part of a distant object; 2) They had to grasp or, in a different session, point to the same target object, with the tactually stimulated hand. Visuo-tactile stimulations were delivered before, at the onset or during action execution (250 ms from action onset). Results showed that right-hand actions modulated the visuo-tactile interaction, which increased at the onset of the movement and during its execution. Crucially, grasping induced a stronger effect than pointing to the object. Different actions thus induce different re-mapping of the multisensory pps, as a function of action phases.

The role of stereo vision in visual and vestibular cue integration

John S. Butler[1], Heinrich H. Bülthoff[1], Stuart T. Smith[2]

[1]Max Planck Institute for Biological Cybernetics, [2]Prince of Wales Medical Research Institute

Self-motion through an environment is a composite of signals such as vision and vestibular cues. Recently, it has been shown that visual-auditory cues and visual-haptic cues combine in a statistically optimal fashion. We asked what role does stereo vision play in optimal integration of visual and vestibular cues for linear heading. Participants performed the task in visual alone, vestibular alone or combined visual-vestibular (self-motion). The conditions were grouped into two experiments; bi-ocular, 2-D experiment and stereo, 3-D experiment. Participants were seated on a Stewart motion platform and presented with two motions consisting of a standard heading of straight ahead and a comparison heading and judged which movement was more to the right. From the responses individual JND were calculated (i.e., reliability measure). In the 2-D experiment 40% of participants' self-motion reliability was worse than their most reliable unimodal cue, thus violating optimal cue combination. In the 3-D experiment all subjects self-motion reliability was not statistically different from the optimal predicted self-motion and therefore more reliable than either unimodal cue. These results can be evaluated with respect to a neuronal population model. These findings show that visual-vestibular cues combine in statistically optimal fashion with the caveat of stereo visuals.

Must the hand be seen or only imagined for visuoproprioceptive integration? Evidence from ERP

Pascale Touzalin-Chretien, Andre Dufour

Behavioral studies have employed various types of experiment to investigate the links between vision and proprioception. The present study sought electrophysiological evidence of the contribution of visual inputs to visuoproprioceptive integration. Using the brain event-related potential called the lateralized readiness potential, which reflects cortical activity in the primary motor cortex, we showed that viewing the movements of one hand is sufficient to generate cortical motor response preparation related to this hand, even if it is not the one that actually moves. Indeed, we detected LRPs related to movements of a hand seen in a sagittal mirror – indicating the presence of neural activity in the primary motor cortex related to this hand – while the other hand was active. Furthermore, we showed that this cortical activity does not depend on proprioceptive information, since LRPs were recorded even when the apparent position of the hand in the mirror and the real position of the hidden hand were incongruent. The present study also showed that this motor activation only occurs when acute visual information about the hand is available. When the visual information of the hand in the mirror was reduced to small lights, yielding its representation by means of a structure-from-motion process, no motor activity was recorded in the cortical area of the inactive hand. These results indicate that cortical motor activity relies on the viewed image of the hand rather than on its actual position, and that this cortical motor activity can be modulated by visual information. These results give new insights into how the brain integrates visual and proprioceptive information during the execution of voluntary movement.

Optic ataxia is not only 'optic': Impaired spatial integration of proprioceptive information

Annabelle Blangero

INSERM U864, Espace et Action, Lyon

Optic ataxia is considered to be a specific visuo-manual guidance deficit, which combines pointing errors due to the use of the contralesional hand ("hand effect") and to the presentation of the visual target in the contralesional field ("field effect"). The nature of the hand effect has not been identified. The field effect is acknowledged as an impaired spatial integration of visual target location. However, spatial integration of proprioceptive information from the arm has never been experimentally tested in these patients. Here, we specifically investigated the capacity of two patients with unilateral optic ataxia in tasks requiring different levels of proprioceptive integration from primary information processing to proprioceptivo-motor integration. In a first experiment -proprioceptive pointing with the ipsilesional hand toward the index finger of the contralesional hand- revealed a large mislocalisation of the ataxic hand accounting for the hand effect. In a second experiment -proprioceptive pointing with the ataxic arm toward the finger of the ipsilesional hand- revealed reaching errors for non-visual targets, i.e. optic ataxia is not specific to 'optic' targets. Altogether, the present results call for a redefinition of this neurological condition in the framework of parietal functions for multimodal integration.

Is visuo-proprioceptive integration advantageous to update internal models

Fabrice R. Sarlegna[1], Lionel Bringoux[1], Nicole Malfait[2], Jean-Louis Vercher[1], Christophe Bourdin[1]

[1]Institute of Movement Sciences, Marseille, [2]Pole 3C, Marseille

Motor learning of new force fields has been examined to explore how the nervous system may modify sensory-to-motor transformations. When the kinematics of limb movement are perturbed by altered force environments, somatosensory as well as visual error signals may drive adaptive update of the motor commands. It has been suggested that proprioceptive (rather than visual) information is critical to update internal models of limb dynamics. Consistent with this view, DiZio and Lackner (2000) reported that blind subjects can adapt their goal-directed arm movements as well as sighted subjects, when moving in a new force field. However, recently our group found that vision may in fact contribute to dynamic adaptation, presumably via its integration with proprioception (Bourdin et al. 2006). In the present study, we assessed how a deafferented patient, totally deprived of proprioception, adapted to a novel force environment as compared to healthy controls. Subjects were required to point toward visual targets while seated at the center of a rotating platform producing a new force field. Surprisingly, we found that the deafferented patient adapted as efficiently as controls. This highlights the flexibility of the central nervous system which can use information from different sensory modalities to achieve identical adaptation outcomes.

16:00 – 18:00 Poster Session III

fMR-adaptation reveals multisensory integration in human superior temporal cortex

Nienke van Atteveldt, Vera Blau, Leo Blomert, Rainer Goebel

Maastricht University, Faculty of Psychology, Dept. of Cognitive Neuroscience

Functional magnetic resonance imaging (fMRI) investigations are important to understand human multisensory integration; however, the relatively coarse spatial resolution limits the possibility to make inferences about neuronal mechanisms. Here, we explored the fine-scale organization of human multisensory cortex using fMR-adaptation, a method hypothesized to measure functional properties of neuronal populations beyond the resolution of averaged fMRI-signals across voxels. We adapted fMRI responses to repeated audiovisual stimuli and varied the associative relation between the auditory and visual inputs, while keeping unisensory inputs constant. Adaptation in several smaller clusters distributed over superior temporal sulcus and gyrus (STS/STG) showed sensitivity to the audiovisual relation, whereas a larger occipital-temporal network adapted independently of this relation. The differential adaptation effect in STS/STG is unlikely to result from two separate unisensory populations within the identified voxels, since these respond only to one modality and thus should be “blind” to how the different inputs are combined. Our results therefore strongly suggest multisensory integration on the neuronal level in distributed STS/STG clusters, in accordance with previous high-resolution human fMRI and animal electrophysiological recordings. In sum, this study contributes to link invasive animal and human fMRI findings, and thereby offers an important new approach to study human multisensory integration.

Auditory capture during focused visual attention

Thomas Koelewijn[1], Adelbert Bronkhorst[1,2], Jan Theeuwes[1]

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It is well known that a sound coming from a particular location can capture visual attention, as previously shown in crossmodal cueing studies. The current study shows that when performing a task involving the discrimination of a visual target, an irrelevant auditory cue near the target location results in performance benefits relative to a neutral condition. In contrast, when the irrelevant auditory cue comes from a non-target location there are performance costs. We have determined whether it is possible to suppress such auditory capture by endogenously focusing visual attention to a restricted area in space. Previous studies have shown that endogenously focusing attention can eliminate capture by visual stimuli. Unlike these studies, the current study shows that even when attention is highly visually focused, auditory stimuli still capture visual attention. However, in this case there are only performance costs from auditory stimuli coming from the non-target location; cueing benefits of a sound presented near the visual target are no longer present.

Visual anticipatory information modulates audiovisual cross-modal interactions of artificial stimuli

Jean Vroomen, Jeroen Stekelenburg

Tilburg University

The neural activity of speech sound processing (the N1) can be suppressed if a speech sound is accompanied by concordant lip movements. Here we demonstrate that this audiovisual interaction is not speech-specific or linked to human-like actions, but it can be observed with artificial stimuli as well. When a pure tone was accompanied by the squeeze of a rectangle, there was an N1-suppression if the temporal occurrence of this audiovisual event was made predictable by two moving disks that touched the rectangle. There was no N1-reduction by synchronized visual information that did not precede sound onset. The N1-reduction was also abolished if the delay between the audiovisual event and the disks varied from trial-to-trial. These results demonstrate that the N1-suppression is induced by visual information that precedes and reliably predicts sound onset, without a necessary link to human action–related neural mechanisms.

A Finite element fingertip model for simulating tactile sensation

Fei Shao

The analysis of the mechanics of the contact interactions of fingertips/textured surfaces and the stress/strain distributions in the skin of the fingertip is essential to understand and then manufacture surface texture for specific tactile affects. Solid mechanics models may help explain how skin microstructure, in particular the epidermal ridges, influences fingertip mechanoreceptors' sensitivity to a textured surface. In the present study, a two-dimensional (2D) finite element (FE) model of a fingertip is proposed to simulate the responses of a fingertip when it is statically loaded or move over a textured surface. Results shows that the epidermal ridges have little effect on stress/strain distribution within the fingertip in static loading and increase the vibration significantly when a fingertip slides over a textured surface. The friction force fluctuations during the sliding of the fingertip model with epidermal ridges are four times greater than for the model without epidermal ridges. This initial study demonstrates that skin microstructure may aid tactile perception.

Touching the sound: High-frequency oscillations in a distributed cortical network reflect cross-modal semantic matching in haptic-to-auditory priming

Till R. Schneider, Simone Lorenz, Daniel Senkowski, Andreas K. Engel

Department of Neurophysiology and Pathophysiology, University Medical Center Hamburg-Eppendorf

When visual input is restricted like in darkness, we often rely on haptic and auditory information to recognize objects. While haptic object information is provided via the tactile and kinaesthetic senses stimulated by touching the objects, auditory object information is conveyed via the auditory system activated by sounds of objects. Here we examined in a cross-modal priming paradigm how active haptic exploration of natural objects affects the neural encoding of subsequently presented sounds of objects. Sounds were either semantically congruent or incongruent with the haptic objects. High-density electroencephalogram measurements and source reconstruction by means of linear beamforming were applied to examine neural responses in the gamma-band (30-100 Hz) to semantically congruent and incongruent stimuli. Shorter reaction times for semantically congruent compared to incongruent auditory inputs were observed, suggesting a haptic-to-auditory priming effect. Enhanced neural responses for semantically congruent compared to incongruent auditory inputs were observed in early evoked (50-100 ms) and long latency total (200-400 ms) gamma-band activity. These latter effects were projected to a network of multisensory convergence areas including left superior and middle temporal gyrus. Our results demonstrate that active haptic exploration primes auditory object recognition in modality independent semantic networks during multiple-stages of information processing.

The impact of gravitoinertial cues on the perception of lateral self-motion

Hans-Günther Nusseck, Harald Jürgen Teufel, Jennifer L. Campos, Heinrich H. Bülthoff

Max Planck Institute for Biological Cybernetics

It is typically assumed that during passive motion in darkness, velocity and traveled distances are estimated by inertial signals. The forces occurring during linear acceleration can be detected by vestibular and other sensory systems. These inertial forces are in principle indistinguishable from comparable gravitational forces during tilted orientations. In this study, we used this tilt-translation ambiguity to systematically alter gravitoinertial forces and evaluated the effect on the perception of curved-linear translation. Participants were seated in a completely dark room on the MPI Motion Simulator and used a steering wheel to control lateral motion on an arc. A target was briefly flashed in the darkness and participants were asked to move to it. A sideways tilt was applied either in the same or in the opposite direction of lateral movement to attenuate or enhance gravitoinertial forces. Attenuating gravitoinertial forces did not affect distance estimates, whereas enhancing gravitoinertial forces resulted in a significant but small decrease in produced distances. This suggests that self-motion perception in the absence of visual information might not be as strongly influenced by gravitoinertial forces as typically assumed. It might be based more on non-directional sensory information such as noise and vibrations that accompany almost any motion.

The long road to automation: Neurocognitive development of letter/speech-sound processing

Dries Froyen, Milene Bonte, Nienke van Atteveldt, Hanne Poelmans, Leo Blomert

Maastricht University

Automatic integration of letters and speech-sounds is necessary to establish fluent reading. In a recent event-related potentials (ERP) study we demonstrated early and automatic integration of letters and speech-sounds in adult readers within a narrow temporal integration window [1]. The present study further investigated when and how letter/speech-sound integration becomes automatic by employing the same ERP-paradigm in beginner (8y) and advanced (11y) readers. Speech-sounds were presented in isolation or in the context of letters appearing either simultaneously with or 200ms before the speech-sound. As opposed to adult readers, no early effect of letters on speech-sound processing (at 150ms) was found in beginner readers. Instead, beginner readers exhibited a late deviant ERP response at 650ms. Even advanced readers, despite four years of reading instruction, showed the adult-like early effect (at 150ms) only for 200ms stimulus onset asynchrony. At simultaneous presentation of letters with speech-sounds, advanced readers revealed only a late effect (at 650ms). The double shift in timing properties of letter/speech-sound processing (both in latency and temporal integration window) indicates a qualitative shift from mere association in beginner readers to automatic, but still not adult like, integration in advanced readers. [1] Froyen, Van Atteveldt, Bonte, & Blomert, 2008, NSL.

Encoding differences in visual and haptic face recognition

Lisa Dopjans, Christian Wallraven, Heinrich H. Bülthoff

MPI for Biological Cybernetics

In previous experiments, we provided further evidence that 3-D face stimuli can be learned and recognized by touch alone. Performance was significantly improved when haptic memory was refreshed during the experiment, indicating high memory demands due to the serial encoding process of haptic exploration. We also found that performance in a complementary visual experiment was better than in the haptic one. We suggested that these results arise from differences in encoding procedures (holistic in vision vs. serial in haptics). To test this hypothesis we designed the following two experiments which promoted serial encoding also in vision: Experiment 1 used the same old/new recognition task for which three faces were learned with three subsequent test-blocks. Participants used a mouse to move a Gaussian window which uncovered 2° of a photograph of the 3-D face. Recognition accuracy was low(d'=.98), equivalent to non-refreshed haptic performance, and significantly lower than for unrestricted visual recognition(d'=2.12). Using the same design in Experiment 2, memory was refreshed by repeated exposure to the learned faces. Performance increased significantly(d'=1.64) to levels of memory-refreshed haptic performance and unrestricted visual recognition. The performance differences in visual and haptic face recognition therefore might be attributed to modality-specific encoding strategies and memory demands.

Vection during walking: effects of vision-action direction congruency and visual jitter

Michiteru Kitazaki[1], Atsushi Murata[2], Shinichi Onimaru[3], Takao Sato[4]

[1]Research Center for Future Vehicle, Toyohashi University of Technology, [2]Department of Knowledge-based Information Engineering, Toyohashi University of Technology, [3]Department of Electronic and Information Engineering, Toyohashi University of Technology, [4]Department of Psychology, University of Tokyo

We aimed to investigate effects of optic-flow direction and visual jitter on the vection during walking. In Experiment1, viewpoint motion along line-of-sight was simulated in a three-dimensional cloud of dots (4km/h), and its optic flow was presented on a 120-inch rear-screen. The direction of simulated motion was forward (expansion) or backward (contraction). Visual jitter (vertical oscillation at 1Hz, amplitude 10cm) was added on the optic flow for half trials. Eleven subjects observed the stimulus during walking (4km/h) or standing still on a treadmill at 1.2m viewing distance for 60s. Vection latency was measured. All 8 conditions (forward/backward x with jitter/without jitter x walking/standing) were repeated 4 times. We found the near-significant interaction of walking and optic-flow direction conditions ($p=.08$). The latency was shorter with the backward optic flow than the forward only when observers were walking. The interaction of walking and jitter conditions were significant ($p<.05$). The jitter facilitated vection only when observers were standing still. In Experiment2, we simulated viewpoint motion horizontally (leftward/rightward). Any main effect or interaction was found. These results suggest the vection is inhibited when the self-motion directions in vision and action are identical, and the visual-jitter effect is limited for stationary observers.

Analyzing haptic and visual object categorization of parametrically-defined shapes

Nina Gaißert, Christian Wallraven, Heinrich H Bülthoff

Max Planck Institute for Biological Cybernetics

To investigate multi-sensory, perceptual representations of three-dimensional object spaces, we generated complex, shell-shaped objects by altering three parameters defining shell shape. For haptic experiments, 3D-printed plastic models were freely explored by blindfolded participants with both hands. For visual experiments, we used 2D images of these objects. Previously, we reported results of a similarity rating task in which we split the three-dimensional object space into three orthogonal planes. Multidimensional scaling (MDS) of the pair-wise similarity ratings showed that participants reproduced the three planes almost exactly both visually and haptically. Here, we report results of a categorization task in which all objects were presented simultaneously either visually or haptically to ten participants who then categorized the objects in as many groups as they liked to. MDS analyses revealed a three-dimensional perceptual space underlying both visual and haptic data. Interestingly, the three dimensions corresponded to the parameters of shell shape with a different weighting of the dimensions in the visual and the haptic condition. Our results show that humans are able to reproduce the underlying parameters of a complex, three-dimensional object space in a similarity and categorization task using either visual or haptic modalities surprisingly well.

Active touch vs. passive touch in roughness discrimination: An fMRI study

Cristina Simoes-Franklin, T. Aisling Whitaker, Fiona Newell

Institute of Neuroscience and Department of Psychology, Trinity College Dublin

Several studies have addressed the differences between active and passive touch using a number of methods but no consensus exists concerning the superiority of one exploration type over another. This work aims to investigate the brain correlates of active and passive touch in a roughness discrimination task. Subjects performed a roughness estimation task in two different conditions: in the active touch (AT) condition subjects actively explored a surface with their finger, whereas in the passive touch (PT) condition the surface moved under the subject's finger. The stimuli consisted of three different grades of sandpaper. Behavioural results revealed that roughness estimations were less accurate for the medium surface than for either the smooth or rough surfaces. Preliminary analysis of the functional data shows wider activation in the somato-motor regions for the AP condition. Overlapping brain regions for the AT and PT conditions, include somatosensory, cognitive and limbic regions. Only the ACC/pre-SMA shows a difference between the two conditions, with stronger activation for AT than for PT. This difference might be due to execution of the movement during the AT condition. Preliminary investigations suggest that neural differences between active and passive explorations are manifest in the more cognitive areas of the brain.

Different learning strategies in intra- and inter-modal 3-D object recognition tasks revealed by eye movements

Yoshiyuki Ueda, Jun Saiki

Kyoto University

The different pattern of recognition performance was found whether participants recognized 3-D objects by the same or different modalities as they learned (Ueda & Saiki, 2007). We investigated eye movements to estimate strategies used in within- and cross-modal 3-D object recognition. In the experiment, an unfamiliar 3-D object was presented visually for 2 seconds, followed by a recognition test. Participants were told the test modality before the study phase, during which their eye movements were recorded. For the recognition test, the test stimuli were presented either visually or haptically from various viewpoints, and participants responded as to whether or not it was the same as the object presented earlier. The patterns of eye movements during the learning phase were different depending on prespecified test modality. Participants focused on combination of parts when the test modality was also vision (intra-modal recognition), whereas they focused on the shape of distinct parts when the test modality was haptics (inter-modal recognition). These different patterns of eye movements may reflect different strategies in learning of 3-D objects, leading to different recognition performance.

Biasing saccades with sound

David McCormick, Pascal Mamassian

Université Paris Descartes

In an audio-visual task, we established that saccade landing-positions are susceptible to bias when a visual target is presented in conjunction with an auditory event at an incongruent location. In our experimental paradigm, the exhibition of this bias is contingent on two additional criteria. First, a simultaneous visual distractor must also be present. Second, observers must have prior knowledge of the overall audio-visual location congruence in the task. Observers were required to perform a saccade toward a cloud of black dots presented at a random, eccentric, screen location. A cloud of white dots was presented simultaneously on the opposite side of the screen. Experiment 1: in 75% of trials, a tone was presented, via headphones, to the ear congruent with the black dots' location; the remaining 25% of trials contained a tone presented to the ear congruent with the white dots' location. The frequency of (error) saccades toward white dots increased in incongruent-trials. Experiment 2: audio-visual location congruency was 50%; overall time to saccade onset was increased, but differences in congruent-/incongruent-trial errors were insignificant. In light of the results from experiment 2, we interpret experiment 1's diverging congruent/incongruent error-rates in terms of attentional cueing, rather than multisensory integration.

EEG and fMRI during an unimodal and a crossmodal flanker task

Matthias Bischoff[1], Roman Pignanelli[1], Helge Gebhardt[1], Carlo Blecker[1], Dieter Vaitl[1], Gebhard Sammer[2]

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This study compares a visual Eriksen flanker task and a flanker task with auditory distractors with respect to differences in electrophysiological and hemodynamic activation measured with EEG and fMRI. In the flanker task observers are asked to selectively attend to a central target and signal the direction it points to, while ignoring flanking stimuli. Depending on condition the flanker stimuli point in the same direction as the target (congruent), in the opposite direction (incongruent) or they offer no direction information (neutral). In the crossmodal flanker task only neutral visual flankers are presented, congruency is manipulated by beeping sounds originating from the left/right or center. In the unimodal as well as in the crossmodal version a lateralized readiness potential is observed in the EEG at electrodes C3 and C4 - like expected for the flanker task. Reaction times were shorter in congruent trials than in incongruent trials, reactions were faster in the crossmodal task compared to the unimodal task. Contrasting fMRI-data (region of interest analyses) of congruent and incongruent trials with neutral trials shows higher brain activation in primary sensory cortices according to the modality of distractors, i.e. in the primary visual cortex in the unimodal task and in the primary auditory cortex in the crossmodal task. In the unimodal task a broad frontoparietal network is found activated when contrasting incongruent trials with congruent trials. The same contrast reveals a more specific activation in the inferior parietal gyrus in the crossmodal task. Both flanker tasks evoke similiar behavioral and electrophysiological responses, the unimodal visual task shows a more distributed brain activation than the crossmodal task.

Audiovisual depth perception in real and virtual environments

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Depth perception has proven to be a significant hurdle for virtual reality. It has been demonstrated that there is a consistent underestimation of visual and auditory depth perception. However, these studies only explored depth perception through one modality. In this study we decided to take a multisensory approach. We conducted a 5x3x2 mixed design with Location (25m, 22.5m, 20m, 17.5m, 15m) and Modality (vision only vs. auditory only vs. audiovisual) as the within subjects factors and Environment (real vs. virtual) as the between subjects factor. Participants either saw, heard, or saw and heard a target location 10 seconds. The participants' task was to bisect the distance between the start position and the target location while wearing a blindfold. In the real environment, participants saw the real target and heard the loudspeakers. In the virtual condition, the hallway and stimuli were presented via head mounted display. The auditory stimuli were created by recording the sounds through probe microphones to acquire the participants' ear convolutions. Results show a clear underestimation of perceived distance in both unimodal conditions with larger underestimations on the auditory conditions. Performance in the multisensory condition fell between the performances from the two unimdodal conditions.

Research on the interaction between the perception of music and flavour

Kai Bronner, Herbert Bruhn, Rainer Hirt, Dag Piper

Up to the present day there is still a lack of research on the interaction between music/sound and flavour/taste. The main question is whether the psychological reality has a physiological origin, is formed by culture, or whether it is simply a figment of the imagination without physiological basis. The aim of the present study is to validate methods for research on the relation between music and flavour. Two experiments were conducted, in which flavours had to be imagined (virtual, online) or really tasted (real, laboratory). Short sound samples, varied in basic acoustic parameters, were used as auditory stimuli. Five modes of measurement were tested: 1. Verbal free association, 2. Ratings with selected adjectives, which were considered to describe intermodal properties, 3. Matching sounds of different acoustic properties with flavours, 4. Matching visual stimuli with flavour-related sounds, 5. Matching of flavour-related sound with tactile stimuli (virtual and real situation). The experiments led to the conclusion that flavours can be discriminated by either method. Remarkable were differences between the virtual and real presentation of the flavours. The results from the matching experiments enabled the design of audio logos (3 seconds duration) and sound moods (15 seconds duration), significantly related to the intended flavour.

Neuronal correlates of spatial audio-visual temporal order perception

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In a combined psychophysical and electrophysiological study of audio-visual integration and perception of temporal order we employed a spatial AV-TOJ task with bimodal and unimodal conditions, similarly to the study of Zampini et al. (2003). Participants were asked, irrespective of the sensory modality, to report on which side they perceived the onset of the first stimulus. Moreover, to contrast the neuronal correlates of bimodal and unimodal processing, this spatial design allowed us to use in our ERP analysis the term (AV+VA)-(AA+VV) (Gondan et al., 2005). This avoided possible overestimation in case of a third unknown but unspecific factor "C" in all three conditions applying the often used term AV-(A+V). Our psychophysical analysis confirmed Zampini's (2003) observation that in such a spatial TOJ, the bimodal temporal resolution measured by the just noticeable difference (JND) is smaller (higher JNDs) than the unimodal temporal resolution, especially than the visual. For the bimodal condition, however, we could not find a clear necessity for the visual modality to lead the auditory modality in order to be perceived as simultaneous. Looking on the participant’s level it was rather evident that the results in the bimodal conditions were characterized by high interindividual differences. ERP-correlates will be presented.

Intermodal attention modulates early and late stages of multisensory processing

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Animal and human studies support multisensory interactions (MIs) early in the sensory processing stream. We assessed whether intermodal attention influenced early multisensory interactions. We used event-related potentials (ERPs) to investigate the latencies and scalp topographies at which an auditory-visual multisensory stimulus elicited different ERP amplitudes than the sum of auditory and visual stimuli presented alone. Participants selectively attended to the auditory, visual, or tactile modality in a trisensory intermodal attention task. With auditory attention, early (~20 ms) MIs were observed over frontal electrodes. Visual attention delayed the MI latency to 35-75 ms with more widespread effects over frontal, central, and posterior scalp electrodes. Attention also modulated longer latency MIs with auditory and tactile attention. MIs were observed over frontal electrodes at 100--140 ms. MIs with visual attention were broadly distributed at 200-240 ms and current source density topographies revealed a posterior-contralateral distribution of the MI, significant at 140-150 ms and 210-220 ms. A centrally distributed and negative polarity MI ERP at 270-315 ms was apparent in all three attention conditions. These results indicate that multisensory interactions are modified by intermodal selective attention at multiple stages in the sensory processing stream.

Auditory-visual multisensory interactions in depth

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Multisensory interactions are a fundamental feature brain organization facilitating behaviour and enhancing sensory-cognitive processes. To date, the overwhelming majority of studies have investigated the ‘spatial rule’ of multisensory processing using spatial variation in azimuth. There is comparatively sparse evidence concerning multisensory integration of spatial cues in depth. Depth cues convey meaningful signals such as looming/approaching and recession that will inform an organism of impending dangers/collisions. These studies suggest that unisensory looming stimuli receive a processing advantage over receding stimuli and that multisensory integration in depth may be limited to looming stimuli. The present study addressed these issues in humans. Participants were presented with looming, receding, or constant intensity stimuli that were visual, auditory, or multisensory. Their task was to indicate, irrespective of sensory modality, whether they perceived a change in distance/movement. All multisensory stimulus conditions facilitated performance relative to their constituent unisensory conditions, irrespective of whether the perceived motion was in the same or different directions. Consistent with integrative processes, facilitation in all cases exceeded predictions based on probability summation. Multisensory benefits were further enhanced for looming stimuli over all other conditions. Finally, we present preliminary electrical neuroimaging results concerning the spatio-temporal brain dynamics of these effects.

An fMRI study on crossmodal interactions during object processing

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The aim of this study was to investigate which brain regions are involved in the integration of multisensory object information. Familiar objects were presented in an S1-S2 paradigm (in which two stimuli - S1 and S2 - are presented consecutively with a short time delay). The modality of S1 was varied blockwise (visual, haptic, auditory), while S2 was always auditory. Within a trial, S1 and S2 either referred to the same object or to two different objects. Thirty-one participants took part in this event-related fMRI study. We compared BOLD responses in object-incongruent and object-congruent trials. In the two crossmodal conditions the dorsolateral prefrontal cortex, the insula and the anterior cingulate cortex (ACC) were significantly more activated in object-incongruent than in object-congruent trials. Parts of the ACC were activated in the unimodal condition as well, suggesting that the ACC activation was due to incongruence of S1 and S2 independent of the modality of the objects. Additionally, we found specific activation for each crossmodal condition: in visual-auditive trials, the superior colliculi and in haptic-auditive trials, the intraparietal sulcus were more activated in object-incongruent than in object-congruent trials. Our data provides evidence for the interaction of multiple brain sites in multisensory object recognition.

Spatial modulation of auditory-somatosensory interactions: Effects of stimulated body surface and acoustic spectra

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Recent research on auditory-somatosensory interactions has shown contradictory results regarding their spatial modulation. In the present study we report on three experiments addressing auditory-somatosensory interactions in the region close to the head. Participants made speeded simple detection responses to single auditory, somatosensory or double simultaneous auditory-somatosensory stimuli. In Experiment 1, electrocutaneous stimuli were presented to either earlobe, while auditory stimuli were presented from the same versus opposite sides, and from one of two distances (20 or 70 cm) from the participant's head. The results demonstrated a spatial modulation of auditory-somatosensory interactions, especially when auditory stimuli were presented from close to the head. Experiment 2, with electrocutaneous stimuli delivered to the hands (placed either close to, or far from, the participants' head), suggests that the spatial modulation is dependent on the particular body part stimulated (head) rather than on the region of space (around the head) where the stimuli is presented. Experiment 3 shows that this auditory-somatosensory spatial effect occurs primarily for sounds containing high-frequency components. Taken together, these results show that the auditory-somatosensory multisensory integration is facilitated by stimuli occurring at the same location, and that this integration is dependent on stimulated body surface and stimuli acoustic spectra.

Interactions of different body parts in the peripersonal space and in the body schema

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The peripersonal space is thought to be represented by multimodal neurons whose receptive fields for the different modalities overlap in space. The crossmodal congruency (CC) task has been used to demonstrate a representation of peripersonal space in humans. In this task, participants judge the elevation of a touch while trying to ignore the elevation of a visual distracter. Despite this instruction, the elevation of the distracters influences performance, and most strongly so when the distracters are presented near the touched body part. We found that the CC effect is also enhanced when the visual distracters are presented somewhere else in the peripersonal space of the body (e.g., near the foot), but not near the touched body part (e.g., the hand). We furthermore report that the spatial remapping of touch into visual coordinates in the CC task is modulated by the position of body parts which are physically connected to the touched body part (e.g. the elbow and hand). The results of both experiments are not explained by the current conception of peripersonal space representations simply as overlapping receptive fields of different sensory modalities. Rather, they suggest interactions of the peripersonal space representations of different body parts, or a whole-body representation of peripersonal space.

Investigating the role of audition in spatial perception of natural visual scenes

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Crossmodal links in spatial perception of real environments has been well documented in recent years. While there has been much research into the visual effects on sound localization (e.g ventriloquist effect), relatively little is known about how sound can affect visual localization in a scene. Here we investigate whether a spatially congruent sound enhances visual target detection in a visual scene compared to spatially incongruent multisensory stimuli. We also examined how scene context affects participants' ability to identify the presence of the visual target. In our experiment, participants had to detect the presence or absence of a visual target in a sequence of randomly presented visual scenes while simultaneously listening to task irrelevant sounds. We hypothesized that target detection would improve for scenes when the auditory and visual stimuli were spatially congruent. There was found to be a significant congruency effect in the target present condition. The results will be discussed in further detail at the conference.

The combined effect of color and temperature on thermal sensation and subject's gazing behavior

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The purpose of this study is to clarify the combined effect of color and temperature on thermal sensation and the gazing behavior of subjects. In the experiment, 12 subjects wore the cap with eye camera and sat in the experimental chamber. Thermal conditions of the chamber were set as 3 steps (23°C, 27°C and 30°C), and they asked to evaluate thermal sensation and thermal comfort of the room. With the monitor which settled in front of subjects, we presented the pictures of another room, in which walls were painted in orange (5YR7/12) or blue (5B8/4) and we recorded how much they gazed at these colors. Results of this experiment showed that 1) In the condition which thermal sensation felt "slightly cold", thermal comfort was evaluated as "most comfortable", 2) Subjects frequently gazed at blue wall of the picture in the high temperature condition, however they frequently gazed at orange wall in the low temperature condition.

Action perception from audio-visual cues: the role of human voice and body orientation in determining locus of attention

Iwona Pomianowska, Jason S. Chan, Fiona N. Newell

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To interact with others, one needs to infer other people's intentions and actions. In order to do this, we have to rely on a set of social skills usually referred to the theory of mind, social attention, and social cognition. According to Baron-Cohen (1995), people are highly adept at using gaze cues to decode the behavioural intentions of others. Previous behavioural studies have shown that people have a tendency to attend to the location where another person is attending to (e.g. Driver et al. 1999). Our study investigates the role of auditory and visual cues within the initial stages of processing of socially relevant information. The aim of our study was to assess the individual contributions of the human voice and the body orientation to the direction of attention while perceiving other people. The study used adapted versions of Posner's central and lateral cueing paradigms, which in previous studies have demonstrated that such social cues (gaze direction, head orientation) efficiently triggered shifts of a viewer's visual attention (Driver et al. 1999; Langton & Bruce, 1999). Our study investigates how attention is oriented while perceiving human action and voice. Result will be discussed on the conference.

Is cross-modal transfer of perceptual learning and viewpoint-independence possible?

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In contrast to the viewpoint-dependence of within-modal recognition of previously unfamiliar objects, their cross-modal recognition is viewpoint-independent (Lacey et al., 2007, PLoS ONE 2:e890). Since within-modal viewpoint-independence characterizes recognition of highly familiar objects, we tested whether such viewpoint-independence can be acquired by learning, and if so, transferred cross-modally. Participants were exposed to objects in sets of four, after which recognition was assessed for the objects in the set, in unrotated and rotated orientations. Baseline visual and haptic within-modal trials were followed by a series of within-modal learning trials, either visual or haptic. To test cross-modal transfer, visual learning was followed by a final haptic trial and vice-versa. This design contrasts with studies that used a series of visual-haptic/haptic-visual trials (Norman et al., 2008 Perception 37:185-196) which may demonstrate learning to switch between modalities rather than the transfer of learning across modalities. Initial analyses suggest that viewpoint-independence is not easily learned and that within-modal learning does not transfer cross-modally. This implies that visual and haptic viewpoint-dependent representations are separate from each other and from cross-modal representations.

Indivisuality distinction judgment of the movie with scene shake by walking

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Does visual input tell us about ourselves in addition to our status in the external space? In particular, do dynamic aspects of the visual input (scene shake by walking) make it possible to distinguish “my” vision from others? The author examined this question by asking subjects to distinguish a movie taken by a CCD camera placed at their forehead from a movie of other subjects, eliminating any episodic visual event from the content of the movie, and reported that the performance of individuality distinction is significantly higher than that of control experiment in which subjects’ judgment were based on a still image from their viewpoint. [T.Kayahara (2007) Perception, 36(Sppl), pp.186] In this study, the movie was taken by CCD camera placed in front of subjects’ body which height was constantly 1 m from ground surface, because head movement contained in the movie taken at forehead and the difference of viewpoint height might be either a distracter or episodic information for individuality distinction judgment. The performance of the individuality distinction judgment of 5-sec movie with 2IFC procedure will be compared to that of the movie taken at forehead and that of still image (control condition).

Effect of a congenital deafness on the organization of the thalamo-cortical connections in the cat

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There is a large body of evidence, from psychophysics to brain imaging studies, that have shown in deaf human a functional reorganization that affects the remaining sensory modalities. Here, in a congenital deaf cat (CDC), we search for the possibility that the thalamo-cortical pathway could be the origin of such a cross-modal reorganization in the auditory system. Pairs of retrograde dyes injections were performed in the primary auditory cortex of CDC and normal hearing animals (NHC). Preliminary results in the CDC showed that the main inputs (over 80%) to the primary auditory cortex originate from auditory nuclei of the ventral, dorsal and median division of the median geniculate body of thalamus (MGB) and from PO. The topographical organization of projection was similar to that observed in NHC with respect to the tonotopy of the MGB. We only found in CDC a sparse projection arising from the lateral posterior nuclei of thalamus (LP) that could relay non-auditory information to A1. These preliminary findings suggest that the cortical crossmodal reorganization observed in human subjects suffering of deafness, is probably mediated by a network outside the thalamo-cortical pathway. Grant support: ANR-06-NEUR-021-01. BQR ATUPS 2007 Université Paul Sabatier.

The effect of looming and receding sounds on the in-depth perception of point-light figures

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Being highly sensitive to looming (biological) entities could provide a substantial selection advantage: A sound with a rising intensity or an increasing visual projection of an object or animal can signal movement towards the observer. The auditory system seems to provide us with a perceptual bias for such behaviourally relevant stimuli (Neuhoff, 1998, Nature). In the visual modality, Vanrie et al (2004, Perception) found that even though the orthogonal 3D to 2D projection of a point-light walker (plw) is perceptually bistable, it induces the convincing percept of a walker facing the viewer in about 80% of the cases. The current research explores to what extent a looming or receding sound as compared to a stationary sound and no sound can affect the in-depth interpretation of a plw. To allow effects in both directions the perceived in-depth orientation of the plw was manipulated from convincingly looming to convincingly receding with perspective cues. Looming, receding, and stationary sounds respectively consisted of ticks of increasing, decreasing, or stable intensity, synchronized with the footsteps of the plw. Results suggest that a looming and receding sound can alter the in-depth interpretation of a point-light walker. However, this effect appeared not to be mandatory.

Does optimal integration of auditory and visual cues occur in a complex temporal task?

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When multiple sources of sensory information about a single environmental property are available, combining them can form improved estimates of that property. For simple physical dimensions such as object size (Ernst & Banks, 2002) and location (Alais & Burr, 2004), studies using a standard paradigm, show that humans integrate different sensory sources in a statistically optimal fashion. It is unclear whether this paradigm can be used to understand integration of auditory and visual cues in the temporal domain (Roach, Heron & McGraw, 2006). We investigated this question whilst using a more complex stimulus: drumming point light displays. Stimuli were created from 3D motion capture data of a drummer performing swing groove drumming, which was converted into visual point light displays. Sounds were obtained by simulation of 25 modes of a circular membrane. Parameters for the sound model were the physical parameters of the membrane and the time and impact velocity of a strike. There were three main conditions in the experiment: audio-alone, vision-alone and audio-visual combined. Auditory noise was added to the audio-alone and audio-visual conditions and discrepancies between the cues occurred in the audio-visual. For each of these conditions, we measured tempo discrimination performance in a 2IFC task.

Neural bases of phase shifted audiovisual stimuli

Daniel Bergmann, Hans-Jochen Heinze, Toemme Noesselt

Otto-von-Guericke-University

In order to generate unified perceptions of the environment information from different sensory inputs needs to be integrated; spatial, contextual and temporal constraints can determine multisensory integration (e.g. Driver & Noesselt, 2008). Focusing on temporal processes, previous publications have emphasized the role of (multisensory) brain areas such as insula, intraparietal sulcus and superior temporal sulcus for the temporal integration of complex audiovisual inputs. This fMRI-study investigates the neural correlates of audiovisual temporal processing and perception using simple stimuli. We employed stimulus sequences of combined LED flashes and sound bursts that could be either phase-shifted or synchronous with a presentation rate of 4 Hz. Stimuli were presented through LEDs and Piezo-speakers inside the scanner. SOAs were either 125 ms or 63 ms in each direction (phase shift 1800/900). Each of the asynchrony conditions was judged by the participants by means of synchrony judgments. A rapid sparse sampling design with silent interscan periods for stimulus presentation was applied (TR=2 s, pause=2 s). Behavioral results indicate a reduction in synchronous percepts with increasing phase shifts. In accord, fMRI-analysis revealed a cortical network of sensory-specific and multisensory brain areas that are modulated by audiovisual physical (a)synchrony and the participants' percepts.

An indirect measure of body distortions in patients with eating disorders

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People suffering with eating disorders, such as anorexia and bulimia nervosa, often refer distorted perception of specific body parts (e.g., thigh or stomach). Here we examined whether these experienced distortions of body parts can affect tactile perception of an object in contact with the skin. Ten young female participants with eating disorders (4 anorexic, 3 bulimic, 3 non-specified) and 13 healthy age- and gender-matched controls were touched with the two tips of a digital caliper on a body part. Between blocks the touched body-parts were either affected (i.e., thigh or stomach) or unaffected (i.e., forehead, forearm) by the reported eating disorder distortions. Participants received tactile stimulation with their eyes closed, and afterwards chose among several visually presented lines which best matched the perceived tactile distance. All participants underestimated tactile length on the skin. However, underestimation was significantly smaller for eating disorder patients, selectively for touches delivered to the disorder-affected body parts (i.e., thigh or stomach). This finding is compatible with the percept of a distorted (enlarged) body part. Our findings provide the first non-subjective evidence of the perceptual consequences of body distortions in patients with eating disorders.

An fMRI investigation of the role of vision and touch in the perception of "Naturalness"

T. Aisling Whitaker, Cristina Simoes-Franklin, Fiona N. Newell

Trinity College Dublin

The ability to readily discriminate between natural things and synthetic mimics in our environment is an important tool for many species. Making these judgements relies on the acuity of the different senses, and the material characteristics of the objects at hand. Here, we investigated the relative contribution of vision and touch, alone and in combination, to the categorisation of wood stimuli as natural or unnatural. Further, we examined the brain correlates associated with the perception of these stimuli as natural across the different modalities. The stimuli comprised of eight wood samples, four consistently judged as natural and four consistently judged as not natural, based on results from a previous categorisation study. Behavioural results indicated that natural and unnatural stimuli were perceived as such, although performance varied as a function of modality. Specifically, performance was better when vision and touch were used simultaneously. Preliminary analysis of the neuroimaging data indicates that neural differences exist between the unimodal and bimodal conditions when the stimuli were perceived as natural. These results will be discussed further at the conference.

The way of touch affect the relationship between vision and touch

Kensuke Oshima

Tokyo Metropolitan University

Objectives: The several studies showed that the visual impression dominates tactile impression (e.g. Rock & Victor, 1964) when people manipulate a object. On the other hand, some studies asserted that vision is not always dominant. The several factors affect the interaction between vision and touch (Welch & Warren, 1980). We think the way of touch is one of the important factors for the interaction between vision and touch. In this study, we analyzed the extent that vision adjusted touch and compared the ways of touch, “grasp” and “trace”. Method: Fourteen participants estimated the size of squares that they grasped or traced in their fingers and simultaneously viewed thorough the equipment that reduced the squares’ visual size. They selected a match either visually or haptically from a set of comparison squares. Results: Participants judged smaller than veridical size when they looked and felt. So it showed that vision affected haptic size judgement. The judged size when they grasped the square was smaller than the judged size when they traced the square. Conclusions: The results indicated that the way of touch affected the relationship between vision and touch and was important factor for interaction vision and touch.

Bayesian calibration of simultaneity in audiovisual temporal order judgment

Shinya Yamamoto, Makoto Miyazaki, Takayuki Iwano, Shigeru Kitazawa

Juntendo University

After repeated exposure to a pair of audiovisual stimuli with a constant lag, subjects eventually judge the pair as occurring simultaneously (lag adaptation). In contrast, perceptual changes occur in the opposite direction with tactile stimuli, which conforms to a Bayesian integration theory. We previously showed in theory that the effect of Bayesian calibration cannot be observed when the lag adaptation is working in full. This led us to hypothesize that the Bayesian calibration is working even in the audiovisual temporal order judgment, but the effect is concealed behind the lag adaptation mechanism. In the present study, by using two pitches of sounds (1046 and 1480 Hz), we show that lag adaptation is pitch-insensitive. This enabled us to neutralize lag adaptation by associating one pitch of sound with sound first stimuli and the other with light first stimuli. When we delivered each type of stimuli in a randomized order, the point of simultaneity shifted to ‘light-first’ for one pitch of sound associated with sound-first stimuli, and vice versa for the other pitch. The results clearly show that the Bayesian calibration is also working in the audiovisual temporal order judgment in a pitch specific manner behind pitch-insensitive lag adaptation.

The dual role of the non-target in visual-auditory saccadic integration

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In a focused attention (FA) paradigm, saccadic reaction time (SRT) to a visual target is reduced when an acoustical non-target is presented in close spatial or temporal proximity. Beyond such a window of integration, an acoustical stimulus does not affect SRT in a spatially specific way, but it may have a (temporally specific) warning effect (Diederich & Colonius, 2008, ExpBrRes). The purpose of the present study is to dissociate the non-target's warning effect from its spatial effect, and to investigate the time course of both characteristics. In the experiment, the task of the participant was to gaze as fast and as accurately as possible to a visual target and to ignore an auditory non-target (white noise burst) presented at various stimulus-onset asynchrony values. In the spatially specific condition, the auditory non-target appeared either at the same position or at a position vertically opposite to the target. In the spatially non-specific condition, the non-target was presented from both positions simultaneously such that no positional information was available. To prevent discriminating between the two conditions via loudness differences, the intensity level of the non-targets were slightly roved in intensity.

The effect of adaptation on tactile temporal order judgments

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University of Bradford

The perception of temporal order is not fixed, but strongly depends upon recent experience. For example, adaptation to pairs of audiovisual stimuli in which audition leads vision results in an observer requiring a lead of sound over vision for subsequent pairings to be perceived as simultaneous (Fujisaki et al., 2004). The same is true of multisensory pairings involving tactile stimulation (Hanson et al., 2008). A notable exception to this sensory realignment seems to occur when the temporal order of two tactile stimuli, one to each hand, is judged (Miyazaki et al., 2006). In this case a reverse recalibration effect is found – post adaptation, perceived synchrony requires the opposite temporal order. In the present study, we investigate the effects of adaptation to tactile temporal order for digits belonging to the same hand. Adaptation to the stimulation of one digit 90ms prior to the other produces a substantial realignment of subsequent temporal order judgments in the same direction as the adapting sequence, suggesting an effect of adaptation which depends critically on whether the adaptation is within or between hands. Fujisaki, W, Shimojo, S et al. (2004) Recalibration of audiovisual simultaneity. Nature Neuroscience, 7, 773-778. Hanson, JVM, Heron, J & Whitaker, D (2008) Recalibration of perceived time across sensory modalities. Experimental Brain Research, 185, 347-352. Miyazaki, M, Yamamoto, S et al. (2006) Bayesian calibration of simultaneity in tactile temporal order judgment. Nature Neuroscience, 9, 875-877.

Is the Colavita effect an exclusively visual phenomenon?

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Previous studies have demonstrated that people often fail to report one component of bimodal targets in a speeded response task setting: Participants respond preferentially to the visual component of audiovisual (Koppen & Spence, 2007) or visuotactile (Hartcher O'Brien et al., 2008) stimulus pairs. The present study was designed to investigate whether this phenomenon (known as the "Colavita effect") would extend to the audiotactile modality pairing as well. Participants had to make speeded detection responses to brief unimodal auditory, unimodal tactile or bimodal audiotactile suprathreshold stimuli. Although participants failed to respond correctly in the bimodal trials more often than in the unimodal trials, no imbalance between audition and touch was observed (i.e., participants did not preferentially respond to either auditory or tactile sensory components of the bimodal stimuli). The performance of both naïve and non-naïve participants showed the same pattern of results (Exp.1). The null effect was still observed when different kinds of auditory stimuli (pure tones vs. white noise bursts; Exp.2) were used, and when differing stimulus intensities were presented (Exp.3). These results therefore suggest that the Colavita effect exclusively affects modality pairings involving vision, thus confirming this effect as one of the most striking demonstration of visual dominance over other sensory modalities.

On the correlation between the spatial extension of touch pharmacological synaestesia and the plastic chategorization of the human body schema

Isadora Olive

LPPA Collège de France

The spatial extension synaesthesia has been studied by several early authors, and reviewed by Richard E. Cytowic in
his book Synaesthesia: Union of the Senses3. It's characterized, as the name indicates, by an ability to spatially extend one percept belonging to a given sensory modality, e.g. touch; which is induced by a percept belonging to yet another sensory modality, e.g. vision. The projection of the percept takes place in the peripersonal space of the synaesthete, rather than being in his mind's eye. Here, we'll be interested in a particular case of pharmacological synaesthesia6 in which the spatial extension of touch is experienced as an outstretching of the own bodily boundaries in mescal users9. Their limbs assumed a spiral form echoing the spiral rotation of the visual stimulus that induced such perception. The main goal of the present work is to produce a comparative study amongst what is known about the spatial extension of touch pharmacological synaesthesia, and the most recent studies demonstrating that the human body schema is liable to be induced into rapid plasticity processes even on non-synaesthetes, healthy subjects. More specifically, we'll review recent studies targeting the Rubber Hand Illusion (RHi) 2,5,8,11,13 and the Out-of-Body Experiences (OBE)4,10. In a second moment, we'll also speculate on the putative neural substrates of this specific type of synaesthesia, highlighting recent literature that reveals the multisensory role of traditionally considered unimodal visual structures, which indeed are actively involved in the processing of correlated tactile information1,7,12. We would like to learn if and how all those phenomena can help to better understand one-another, defining its putative phenomenological resemblances, as well as potential common neural substrates. Reference List 1. Amedi A., Jacobson G., Hendler T., Malach R., and Zohary E. (2002) Convergence of visual and tactile shape processing in the human lateral occipital complex. Cereb. Cortex 12, 1202-1212. 2. Costantini M. and Haggard P. (2007) The rubber hand illusion: sensitivity and reference frame for body ownership. Conscious Cogn 16, 229-240. 3. Cytowic R.E. (2002) Synesthesia a union of the senses. MIT Press, Cambridge, Mass. 4. Ehrsson H.H. (2007) The experimental induction of out-of-body experiences. Science 317, 1048. 5. Graziano M.S. (1999) Where is my arm? The relative role of vision and proprioception in the neuronal representation of limb position. Proc. Natl. Acad Sci U. S. A

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A novel method of dealing with the dynamic and fuzzy information from multi sensors

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To analyze fuzzy data in uncertain evidential reasoning, some researchers have recently extended the Dempster-Shafer (D-S) Evidence Theory to fuzzy sets. But there are some insufficiencies in the definition of the fuzzy belief function and the combination rule on fuzzy sets of the D-S evidence theory. This paper describes a new definition of the similarity degree between two fuzzy sets and presents an improved extension combination rule of the evidence theory on fuzzy sets. It also presents the corresponding mathematical proof to validate the improved combination rule. To research the application of this method to coal mine gas outburst prediction, we add olfaction information as a real-time and dynamic data source with a self- navigating robot. There is variance or conflict between information from different kinds of sensors which serves as the evidence of the D-S fusion. So firstly, before the decision-making with the D-S Evidence Theory, we use a neural network to pretreat and extract the nonlinear information. Secondly, we adopt the AND-algorithm to combine the coherence evidence, and reallocate the conflicts to various focal elements according to the credibility of the coherence evidence. This improved combination rules for the D-S Evidence Theory for resolving the problem of evidence conflicts was proved to be effective. Compared with other generalizing combination rules, the results of the numerical and practical experiments show that the new combination rule in this paper can acquire more changing information about the change of fuzzy focal elements more effectively, and it overcomes the insufficiencies of other existing combination rules and effectively enhances the robustness of fusion decision systems.

The application of water environment monitoring based on the multisensory data fusion

Liang Chun

Environmental protection directly affects the development of resources, environment and economy, and the protection of the water resources is one part of the primary coverage. In China, the water pollution is very serious, about 80% of the rivers are suffering sever pollution. On the basis of the real-time dynamic monitoring of a large part of natural water resources, this project researches the network-based theoretic approach and technology of multisensory management and data fusion, and constructs the architecture of a data fusion system for monitoring the state of the water. First, considering the performance of sensors, the system computing ability, the communication bandwidth, the expected accuracy, the disposable funds and so on, we present the multisensory management mode, the coordinated control policy, and the relevant intelligent algorithm. Then we complete the simulation test for the original process system for data fusion of the water monitoring system, and the simulation experiments on data-fusion algorithm. Finally, associating with the actual project, we present the approaches of data acquisition and screening, and the remote reconfiguration technologies for the sensors' operate modes and running parameters.

Analysis of multisensory simultaneity perception in adults using event related potentials

Andrea R. Hillock, Albert R. Powers, Juliane Krueger, Alexandra P.F. Key, Mark T. Wallace

Vanderbilt University

Psychophysical research in adults has defined a temporal window for binding auditory and visual stimuli into a unified perceptual construct. In an effort to gain insight into the neurophysiological correlates of this multisensory temporal binding window, perceptual reports and cortical event related potentials (ERPs) were collected in adults during a simultaneity judgment task. Objectively synchronous and asynchronous visual and auditory stimuli were presented in a randomly interleaved fashion and subjects were asked to report on their perception of simultaneity. In the asynchronous conditions, the onset of the visual stimulus preceded the onset of the auditory stimulus in 100 ms steps. Examination of perceptual responses revealed that the probability of reporting the stimuli as synchronous decreased rapidly across visual-auditory delays of 100 to 300 ms. Analysis of the auditory P1, N1, P2 complex relative to the tone pip revealed differences in the amplitude of responses to the veridical simultaneous condition relative to asynchronous conditions, and suggest a relationship between the perceptual binding of the multisensory stimuli and ERP responses. Ongoing work seeks to further elucidate the components of this ERP complex, and will focus on correlating the perceptual and physiological data in both the amplitude and latency domains.

Time-to-Contact estimation for visual stimuli approaching the hand

M. Luisa Dematte[1], Massimiliano Zampini[1,2], Francesco Pavani[1,2]

[1]Center for Mind/Brain Sciences, University of Trento, [2]Department of Cognitive Sciences and Education, University of Trento

In three experiments, we tested whether the multisensory encoding of the space surrounding the hand may play a role in the estimation of the time elapsing before a visual stimulus collides with the hand. Participants were instructed to try and stop a moving disk at the exact moment it collided with a fixed target. The distance (near vs. far) between the target and the participants' hands was manipulated between trials. Moreover, other additional parameters were considered across experiments: Feedback provided (temporal, i.e., milliseconds before/after collision when the disk was stopped; temporal + semantic, when also incitements were used; temporal + semantic + tactile, when the index fingers were also touched at collision); visibility of the last part of the disk path (visible vs. occluded); response proximity with respect to the target (response far with foot vs. near with hand on screen). The main result revealed that the disk was stopped farther from the target when this corresponded to hand position than when it did not correspond to hand position. Time-to-contact estimation appears to change as a function of the target-hand distance, suggesting a role of peri-hand space encoding in the temporal evaluation of visual stimuli approaching the hand.

Changing representations during tactile encoding

Elena Azañón[1], Salvador Soto-Faraco[2]

[1]Departament de Psicologia Bàsica, Universitat de Barcelona, [2]ICREA, Parc Científic de Barcelona, Universitat de Barcelona

The seemingly mindless act of swatting a mosquito on your hand poses a challenge for the brain. Given that the primary somatosensory cortex maps skin location independently of arm posture, the brain must re-align tactile coordinates in order to locate events in external space. Here we track the time course of how these externally-based representations are built using a crossmodal cueing paradigm. Participants held their arms crossed and performed a discrimination task on lateralised visual targets presented near the hands, after receiving a non-predictive tactile cue. During the first hundred milliseconds after the cue, reaction times to the lights were speeded up for anatomically congruent but spatially incongruent tactile cues. This pattern reversed after about two hundred milliseconds so that tactile cues produced a facilitation of targets presented at the same external location. When participants were asked to explicitly compare the location of tactile and visual events, they responded according to an external frame of reference, thus indicating no awareness of early somatotopic representations. These results reveal the time course of the dynamic remapping of tactile space, with early unconscious somatotopic representations giving way to the later external frame of reference that characterizes our conscious experience.

An extended temporal window for multisensory integration in ASD

Leslie Ellen Dowell, Jennifer H. Foss-Feig, Haleh Kadivar, Laura Jenelle Stabin, Courtney P. Burnette, Eric A. Esters, Tiffany G. Woynaroski, Carissa Cascio, Wendy Stone, Mark Thomas Wallace

Vanderbilt University

There has been much speculation that disruptions in multisensory processing may be important in autism. However, there is little empirical evidence to support this claim. In the current study we compared multisensory processing between children with typical development and ASD, with an emphasis on the temporal window within which audiovisual stimuli are bound. We adapted three tasks which have been used in prior work to examine multisensory temporal processing (multisensory temporal order judgment [mTOJ], the flash-beep illusion [FB], and the McGurk), as well as tasks to assess unisensory temporal performance. There were no significant differences in unisensory temporal processing between the two groups. In contrast, children with ASD showed task performance improvements on the mTOJ over an interval two to three times larger than for typically developing children. Similarly, in the FB task illusory flashes were seen over a larger range of intervals for children with ASD. However, no differences were seen on the McGurk. Although our findings are preliminary, they suggest that there may be key differences in the time interval during which children with ASD integrate multisensory stimuli. These differences may ultimately provide a foundation upon which more effective diagnostic and interventional strategies may be developed.

The neural network underlying letter and speech-sound integration

Maria Mittag, Rika Takegata, Teija Kujala

The integration of letter and speech sounds is essential when learning to read. Recent studies suggested that the integration of letters and speech sounds takes place automatically. In our study, we wished to determine the neural networks associated with an automatic integration of written and heard syllables in literate adults. We used the mismatch negativity (MMN), an index of automatic change detection in the brain. Subjects were presented with several speech sounds in an experimental and a control condition. In addition, in the experimental condition syllables were presented on the screen synchronously with the sounds, whereas in the control condition scrambled images of the written syllables were used. During stimulation, the subject's primary task was to press a button to targets presented on the screen and ignore interspersed distractors. Changes in auditory stimuli elicited an MMN, in both conditions. The MMNs were diminished in the experimental condition compared with the control condition. The decrement of the MMN was most prominent for phonologically relevant features in the subject's native language. The implications of the results are discussed.

Anatomically and functionally distinct regions within multisensory superior temporal sulcus differentially integrate temporally-asynchronous speech

Ryan Andrew Stevenson, Nicholas A. Altieri, Sunah Kim, Thomas W. James

Indiana University, Bloomington

While superior temporal sulcus is a known site of multisensory convergence (mSTS), it is a large structure with regions that respond differentially to select stimulus properties, such as facial movements, whole-body motion, and auditory speech. Previous studies have used several different methods of localizing mSTS. Here, we explored the possibility that these different methods may localize functionally-distinct, sensory-integrating sub-regions within a larger mSTS complex. Specifically, we compared two previously-used contrasts to identify mSTS: first, a contrast of synchronous versus asynchronous audio-visual speech trials, and second, a conjunction of two unisensory contrasts, audio speech > baseline and visual speech > baseline. Importantly, both of our contrasts identified regions of mSTS (among other previously found regions) however, these regions were anatomically distinct, with the synchrony-defined region superior and lateral to the audio-visual conjunction-defined region. Furthermore, the activation patterns in response to stimulus asynchronies differed between these regions. As expected, the synchrony-defined region responded preferentially to synchronous stimuli, but unexpectedly, responded only to synchronous speech, not to any level of asynchrony including 100ms offsets. The audio-visual conjunction-defined region, however, increased monotonically with asynchrony. We propose that mSTS is a complex comprised of a number of smaller, functionally distinct regions of multisensory convergence.

Evidence for ventral and dorsal neural pathways for visuo-haptic object recognition

Sunah Kim, Daniel Eylath, Ryan Andrew Stevenson, Thomas Wellington James

Indiana University at Bloomington, IN, USA

There is ample evidence that the primate visual system comprises two visual pathways: a ventral pathway for the identification of objects and a dorsal pathway for visually-guided action and/or spatial processing of objects. A few behavioral and neuroimaging studies have shown that there also exist separate ventral and dorsal processing pathways in human somatosensory system. In the current functional magnetic resonance imaging (fMRI) study, visuo-haptic object-selective brain regions that responded more to both visual and haptic objects than textures were defined in seven participants. We specifically analyzed three bimodal regions of interest, the left lateral occipital tactile-visual area (LOtv) and the anterior aspect of the left fusiform gyrus (FG) in the ventral pathway, and the left anterior intraparietal sulcus (aIPS) in the dorsal pathway. Patterns of BOLD (Blood Oxygen Level-Dependent) activation in these bimodal regions were analyzed for evidence of multisensory integration by presenting unimodal and bimodal visual and haptic stimuli at two levels of saliency. Results showed different patterns of BOLD activation in the ventral and dorsal pathways, suggesting that the two pathways integrate visual and haptic sensory inputs using different mechanisms.

Saturday 19th

9:00 – 11:00 Poster Session IV

Spatial and temporal factors in audiovisual integration: An fMRI study

Bjoern Bonath[1], Steven A. Hillyard[2], Sascha Tyll[1], Jyoti Mishra[2], Hans-Jochen Heinze[1], Toemme Noesselt[1]

[1]Department of Neurology II Otto-von-Guericke University Magdeburg , [2]Department of Neurosciences University of California, San Diego

Spatial and temporal constraints can influence multisensory integration (e.g. Driver & Noesselt, 2008). Recent neuroimaging studies investigated the neural basis of audiovisual interactions in perception (e.g. Noesselt et al. 2007, Meienbrock et al. 2007, Bonath & Noesselt etal. 2007) but none of these have studied both temporal and spatial factors concurrently using fMRI. Moreover, attention to either the spatial or temporal domain may further modulate the neural underpinnings of audiovisual processing. In the present fMRI-study, we varied both spatial and temporal properties of audiovisual stimuli, while subjects performed either a temporal or spatial audiovisual discrimination task. Sounds were presented at two different spatial positions (left/right) with both simultaneous and non-simultaneous light flashes (SOA 300 ms). These sound/light combinations occurred either within the same hemifield (sound/vision left/right) or at opposite hemifields (sound left/vision right and sound right/vision left). Preliminary results revealed modulations within superior temporal and visual cortical areas that were differentially modulated by the attended domain (spatial/temporal) and by physical congruency. Implications of the results will be discussed.

Multisensory integration causes non-informative auditory stimuli to facilitate visual search: An event-related potential investigation of the "Pip and Pop" phenomenon

Durk Talsma, Erik van der Burg, Christiaan Olivers, Jan Theeuwes

Vrije Universiteit

It has recently been demonstrated that non-informative auditory stimuli can facilitate visual search (Van der Burg, Olivers, Bronkhorst, and Theeuwes, in press, JEP:HPP). This effect, labeled the "pip and pop" phenomenon has been attributed to multisensory integration. Here we present an event-related potential study that elucidates the neural mechanisms behind this effect. Diagonally oriented line segments were presented in two confined regions in visual space; one region in the left visual field, and one region in the right. All elements could change orientation at random moments. A target stimulus was defined by one line element that changed to a horizontal or vertical orientation. Participants were required to report the orientation of the target item at the end of the trial. On one-third of the trials, a tone was presented that was synchronized with the orientation change of the target stimulus (AV trials). On one third of the trials, a tone was presented that was not synchronized with any visual stimulus (auditory-only trials). On the remaining trials no sound was presented (i.e. visual-only trials). We expected to find increased accuracy on the AV trials, and an early multisensory integration related modulation of the ERP wave. Furthermore, we expected that a shift of attention to the target location in the AV condition would be reflected in an N2pc component. Both behavioral and ERP result largely adhere to our expectations. We therefore conclude that multisensory integration can cause a bottom-up driven spread of attention from the auditory to the visual modality.

Effects of visual cues on acquisition of multiple prior distributions in tactile temporal order judgments

Yasuhito Nagai[1], Mayu Suzuki[1], Makoto Miyazaki[2], Shigeru Kitazawa[1]

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Human judgment of the temporal order of two sensory signals is liable to change depending on our prior experiences. Previous studies reported that these changes occur so that signals presented repeatedly are judged as occurring simultaneously. In our previous study (Miyazaki et al., Nat Neurosci, 2006), we reported opposite perceptual changes in judging the order of two tactile stimuli delivered one to each hand. When stimulations were drawn from a single Gaussian distribution with the mean of -80 ms (left hand first) or +80 ms (right hand first), the perceptual changes occurred in agreement with a Bayesian integration theory. In this study, we raise a question of whether we are able to acquire two prior distributions simultaneously by using visual and/or eye movement cues. Tactile stimulation intervals were randomly sampled from one of the two Gaussian distributions in association with a color cue (green/red), an eye-position cue (look up/down), a retinal-position cue (up/down) or a mouth-shape cue (open/shut). Subjects were able to acquire two distributions with the eye-position and/or retinal position cues but not with color or mouth-shape cues. The results show that visuospatial cues effectively set conditions for acquiring multiple prior distributions in tactile temporal order judgments.

Is bias and variance of multimodal temporal numerosity judgement consistent with Maximum Likelihood Estimation?

Tom Gijsbert Philippi[1,2], Jan B. F. van Erp[2], Peter J. Werkhoven[1]

[1]Utrecht University, [2]TNO Human Factors

In Temporal Numerosity Judgment (TNJ) observers naturally underestimate the number of pulses presented in a rapid pulse sequence. We investigated if bimodal presentation affects performance and whether this effect is in agreement with Maximum Likelihood Estimation (MLE). MLE predicts that the bimodal underestimation should lie in between the unimodal underestimations and the bimodal variance should be smaller than the unimodal variances. We tested congruent and incongruent audiovisual pulse sequences (1 10 flashes or beeps with equal, +1, or -1 distractors; ISI's 20 or 60 ms) and instructed participants to either report the number of flashes, beeps or both. Our results show that the audiovisual underestimation is smaller than each unimodal underestimation when counting beeps or both, but not when counting flashes. When counting both, the audiovisual variance is equal to the lowest unimodal variance, but when counting beeps or flashes the variance is larger than each of the unimodal variances. This suggests that multimodal TNJ is inconsistent with the predictions of MLE models, regardless whether integration is partial or complete.

Probing vision utilization using an audio-visual illusion: Evidence for modulation of visual afferent information processing during goal-directed movements

Luc Tremblay, Thanh Nguyen

University of Toronto

Vision manipulation influences movement endpoint accuracy the most if manipulated early in the movement (e.g., Hansen, Tremblay, & Elliott, 2008). We tested if a visually-guided goal-directed pointing movement influences the magnitude of an audio-visual illusion (e.g., Shams et al., 2000). Participants pointed to a target and reported how many flashes they saw after the movement. The experimental design was: 2 Flash (1, 2) by 2 Beep (1 or 2) by 4 Movement Presentation Time (Start (S), 50 ms after S (S+50), End (E), or 500 ms after E (E+500)). The number of perceived flashes as well as the accuracy and variability of the perceptual judgments were submitted to separate ANOVAs (Post-hoc: Tukey HSD; alpha = .05). All analyses yielded a Flash by Beep interaction, which replicated the illusion (e.g., Shams et al., 2000). Most interestingly, the variability of the perceived flashes analysis also yielded a Presentation Time by Flash interaction ($p < .01$). Specifically, when one flash was presented, participants were more variable in their judgments early in the movement (S+50) than at the beginning (S) or after the end (E+500) (ps < .05). As such, these results support the idea that afferent visual information processing is modulated during pointing.

Spatial audio-visual integration without localizing the auditory stimulus?

Rike Steenken[1], Hans Colonius[1], Adele Diederich[2]

[1]Oldenburg University, [2]Jacobs University

It is well known that in a focused attention task saccadic reaction time (SRT) to a visual target is modulated by the position and time of occurrence of an auditory non-target (Diederich & Colonius, 2004, Hdbk Multisensory Processes, Frens et al., 1995, P&P). The question addressed here is how the localizability of an auditory stimulus affects the response to a visual target stimulus. Two experiments were conducted to approach this issue. In the first, awareness of the acoustical stimulus location was manipulated by varying the amplitude of an additional auditory masker; in the second, a temporal masking paradigm was used. The performance levels in the localization tasks were correlated with the mean SRTs obtained from presenting identical stimulus configurations in separate blocks (Schmidt & Vorberg, 2006, P&P). The data indicate that there is no direct relation between the spatial SRT effect and the localizability of the auditory non-target, as has been previously suggested (Steenken et. al. 2007, Brain Res.). More specifically, it is suggested that localizability is not the dominant factor in determining the SRT and that localizing an auditory stimulus occurs on a higher level of processing generally not influencing the initiation of a saccade, respectively.

Mirror symmetry topographical mapping is a fundamental principle of cortex organization across sensory modalities: A whole brain fMRI study of body representation

Ran Geva, Zohar Tal, Uri Hertz, Amir Amedi

Dept. of Physiology - Faculty of Medicine & Program of Cognitive Science, The Hebrew University of Jerusalem

The three topographical senses (vision, audition and touch) are characterized by a topographical mapping of the sensory world onto primary and secondary cortices. In such topographical maps, adjacent neurons represent adjacent sensory building blocks (e.g. visual field, tone frequency and body parts) in each sense. But how common are such topographical maps outside primary sensory areas? And can we characterize similar principles of organization across modalities? Using fMRI, we applied continuous and periodic sensory stimulation, to detect further topographically sensitive areas in the somatosensory modality. We used phase locking Fourier techniques combined with a spherical cortex-based alignment approach to detect such topographic maps. Using these methods, we report here the preliminary finding of several novel somototopics maps in the human brain, beyond the well-known homunculus in the post-central gyrus. We also find additional topographic body sensitivity in parietal and occipital cortex. Our results suggest that mirror symmetry topographical mapping may be a fundamental principle of mapping in vision, audition and as we show here, of touch and might be a more common characteristic of associative and multisensory cortex than previously suspected.

Incongruent visual image impairs discrimination of tactile stimulus on a finger

Yuki Hongoh[1], Taku Konishi[2], Koichi Hioki[2], Hirokazu Nishio[2], Takaji Matsushima[2], Satoshi Maekawa[3]

[1]Kobe University, JSPS Research Fellow, [2]Kobe University, [3]National Institute of Information and Communications Technology

We examined that incongruent visual image of one's hand impaired the tactile perception to the finger. Participants judged which one of the left hand fingers was tapped as quickly and correctly as possible, ignoring the light tap on the right hand finger. We used a mirror in order to manipulate the presence of visual image of the left hand. In the visual-image-presence condition, the mirror was placed between participants' hands and thus the mirror image of the right hand was seen as if it was the image of the left hand. Therefore the visual image and the tactile stimulus were incongruent when the tapped fingers were different between both hands. The participants' responses in the visual-image-presence condition were compared with the condition in which an opaque board was used instead of the mirror (the control condition). In the results, the incongruent visual image prolonged the response times and increased the error rates compared with the same situations in the control condition. Participants rarely made incorrect responses or had difficulty in responses when there was no incongruent visual image. These results indicated that vision strongly influenced the tactile perception even in the very easy tactile discrimination task.

Perceptual interactions between vibrotactile and auditory stimuli: Effects of frequency

E. Courtenay Wilson, Charlotte M. Reed, Louis D. Braida

MIT, Speech & Hearing Bioscience and Technology Program, Research Laboratory of Electronics

Perceptual interactions between vibrotactile and auditory tones were studied as a function of the relative frequency between the two senses. Vibrotactile stimuli were delivered through a single-channel vibrator to the left middle fingertip, auditory stimuli were presented binaurally through headphones in broadband noise at a level of 50 dB SPL. Performance was measured in a fixed-level 2I, 2AFC procedure using 0 dB SL signals under the following three conditions: Vibrotactile (V) alone, Auditory (A) alone, and Vibrotactile plus Auditory (V+A). The effect of frequency was examined by (1) setting the auditory frequency to 250 Hz and testing vibrotactile frequencies from 50 to 400 Hz; (2) setting the vibrotactile frequency to 250 Hz and testing auditory tone frequencies from 125 to 2000 Hz. Results show: (1) when the frequency in both modalities is equal to 250 Hz, performance through V+A is significantly higher than through either modality alone; (2) V+A performance decreases as the frequency difference between A and V increases; and (3) the highest scores in the V+A conditions are consistent with integration of the two sensory stimuli into a single percept. We report results from a new experiment with equal auditory and vibrotactile frequencies from 40 to 500 Hz.

Neural correlates of audio-visual biological motion and speech processing

Georg F. Meyer[1], Sophie M. Wuerger, Roland M. Rutschmann, Mark W. Greenlee[2]

[1]Liverpool University, [2]University of Regensburg

Behavioural data suggests that the processing of auditory, visual and audiovisual speech and biological motion signals may be subserved by specialised processing centres (e.g. [1,2.3]). We conducted an fMRI study to investigate which areas are involved in the processing of auditory (A), visual (V) and audio-visual (AV) speech, biological motion and scrambled (meaningless) signals. A localiser experiment was conducted to identify areas that responded to unimodal (A,V) and bimodal (AV) stimuli. Conjunction analysis showed that the pSTS and premotor areas bilaterally responded strongly to speech and biomotion but less to scrambled motion signals. Audiovisual interactions (AV > A+V) were seen in parietal/occipital sulcus, the superior frontal sulcus and the anterior STS. The areas identified in the first experiment are used as the basis for a region of interest analysis in a second experiment where consistent and inconsistent audiovisual stimuli were presented. We find significantly increased activity in the STS for inconsistent AV stimuli than for matching auditory and visual signals. [1] Liberman, MIT Press, 1996 [2] Servos et al., Cereb. Cortex, 2002 [3] Tuomainen,Cognition, 96, 2005

Temporal limits of within- and cross-modal cross-attribute bindings

Waka Fujisaki, Shin'ya Nishida

National Institute of Advanced Industrial Science and Technology

The temporal limit for judging the synchrony of two repetitive stimulus sequences is substantially lower across attributes processed in separate modules/modalities than within the same attribute. Although this suggests a general sluggishness of cross-attribute comparisons, the reported limit is not constant, but slightly higher for cross-modal judgments (~4Hz for audio-visual and tacto-visual judgments; ≥~8Hz for audio-tactile judgment) than for within-modal cross-attribute judgments (~2Hz for color-orientation and color-motion judgments). However, the cross-modal judgments used a synchrony task (e.g., discriminating synchrony/asynchrony between visual and auditory pulse sequences) in which the matching features could be uniquely selected by bottom-up segmentation, while the within-modal judgments used a binding task (e.g., judging color presented in synchrony with a specific orientation for alternations in color and orientation) in which matching features had to be selected by top-down attention. Here we compared the temporal limits of the two tasks for both within- and cross-modal cross-attribute judgments using three visual attributes (luminance, color, orientation), one auditory attribute (pitch), and one tactile (left/right hand) attribute. The results showed that the temporal limit was ~2Hz for the binding task, but ≥~4Hz for the synchrony task, regardless of the attribute combinations, suggesting the existence of a common cognitive bottleneck for cross-attribute binding tasks.

Humans increasingly rely more on haptics in 3D shape perception with higher degrees of visual-haptic conflict

Priyamvada Tripathi, Robert Gray, Mithra Vankipuram, Sethuraman Panchanathan

Arizona State University

We investigated the relative weight placed on touch and vision in the exploration of three dimensional shapes by humans in cases of conflict. Stimuli consisted of 3D renderings of a rigid shape that varied from a sphere to a cube. Intermediate shapes were varied from 25% to 75% range in the empty space between the cube and sphere. The haptic stimuli consisted of the same objects rendered using the Phantom® joystick. Ten participants performed a 2AFC judgment (“more like a sphere” or “more like a cube”) in three main conditions: (1) vision only (2) touch only (3) vision and touch both. Conflicts were introduced between vision and touch ranging from no conflict (delta = 0) to maximum conflict (delta = ±4). The results indicate that in cases of zero conflict the relative weighting of each modality is roughly equal, but as the conflict increases participants increasingly rely more on their haptic sense rather than vision to make the shape judgment.

The role of object categories in auditory-visual object recognition

Clara Suied, Isabelle Viaud-Delmon

CNRS-UPMC UMR 7593

The influence of semantic congruence on auditory-visual object recognition was studied in a go/no-go task. We compared the effect of different object categories (animals and man-made objects) on reaction times. Experiments were run under a realistic virtual environment including 3D images and free-field audio. Participants were asked to react as fast as possible to a target object presented in the visual and/or the auditory modality, and to inhibit their response to a distractor object. Reaction times were significantly shorter for semantically congruent bimodal stimuli than would be predicted by independent processing of information about the auditory and the visual targets presented unimodally. Moreover, reaction times were significantly shorter for semantically congruent bimodal stimuli (i.e., visual and auditory targets) than for semantically incongruent bimodal stimuli (i.e. target represented in only one sensory modality and distractor presented in the other modality). A comparison of the interference effect across the various object different categories is then detailed. These experiments bring new elements about the influence of object categories on the rules of auditory-visual integration.

Audio-visual simultaneity judgments in rapid serial visual presentation

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We investigated the accuracy of audio-visual simultaneity judgments in a rapid serial visual presentation (RSVP) task. Eleven healthy participants indicated which RSVP stimulus was presented simultaneously with a tone. Results showed that on average in 33% of all trials the simultaneously presented letter was correctly identified. As compared to that, the letters preceding or following the tone were respectively identified in about 20% of the trials, and the letters presented two lags before or after the tone in about 6% of the trials. This pattern of results was consistent across subjects ($F=13.85$, $p<0.05$). We furthermore tested whether the accuracy of the simultaneity judgment was related to the number of RSVP stimuli preceding the tone, reflecting the recently described ‘attentional awakening’ effect (Ariga & Yokosawa (2008), Psychol Res, 72(2), 192-202) in RSVP. No significant difference in the accuracy of simultaneity judgments in dependence of the number of RSVP stimuli was observed.

Audiovisual integration in word recognition in typically developing children and children with autistic spectrum disorder

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Visual speech substantially improves the recognition of spoken speech especially under noisy environmental conditions. For the recognition of monosyllabic words this benefit varies as a function of the relative strength of the auditory signal (signal to noise ratio: SNR) with a maximum benefit at “intermediate” SNRs, that is between conditions where the auditory signal is almost perfectly audible (high SNR) and where it is completely unintelligible (low SNR). The aim of this study was twofold: First, we asked whether this pattern is subject to change over the course of childhood development and second, we investigated whether it is atypical in children with autistic spectrum disorder (ASD). For that, we compared audiovisual gain over seven SNRs in typically developing children (TD) with that of neurotypical adults and a pilot sample of high functioning ASD children. Overall, TD children had more difficulty recognizing words when they were embedded in noise and did not experience as much gain from visual articulation as adults. This difference was only apparent at the lowest and the intermediate SNR. In adults, the point of maximal gain was located at a lower SNR than in TD children but was tied to a similar auditory- alone performance. ASD children experienced substantially less benefit than TD children while their auditory- alone and visual- alone performance remained unremarkable. Our data show that overall audiovisual gain increases throughout childhood development and is related to a decrease in susceptibility to noise in auditory speech recognition. This developmental pattern is reflected by an age- related shift of the maximal gain from higher to lower SNRs. Preliminary data suggest that ASD children experience less gain from visual speech.

Effect of eye-position on auditory, visual or audio-visual target localization

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Recent studies showed that eye position influences audio-visual fusion (Hartnagel et al., 2007) as well as auditory localization (Razavi et al., 2007). This behavioral data are based on electrophysiological results showing idiosyncratic neuronal representations in SC (Jay and Sparks 1984) as in cortical areas (Snyder, 2006). In the present experiment we investigate the effect of gaze position on visual and auditory target localization. These stimuli are displayed alone or in synchrony with a variable spatial disparity between them. The subject is sat at the center of a hemi-cylindrical screen, the head, aligned with the body, is kept fixed using a bite-bar, and the gaze is monitored by an eye tracker. Three conditions are tested (intermixed); auditory alone trials, visual alone trials and bimodal AV trials. For each of the 3 conditions the fixation cross is displayed either straight ahead or 15° laterally shifted to the right (randomly intermixed) for a mean duration of 500 ms. Subject has to localize the visual and the auditory part of the stimuli using a trackball to move a white cross. Results do not permit to show significant effect of eye position on auditory or visual localization.

Cognitive interactions between facial expression and vocal intonation in emotional judgment

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Purpose: We investigated how people integrate emotions of the face and vocal intonation, which are congruent or incongruent in emotional contents. Method: Sixteen elderly people (age: 65–80) and fifteen youth (age: 21–22) participated in the experiment. Moving images of faces and voices expressing a neutral message by a few words (I get home, for example) were presented simultaneously with certain emotional face and vocal intonation. Observers judged the real significance of emotion exhibited. Results: When facial and vocal emotions were incongruent, (1) face was a more dominant cue than voice for elderly people, but the youth appropriately used both, depending on the emotion, and (2) incongruent expressions were judged more frequently by elderly people as a new emotion of neither the face nor voice. For instance, in the cases that facial expression was anger, and vocal intonation was in happy or sad or surprising tone, participants judged the real emotion as a new emotion of disgust.

Visual object recognition by prehension movement

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Object motor representation is strictly linked to prehension movements control. In particular the influence of some visual intrinsic object features on hand preshaping during reach to grasp movements is known. In this study we propose a new paradigm to investigate human skill in object features extraction from visually presented actions. We measured the performance of subjects in the recognition of objects by looking at videos of prehension actions obtained by showing only point-light based representations of the grasping hand. Subject were required to recognize the object with different procedures and different experimental conditions were considered. Performance analysis suggests how spatial information of object directed actions varies in time. Furthermore these experiments could provide new insights about the problem of agency in the domain of hand biological motion perception. In our preliminary results recognition errors seem not to be casually distributed among simple objects and response distribution supports the idea that the action of grasping an object encodes information about the shape and size of the object. Moreover performance in object recognition is affected by the perspective from which subjects looked at recorded grasping movements, and this effect is mainly present when subjects were shown their own previously recorded actions.

Assessing the effect of sound complexity on the audiotactile crossmodal dynamic capture task

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We examined the effect of varying the complexity of auditory stimuli (i.e., white noise vs. pure tone) on participants' performance in the audiotactile crossmodal dynamic capture task. Participants had to discriminate the direction of a target streams (auditory in Experiment 1 and tactile in Experiment 2) while trying to ignore the direction of a distractor stream (tactile in Experiment 1 and auditory in Experiment 2). The distractor stream could be either spatiotemporally congruent or incongruent with the target stream. While the crossmodal dynamic capture exerted by tactile distractors was comparable for the two auditory target conditions (white noise vs. pure tone; Experiment 1), the crossmodal capture effect induced by the white noise stimuli was significantly larger than that induced by the pure tones (Exp.2). The fact that participants' performance in Experiment 2 was affected by the nature of the auditory distractors is consistent with the assumption that audiotactile interactions occur predominantly for complex stimuli (cf. Graziano et al., 1999; Farnè & Ladavas, 2002). The difference in the results of the two experiments reported here further suggests that auditory streams are more adequate, regardless of the nature of the stimuli, for conveying dynamic information.

Human trimodal perception follows optimal statistical inference

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Our nervous system typically processes signals from multiple sensory modalities at any given moment, and is therefore posed with two important problems: which of the signals are caused by a common event, and how to combine those signals. We investigated human perception in the presence of auditory, visual, and tactile stimulation in a numerosity judgment task. Observers were presented with stimuli in one, two, or three modalities simultaneously, and were asked to report their percepts in each modality. The degree of congruency between the modalities varied across trials. Crossmodal illusions were observed in most conditions in which there was incongruence among the two or three stimuli, revealing robust interactions among the three modalities in all directions. We compared the human observer responses with those of a simple normative Bayesian inference model that, in contrast to traditional models of cue combination, does not make an a priori assumption of fusion, and allows independent causes for the different signals. The observers' bimodal and trimodal percepts were remarkably consistent with the model. The model contains 3 free parameters and it accounts for 95% of the variance in the data (208 data points). These findings provide evidence that the combination of sensory information among three modalities follows optimal statistical inference in a framework that allows fusion as well as segregation of stimuli.

Audio-visual and visuo-tactile integration in the human thalamus

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Based on invasive electrophysiology it has been recently hypothesized that thalamic regions might play a critical role in multisensory integration. So far, however, non-invasive evidence in humans is almost completely lacking. We employed spatial independent component analysis (sICA) on fMRI data acquired during an audio-visuo-tactile object perception experiment. Among the task-related independent components (ICs) three apparently unisensory ICs were most robustly detected. Each of these ICs suggested a network of functionally connected cortical and subcortical regions processing auditory, visual, and somatosensory-motor information, respectively. Combining these IC-maps provided a surprisingly clear parcellation of the sensory-motor thalamus in its medial geniculate (MGN), lateral geniculate (LGN), and ventral posterior (VPN) nuclei. The same subjects also participated in two independent (audio-visual, AV; visuo-tactile, VT) experiments. These data enabled explicit testing of the hypothesized thalamic involvement in multisensory integration. Our preliminary results indicate AV integration effects (Max-criterion: AV>max[A, V]) in bilateral MGN (but not LGN) and similar VT integration effects in both LGN and VPN. Interestingly, these latter effects were only detectable when our subjects grasped the objects with their non-dominant (left) hand, which suggests that VT integration effects in the human thalamus are most pronounced when unimodal (haptic) stimulation is least effective.

Visual and auditory modulation of perceptual stability of ambiguous visual patterns

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Perception of ambiguous visual patterns changes stochastically from one percept to the other. Although many studies have investigated the temporal dynamics of perceptual alternation, what determines the temporal dynamics remains unclear. We investigated how task-irrelevant sensory stimulation alters the perceptual stability of ambiguous visual patterns. Participants continuously reported the perceived direction of an ambiguous motion stimulus ("quartet dots"), wherein two dots could be seen as moving vertically or horizontally (von Schiller, 1933, Psychol. Forsch.; Leopald et al., 2002 Nat. Neurosci.). Task-irrelevant flashes or beeps were presented with random intervals. In separate sessions, the flash and the beep were presented either in isolation (flash-only or beep-only), synchronously, or asynchronously. The results indicated that perceptual alternations tended to occur with shorter intervals after the sensory stimulations than the prediction assuming no modulation. Interestingly, the effect magnitude on perceptual stability of visual motion did not differ between flash-only and beep-only stimulation conditions. In addition, synchronous flash-beep stimulation did not increase the effect magnitude. These results suggest that the task-irrelevant sensory stimulations alter the temporal dynamics of perceptual stability for ambiguous visual patterns through a modality-independent process.

How the brain could make sense out of complex multi-sensory inputs

Eugen Oetringer

When taking a computer-style approach to the question of how information might be managed inside the brain, fundamental architectural conflicts emerge. To avoid those, the brain needs to operate with about 100 or fewer “straight-line” neurons between thought and muscle activation. Parallel processing needs to happen so computer-style complexity and addressing and administration challenges do not exist. This points toward a switching architecture as opposed to a processing architecture. In addition, the complex nature of the brain suggests an integrated feedback structure is needed to make sense out of complex information coming from different sensory inputs. In line with these criteria, the proposed session introduces the Neural Network Switching Model. This model aligns with the emerging view of the brain operating in a pattern-forming, self-organizing way (and with mini-columns). The session proposes how, with a multi-sensory feedback structure embedded in the model, the brain is able to make sense of highly complex information such as understanding the meaning of a sentence in which the letters are mixed up at word level.

Audiovisual fusion or just an illusion?

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McGurk fusion – ba(audio)/ga(visual) eliciting /da/ (fusion), shows the bimodality of speech perception, and has been investigated extensively for thirty years embedded in various language contexts. However, most researchers have neglected the velar fusion: ba/da eliciting /ga/ fusion and pa/ta eliciting /ka/ fusion, which resulted in fusion rates of 27% and 50% respectively (MacDonald and McGurk, 1978:255). Schwartz (2001), experimenting with only voiceless consonants, claimed that these latter types of fusion are laboratory curiosities which do not occur embedded in French syllables. In this paper we show that such velar perceptions are not just a product of isolated nonsense syllables, but are robust percepts formed by integration of audio and visual channels with high fusion rates, even when the incongruent inputs are embedded in various languages. Our evidence, derived from nonsense syllables and from real words in English, German and Arabic, covers both voiceless and voiced consonants. We further discuss how speech perception theories can be modified to model these velar fusion phenomena. For future studies we propose brain imaging methods, which have the potential to locate fusion events in the neural substrate of subjects from a wide range of language cultures and establish a degree of language-universality.

Optimal integration of auditory and vibrotactile information for judgements of temporal order

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Recent research assessing spatial judgements about multisensory stimuli suggests that humans integrate bisensory inputs in a statistically optimal manner, weighting each input by its normalised reciprocal variance. Is integration similarly optimal when humans judge the temporal properties of bimodal stimuli? Twenty four participants performed temporal order judgements (TOJs) about two spatially separated stimuli. Stimuli were auditory, vibrotactile, or both. The temporal profiles of vibrotactile stimuli were manipulated, producing three levels of TOJ precision. In bimodal conditions, the asynchrony between the two unimodal stimuli comprising a bimodal stimulus was also manipulated to determine the weight given to vibrotaction. Unimodal data were used to predict bimodal performance on two measures: judgement uncertainty and vibrotactile weight. A model relying exclusively on audition was rejected based on both measures. A second model selecting the best input on each trial did not predict the reduced judgement uncertainty observed in bimodal trials. Only the optimal maximum-likelihood-estimation model predicted both judgement uncertainties and weights, extending its validity to TOJs. TOJ tasks investigate an important goal of sensory processing: Event sequencing. We discuss implications for modelling this process.

Incoherent audio-visual motion reveals early multisensory integration in auditory cortex

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We studied how inconsistency between directions in audio-visual motion does effect on the auditory processing. Using a whole-head magnetoencephalography we localized the sources of activity in the primary auditory cortex. We found that when the direction of audio and visual motion was opposite the auditory N1 component (about 100 ms after stimulus onset) had larger amplitude than when the direction was the same. Such an early effect of the audio-visual inconsistency observed in the auditory cortex indicates a starting time point of audio-visual integration which happens in primary sensory areas.

Olfactory-visual interactions in emotional face processing

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Understanding the emotional content of an event can be facilitated by the integration of information from multiple sensory modalities. In how far olfactory cues can affect the processing of emotional visual information is however unclear. The present study investigated whether olfactory primes selectively inhibit or facilitate the recognition of an emotional facial expression. Furthermore, we assessed whether emotion recognition deficits in schizophrenia could be improved by congruent crossmodal priming. In each trial, subjects were exposed to a 1.5 sec odorant airpuff followed by a facial affect recognition task. Three odorants of different valence were used: vanillin (pleasant), ambient air (neutral) and hydrogen sulphide (unpleasant) in combination with the correspondent facial expressions of happiness, neutral affect, and disgust. Each odorant and each face were combined, resulting in nine possible pairings presented in a pseudo-randomized order. For healthy subjects, we found an RT advantage for happy faces under baseline conditions, but not when an odorant prime was presented. Furthermore, there was an effect of crossmodal congruency for disgusted faces; they were recognized faster when preceded by hydrogen sulphide than by ambient air or vanillin. At baseline, accuracy was higher for neutral than for digusted faces; this effect was modulated by the olfactory primes. Preliminary data on schizophrenia patients and matched controls revealed no such RT pattern for the patient group. Furthermore, accuracy was lowest when a disgusted face was preceded by an unpleasant odor. In conclusion, our results point to a cumulative effect of crossmodal stimulation for disgust which healthy controls are able to benefit from behaviorally. The opposite holds true for schizophrenia patients, who show decreased accuracy for the same condition. These findings point to a mechanism of evolutionary significance, which is disturbed in schizophrenia.

Tactile illusion induced by referred thermal sensation

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We know very little about the interactions between cutaneous sensations because of the difficulties to make clear whether the interaction is caused in central nerve system or variance peripheral receptor sensitivity by multiple stimuli. Now, we conducted an experiment to examine whether the thermal sensation bias the tactile hardness perception without actual thermal difference in peripheral receptors by using illusory referred thermal sensation: when the index and ring fingers were placed on warm (cold) material and the middle finger was placed on a neutral thermal material, participant feel warm (cold) by all three fingers. The hardness of comparison stimulus was varied according to double stair case method. Seven participants conducted two-alternative-forced-choice task on perceived hardness on middle finger. The result shows that participant feel sample harder under cold condition than that under the warm condition. This phenomenon implies that that illusory thermal experience induces tactile illusion; warm (cold) material is felt soft (hard).

Perception of the visual double-flash illusion correlates with changes of oscillatory activity in human sensory areas

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When a brief visual stimulus is accompanied by two brief tactile stimuli, subjects often perceive a second illusory visual stimulus ("double-flash illusion", DFI). We investigated the neural mechanisms of this illusion with whole-head 151-channel MEG-recordings. Twenty-two subjects received visuo-tactile stimulations and reported the number of perceived visual stimuli. We sorted trials with identical physical stimulation according to the subjects' percept and assessed differences in spectral power. In DFI trials, occipital sensors displayed a bilateral de-synchronization in the alpha-band (7.5-15 Hz) before stimulus onset (-400 to -200 ms) and a contralateral enhancement of oscillatory activity in the gamma-band (70-130 Hz) in response to stimulation. This enhancement was similar in time- and frequency extent to the somatosensory gamma-band response to tactile stimulation. In somatosensory sensors, the DFI was associated with an increase of spectral power for low frequencies (5-15 Hz) around stimulation and a decrease of spectral power in the 25-30 Hz range between 400-850 ms post-stimulation. Several of the observed components have been frequently related to increased attention or excitability in visual and somatosensory areas. The DFI might therefore occur when the somatosensory gamma-response spreads to visual cortex. This spreading might be supported by the observed modulations in low-frequencies.

How vision and kinesthesia contribute to space perception: Evidence from blind and sighted humans

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It is still an open question whether vision plays a dominant role in space perception. Here, we tested spatial acuity in congenitally blind and sighted volunteers for different unisensory and multisensory spatial coding conditions. In the egocentric condition, participants indicated whether a visual (LED), a kinesthetic (passive right-hand movement), or a visuo-kinesthetic trajectory was left- or right-oriented in reference to the body midline axis. In the allocentric condition, participants judged whether intersecting trajectory segments described either an acute or an obtuse angle. A psychometric function was fitted to the data to define the bias (measure of accuracy) and the uncertainty range (measure of precision). Space perception of sighted participants was more accurate for the combined visuo-kinesthetic information than for the unisensory visual or kinesthetic information suggesting that both vision and kinesthesia contribute to space perception. Sighted participants' estimates based on kinesthetic input were more accurate than those of congenitally blind participants, irrespective of the spatial coding condition. However, early spatial training of congenitally blind adults improved spatial accuracy and precision matching the performance level of the sighted. This effect was more pronounced for allocentric than egocentric coding. Thus, early non-visual experience of space seems to compensate for the lack of vision.

Cross-modal integration of visual and haptic information for object recognition: Effects of view changes and shape similarity

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Four studies contrasted cross-modal object matching (visual to haptic and haptic to visual) with uni-modal matching (visual-visual and haptic-haptic). The stimuli were hand-sized, plastic models of familiar objects. There were twenty pairs of similarly-shaped objects (cup/jug; frog/lizard, spoon/knife, etc.) and a morph midway in shape between each pair. Objects at fixed orientations were presented sequentially behind an LCD screen. The screen was opaque for haptic inputs and clear for visual presentations. We tested whether a 90º depth rotation from the first to the second object impaired people's ability to detect shape changes. This achievement of object constancy over view changes was examined across different levels of task difficulty. Difficulty was varied between groups by manipulating shape similarity on mismatch trials. First, view changes from the first to the second object impaired performance in all conditions except haptic to visual matching. Second, for visual-visual matches only, these disruptive effects of task-irrelevant rotations were greater when the task was harder due to increased shape similarity on mismatches. Viewpoint thus influenced both visual and haptic object identification but its effects differed across modalities and for unimodal versus crossmodal matching. These results suggest that the effects of view changes are caused by modality-specific processes.

Combining sensory cues for spatial updating: The minimal sensory context to enhance mental rotations

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Mental rotation is the capacity to predict the outcome of spatial relationships after a change in viewpoint, which arises arise either from the test array rotation or the observer rotation. Several studies have reported that the cognitive cost of a mental rotation is reduced when the change in viewpoint result from the observer's motion, which can be explained by the possibility to use spatial updating mechanism involved during self-motion. However, little is known about how this process is triggered and how the various sensory cues available might contribute to the updating performance. We used a virtual reality setup to study mental rotations that for the first time allowed investigating different combinations of modalities stimulated during the viewpoint changes. In an earlier study we validated this platform by replicating the classical advantage found for a moving observer (Lehmann, Vidal, & Bülthoff, 2007). In following experiments we showed: First, increasing the opportunities for spatial binding (by displaying the rotation of the tabletop on which the test objects lay) was sufficient to significantly reduce the mental rotation cost. Second, a single modality stimulated during the observer's motion (Vision or Body) is not enough to trigger the advantage. Third, combining two modalities (Body & Vision or Body & Audition) significantly improves the mental rotation performance. These results are discussed in terms of sensory-independent triggering of spatial updating during self-motion, with additive effects when sensory modalities are co-activated. In conclusion, we propose a new sensory-based framework that can account for all of the results reported in previous work, including some apparent contradictions about the role of extra-retinal cues.

Motion discrimination of visual, tactile and bimodal stimuli

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In this study we investigated visual and tactile motion perception and multimodal integration by measuring velocity discrimination thresholds over a wide range of base velocities and spatial frequencies. The stimuli were two physical wheels etched with a sinewave profile that was both seen and felt, allowing for the simultaneous presentation of visual and haptic velocities, either congruent or in conflict,. Stimuli were presented in two separate intervals and subjects required to report the faster motion in 2AFC, using visual, tactile or bimodal information. There was an overall improvement (about root two) in the bimodal detection and discrimination thresholds, that were well predicted by the maximum likelihood estimation model, but this was not specific for direction. Interestingly, both bimodal and unimodal visual and tactile thresholds showed a characteristic "dipper function", with the minimum at a given "pedestal duration". The "dip" (indicating facilitation) occurred over the same velocity range (0.05 – 0.2 cm/sec) at all spatial frequencies and conditions. Most interestingly, a tactile pedestal facilitated a visual test and vice versa, indicating facilitation between modalities. Our results suggest that visual and tactile information of motion are analyzed with similar sensitivities, integrated in an optimal fashion and that the thresholding of these signals occurs at high levels after cross-modal integration.

Activation of visuomotor brain areas reflects the individual smoking expertise: An fMRI study

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Tiffany's (1990, Psychol Rev 97:147-168) model of automatized schemata hypothesizes that addicts may encode drug-taking actions as automatized motor schemata, which can be activated by relevant sensory input. Interestingly, recent studies have shown that smokers exhibit an atypical activation of sensorimotor brain regions when exposed to smoking-related visual cues. We employed functional magnetic resonance imaging (fMRI) and the Fagerström-Test for Nicotine Dependence (FTND) to compare cue-related neural responses in smokers and non-smokers. Smoking-related images induced stronger activations in smokers than non-smokers in regions, which are components of a brain system related to visuomotor integration and tool-use: bilateral posterior middle temporal gyrus (pMTG) and premotor cortex (PMC), left intraparietal sulcus (IPS) and superior parietal lobule (SPL) and right cerebellum; the same pattern of activation was revealed in bilateral caudate nucleus. The smokers' group also showed substantial correlations between FTND scores and cue-induced BOLD signals in left pMTG, IPS and bilateral PMC. As both attention effects and vascular differences between the two groups could be excluded, we conclude that conditioned visual stimuli automatically activate smoking-related motor knowledge and tool-use skills in smokers as predicted by Tiffany's model. Most interestingly, the degree of neural activation in visuomotor regions reflected the individual's "smoking expertise".

Multisensory integration of non-visual sensory information for the perceptual estimation of walking speed

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A variety of sources of sensory information (e.g., visual, inertial and proprioceptive) are available for the estimation of walking speed. However, little is known about how they are integrated. We present a series of experiments, using a 2-IFC walking speed judgment task, investigating the relative contributions of the inertial and proprioceptive information. We used a circular treadmill equipped with a motorized handlebar, to manipulate inertial and proprioceptive inputs independently. In one experiment we directly compared walking-in-place (WIP) and walking-through-space (WTS). We found that WIP is perceived as slower than WTS. The WIP condition creates a special conflict situation because the proprioceptive cue indicates motion whereas the inertial cue indicates an absence of motion through space. In another experiment we presented a range of conflicts by combining a single proprioceptive input with different inertial inputs. We found that the inertial input is weighted more heavily when it indicates a faster walking speed than proprioception. Conversely, it receives less weight if it indicates a lower speed. This suggests that the inertial cue becomes more reliable with increasing velocity. Our findings show a more important role for inertial information in the perception of walking speed than has previously been suggested in the literature.

Tactile capture of auditory localization is modulated by hand posture

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The well-known ventriloquist illusion arises when sounds are mislocalized towards a synchronous but spatially discrepant visual stimulus. Recently, a similar effect of touch on audition has been reported. The present study tested whether this audio-tactile ventriloquist effect depends on hand posture. Participants reported the perceived location of brief auditory stimuli that were presented from left (AL; -10°), right (AR; +10°), and center (AC; 0°) locations, either alone or with concurrent tactile stimuli to the fingertips situated at the left (TL; -22.5°) and right (TR; 22.5°) of the speaker array. Compared to unimodal presentations, auditory localization was biased toward the side of the concurrent tactile stimulus, i.e. for ALTR and ARTL the respective correct responses decreased in favor of responses to the contralateral side. This effect was reduced but still significant when participants adopted a crossed hands posture. Here a localization bias was present only for large audio-tactile discrepancies (ALTR and ARTL), where the respective correct responses decreased in favor of center responses, indicating a partial (incomplete) bias. These results substantiate recent evidence for the existence of an audio-tactile ventriloquism effect and extent these findings by demonstrating that this illusion operates in an external coordinate system. The finding that hand posture modulates the audio-tactile ventriloquist effect, moreover, demonstrates that this effect is not exclusively due to a response bias.

Measuring auditory-visual integration efficiency

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Auditory-visual integration efficiency (IE) is a presumed skill employed by subjects independently from their ability to extract information from auditory and visual speech inputs (Grant, 2002, JASA). However, currently there are no established methods for determining a subject's IE. One approach is based on employing models of auditory-visual integration to predict optimal AV performance. Differences between model predictions and obtained scores are then used to estimate IE. However, the validity of these derived estimates of IE are necessarily based on the accuracy of the model fit. Here we present a novel measurement technique to address this issue without requiring explicit assumptions about the underlying audiovisual processing. It is based on a version of the Theory of Fechnerian Scaling developed by Dzhafarov and Colonius (Reconstructing distances among objects from their discriminability, Psychometrika, 2006, 71: 365-386) that permits the reconstruction of subjective distances among stimuli of arbitrary complexity from their pair wise discriminability. We demonstrate the approach on various data sets including a same-different experiment with phoneme-grapheme pairs from our lab.

Developmental time course of the crossed hands effect for tactile temporal order judgements

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Temporal order judgements (TOJ) for two tactile stimuli, one presented to each hand, are less precise when the hands are crossed over the midline than when the hands are uncrossed. This "crossed hands" effect has been considered as evidence for a remapping of tactile input into an external reference frame. Since late, but not early blind individuals show such remapping, it has been hypothesized that the use of an external reference frame develops during childhood. Five to ten year old children were therefore tested with the tactile TOJ task, both with uncrossed and crossed hands. Overall performance in the TOJ task improved with age. While children older than five and half years displayed a crossed hand effect, younger children did not. Therefore the use of an external reference frame for tactile, and possibly multisensory, localization seems to be acquired at the age around five years.

Musical parameters and audiotactile metaphorical mappings

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Though the relationship of touch and sound is central to music performance, and audiotactile metaphors are pertinent to musical discourse, few empirical studies have investigated systematically how musical parameters such as pitch, loudness, and timbre and their interactions affect auditory-tactile metaphorical mappings. In this study, 40 participants (20 musically trained) rated the appropriateness of six dichotomous tactile metaphors (sharp-blunt, smooth-rough, soft-hard, light-heavy, warm-cold and wet-dry) to 20 sounds, varying in pitch, loudness, instrumental timbre (violin vs. flute) and vibrato. Results (repeated measures ANOVAs) suggest that tactile metaphors are strongly associated with all musical variables examined. Higher pitches and louder sounds were both rated as sharper, rougher, harder and colder than lower pitches and quieter sounds. Higher pitches, however, were lighter than lower pitches, while louder sounds were heavier than quieter sounds. Violin sounds were rated as rougher, harder, and drier than flute sounds. Vibrato sounds were rated as wetter and warmer than non-vibrato. We consider two complementary accounts for these findings:
psychophysical analogies of tactile and auditory sensory processing, and experiential analogies, based on correlations between tactile and auditory qualities of sound sources in daily experience.

Sensory interactions in the claustrum and insula cortex

Ryan Remedios, Nikos K Logothetis, Christoph Kayser

MPI for Biological Cybernetics

Once considered to be components of the same structure, the claustrum and the overlying insula cortex are intricately connected to several sensory areas and are therefore presumptive sites for multisensory integration. We test this hypothesis using a combination of visual and acoustical stimuli while recording from the claustrum and insula cortex of awake non-human primates. Our study revealed that the claustrum was parcellated into sensory zones, one of which was predominantly acoustical while another was predominantly visual. However, within each of these zones, we were not only able to identify neurons that responded to the other modality, but also identify some neurons that were multimodal. Within the posterior insula cortex, on the other hand, sensory representations were preferentially acoustical in nature, and although a third of the neurons were in fact modulated by visual activity, only a fraction of these were actually responsive to both modalities. Using natural sounds we uncovered an insular preference towards conspecific vocalizations wherein neurons here could distinguish between vocalizations themselves, based on the sound's temporal character. Our findings suggest that although various sensory modalities may converge onto a structure, modality dominant zones can still exist within, with multisensory neurons intermingled among them.

Motor performance and motor awareness in a full body agency task using virtual reality

Oliver Alan Kannape[1], Tej Tadi[1], Lars Schwabe[1], Olaf Blanke[1,2]

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Recently, Lenggenhager et al. (2007) studied bodily awareness for one's entire body (ownership) using multisensory (visual-somatosensory) conflict and virtual reality technology, showing that ownership for body parts and the entire body rely on similar multisensory mechanisms. In the present setup we combined this line of research with research protocols on agency in order to investigate motor contributions to the bodily awareness of the entire body (agency). We asked 9 subjects to walk towards 4 different target positions while their body movements were tracked (via optical tracking). Movements were mapped to a virtual body and played back, in real-time, on a projection screen. either spatially deviated or not. The body movement and position of the virtual character were deviated systematically from the participants' movements using different spatial offsets. Motor performance and motor awareness were measured. Results show that subjects are unaware of angular biases of ~10 deg despite participants' motor behaviour (significantly deviated walking paths in the direction opposite to the spatial offset; $p<0.001$). Our paradigm makes it possible to quantify when humans become consciously aware of sensorimotor movement conflicts for the position of their entire body. These data show that despite precise motor control, motor awareness is very limited for full body actions.

On and off the body: Extending the space for visual dominance of touch

Jess Hartcher-O'Brien, Charles J Spence

University Of Oxford

The interplay between vision and touch is a particularly intriguing multisensory interaction, given the propensity for visual dominance. Extending recent findings demonstrating such visual dominance over touch, we investigated how the distance of the visual stimulus from a participant's body influenced the processing of the visual and tactile stimuli. Participants made speeded detection/discrimination responses to a random sequence of visual-only, tactile-only, and bimodal targets. Responses were near-perfect on the unimodal target trials. Bimodal target trial performance was affected by position of the visual stimulus (on vs. off body): Specifically, when the visual stimulus was at the fingertip, there were significantly more tactile than visual errors. However, moving the visual stimulus off the body eliminated the visual dominance effect. In a second experiment, visual stimuli were presented either on the participant's fingertip or on the fingertip of a plausibly-positioned rubber hand. Even though we made no attempt to establish an illusion of ownership, the introduction of the artificial limb reestablished the visual dominance effect. Taken together, these results demonstrate that visual dominance over touch occurs for visual stimuli presented on the body
as opposed to off it, regardless of whether the stimulus was delivered to the actual or to the virtual fingertip.

Plasticity of voice-processing: Evidence from event-related potentials in late-onset blind and sighted people

Julia Föcker, Anna Best, Brigitte Röder

Biological Psychology and Neuropsychology, University of Hamburg

Blind people rely much more on voice cues than sighted people for person identification. Event-related potential (ERP) and brainimaging results have suggested that voice recognition and auditory language processing involve more posterior possibly visual brain regions in the congenitally blind compared to sighted individuals. To test whether these plastic changes in voice processing can still evolve in adulthood, we investigated a group of late-onset blind people.In a priming paradigm two successive voices (S1 and S2) were presented. S1 and S2 belonged either to the same or to a different person. Participants made an old-young decision on the S2. Reaction times were shorter in person-congruent trials than in person-incongruent trials for both, the late-onset blind group and for the sighted controls.ERPs related to the person-incongruent S2 stimuli were characterized by an enhanced negativity in early (around 250 ms) and later time epochs (330 - 380 ms). While these effects reached their maximum at central and parietal electrode clusters in the sighted, the maximal amplitude of this effect was found over the occipital and parietal scalp for late-onset blind individuals. These results provide evidence for adult plasticity of processes related to voice recognition.

Audio-visual object integration in human STS: Determinants of stimulus efficacy and inverse effectiveness

Sebastian Werner, Uta Noppeney

Max Planck Institute for Biological Cybernetics

Combining fMRI and psychophysics, we investigated the neural mechanisms underlying the integration of higher-order audio-visual object features. In a target detection and a semantic categorization task, we presented subjects with pictures and sounds of tools or musical instruments while factorially manipulating the relative informativeness (degradation) of auditory and visual stimuli. Controlling for integration effects of low-level stimulus features, our experiment reveals integration of higher-order audio-visual object information selectively in anterior and posterior STS regions. Across subjects, audio-visual BOLD-interactions within these regions were strongly subadditive for intact stimuli and turned into additive effects for degraded stimuli. Across voxels, the probability to observe subadditivity increased with the strength of the unimodal BOLD-responses for both degraded and intact stimuli. Importantly, subjects' multi-sensory behavioural benefit significantly predicted the mode of integration in STS: Subjects with greater benefits exhibited stronger superadditivity. In conclusion and according to the inverse effectiveness principle that is determined by stimulus efficacy, we demonstrate that the mode of multi-sensory integration in STS depends on stimulus informativeness, the voxel-specific responsiveness to unimodal stimulus components and the subject-specific multi-sensory behavioural benefit in object perception. The relationship between BOLD-responses and behavioural indices show the functional relevance of super- and subadditive modes of multi-sensory integration.

Timing is everything: Modality mediates effects of attention in implicit statistical learning

Lauren Emberson[1], Chris Conway[2], Morten Christiansen[1]

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Implicit statistical learning (ISL)—the discovery of structure using statistical properties of the input—has been documented in multiple modalities including vision, audition, and touch. However, modality-effects have been demonstrated in ISL tasks providing evidence for modality-specific processing. The current work presents the first experimental link between modality effects in ISL tasks and modality-specific processing of attention. In experiments designed to manipulate both modality-specific factors and attention, we report interactions of attention and modality modulated by stimulus timing. Specifically, we find that auditory ISL does not occur for either attended or unattended stimuli in temporally distal conditions. However, under temporally proximal conditions favorable to auditory perceptual grouping, we report significant learning of attended stimuli and marginal learning of unattended stimuli in auditory ISL. There is no corresponding relationship between attention and temporal proximity in visual ISL likely because visual perceptual grouping occurs along spatial rather than temporal dimensions. Thus, this work provides evidence for modality-specific application of attention in ISL tasks, providing insight into the on-going debate as to the role of attention in ISL. More generally, these findings elucidate the manner in which the senses constrain cognitive processing not just in ISL but possibly in learning and memory, more broadly.

Mirror symmetry topographical mapping is a fundamental principle of cortex organization across sensory modalities: A whole brain fMRI study of tonotopic mapping

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The three topographical senses (vision, audition and touch) are characterized by a topographical mapping of the sensory world onto primary and secondary cortices. In such topographical maps, adjacent neurons represent adjacent sensory building blocks (e.g. visual field, tone frequency and body parts) in each sense. But how common are such topographical maps outside primary sensory areas? And can we characterize similar principles of organization across modalities? Using fMRI, we applied continuous and periodic sensory stimulation, to detect further topographically sensitive areas in the auditory modality. We used phase locking Fourier techniques combined with a spherical cortex-based alignment approach to detect such topographic maps. Using these methods, we report here the preliminary finding of multiple novel tonotopic maps in the human brain. These maps stretch from primary auditory cortex to occipito-temporal cortex and are organized in parallel, mirror symmetry bands as found in the visual cortex. We also find additional topographic frequency sensitivity in parietal and occipital cortex. Our results suggest that mirror symmetry topographical mapping may be a fundamental principle of mapping in both vision and audition and might be a more common characteristic of associative and multisensory cortex than previously suspected.

Space and time modulate faster visual detection in the profound deaf

Davide Bottari

University of Trento

Previous literature suggests enhanced visual skills in profound deafness. We examined visual detection and discrimination abilities in profound deaf and hearing controls, as a function of target occurrence in time and space. Modulations in time were obtained by presenting visual targets at one of two intervals after a warning signal: 600ms ± 200 (short interval) or 2000ms ± 200 (long interval). For half of participants, short intervals were standards (i.e., 84% of trials) and long intervals were deviants (14%); for the remaining participants standard/deviant proportions were reversed. Modulations in space were obtained by presenting targets at one of two eccentricities: 3 or 8 degrees. In Exp.1 (detection) profound deaf were overall faster (40ms on average) than hearing controls. Reactivity enhancements were mostly pronounced for targets occurring at short interval and towards the periphery. In Exp.2 (discrimination) faster responses only emerged at the expenses of accuracy. Moreover, no modulation of visual responses emerged as a function of time and space. We suggest that reactivity may be a core aspect of deafness, and it can be modulated as a function of space and time. However, reactivity may reflect faster transmission of visual input (or motor preparation) than enhancement of late perceptual processes.

Gradients of unimodal and crossmodal spatial attention under different processing load

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The present study investigated the influence of processing load upon tuning of spatial attention in the task-relevant (auditory) and task-irrelevant (visual) modalities. Noise bursts were presented via speakers in the free field, and visual stimulus LED was mounted onto each speaker. Processing load was manipulated by alternating auditory targets (one of three possible deviants) randomly in the high load condition, while the auditory target was kept the same in the low load condition. Participants were required to detect auditory targets at the attended location (center or periphery), while ignoring all auditory standard stimuli and all visual stimuli. The N1 attention effect was more negative in the high load condition than in the low load condition. Furthermore, early attention effects were more sharply tuned (steeper ERP gradient) for both the task-relevant auditory and the task-irrelevant visual modalities in the high load condition. These results suggested that both ERP gradients of unimodal and crossmodal spatial attention varied as a function of processing load in the primary modality.

11:30 – 12:30 Keynote address

Combining sight sound and touch, in mature and developing humans

David Burr

Dipartimento di Psicologia, Università di Firenze and Istituto di Neuroscienze del CNR, Pisa

Recently, the so called “Bayesian” (maximum likelihood estimate: MLE) approach has provided many useful insights into multi-sensory integration. In this talk I will the application of this technique to explaining the “ventriloquist effect”. Vision normally “captures” the position of sounds, but when visual stimuli are heavily blurred, sound can capture vision. All results are well predicted by assuming that the brain calculates a weighted sum of the auditory and visual signals, with weights proportional to the reliability of each signal. How quickly can the brain calculate appropriate weights for the integration? We took advantage of the fact that vision is impoverished for a brief but well defined period around the time of saccades, while auditory localization is unaffected. Using auditory probes during saccades, we have shown that both the perceived position and the precision of localizing a visuo-audio sources during saccades are well predicted by maximum likelihood estimation, and that the dynamics of the combination follow a characteristic and predictable timecourse. This result suggests that the brain can rapidly update perceptual weights to take into account dynamic changes in reliability. We also studied development of integration in school-age children using two tasks: a size judgment and orientation discrimination. In neither task did children below eight years of age integrate visual and haptic information: for the size task, haptic information dominated (although the precision from this source was worse than from vision), and for orientation discrimination vision (the least precise sense) dominated. We suggest that prior to 8 years of age, the different perceptual systems calibrate each other, at the expense of optimal integration.

12:30 – 14:00 Symposium

Multisensory processing of visual and tactile information

Organized by Krish Sathian

Emory University, Atlanta, U.S.

Vision and touch share a number of information-processing goals, including extraction of information about the shapes and locations of objects. This symposium brings together a range of methodological approaches that have been applied to the study of visuo-tactile integration, focusing on recent findings. Alberto Gallace will discuss behavioral work showing that crossmodal perception of changes in stimulus location can be disrupted by inserting a visual or tactile mask between stimulus displays (crossmodal change blindness). Marc Ernst will assess the extent to which behavioral integration of visual and haptic information about shape is statistically optimal, and the conditions under which integration starts to fail. Joshua Lucan will present ERP data on the spatio-temporal brain dynamics of somatosensory shape discrimination that suggest activity in the lateral occipital cortex beginning within the first 500ms of information processing. Krish Sathian will outline functional MRI studies showing common visuo-haptic processing of both object shape and object location, and explore the role of visual imagery in the crossmodal recruitment of visual cortex.

Visuo-haptic processing of shape and location

Krish Sathian

Emory University, Atlanta, U.S.

Both visual and haptic perception of object shape engage processing in the lateral occipital complex (LOC) and intraparietal sulcus (IPS). We found that the IPS regions (but not the LOC) are also active during visual and haptic perception of object location. The common processing in IPS regions during perception of both shape and location information suggests that activity in these regions during shape perception may reflect attention to the relative locations of parts of objects, whereas LOC activity may reflect global shape processing. What is the role of visual imagery (VI) in mediating LOC activity during haptic processing of shape (HS)? We found that activations during HS of familiar objects overlapped extensively with those during VI, with the magnitudes of VI- and HS-evoked activation being strongly correlated across subjects. These findings were not true for unfamiliar objects. Analysis of effective connectivity showed that the VI and familiar HS tasks activated similar networks involving top-down pathways into the lateral occipital complex (LOC), whereas the unfamiliar HS task activated a substantially different network characterized by bottom-up inputs into the LOC. Thus, the role of visual imagery in haptic shape perception is prominent for familiar, but not unfamiliar, objects.

The spatio-temporal dynamics of somatosensory shape discrimination.

Joshua Nelson Lucan

The City College of New York

Functional imaging studies have revealed a number of cortical regions associated with somatosensory shape recognition in humans. These include somatosensory association cortex, as would be expected, but activity is also often found in the so-called lateral occipital complex, a cluster of regions primarily associated with visual object processing. We measured high density EEG to investigate the timing of somatosensory shape discrimination processes using a modified version of a paradigm previously employed in functional imaging experiments. Simple geometric shapes were presented to the right index finger of ten participants while the ongoing EEG was measured time locked to the stimulus. In the experimental condition participants discriminated the shape of the stimulus. In the control condition they judged stimulus duration. Using traditional event related potential analysis techniques we found significantly greater amplitudes in the evoked potentials of the shape discrimination condition between 80 and 100ms. Scalp voltage topography and source analysis procedures indicated a greater involvement of contralateral somatosensory association cortex in the shape discrimination condition. Conventional analyses failed to reveal clear stimulus locked activation of lateral occipital areas during sensory–perceptual processing timeframes. We will discuss possible methodological reasons for this apparent divergence from findings in the imaging literature, including differences in the timeframes considered, and explore several approaches toward a resolution.

Similarities between the awareness of change in vision and touch: The role of spatial processing

Alberto Gallace[1], Charles Spence[2]

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[2]Department of Experimental Psychology, Oxford University, Oxford, UK

Studies of change detection have revealed that people are surprisingly poor at detecting changes between two consecutively presented visual scenes/displays, under various stimulus presentation conditions (as, for example, when the two to-be-compared displays are separated by a blank or mask, or by a saccade). More recently, this phenomenon, known as 'change blindness', has been reported within touch as well. In the studies reported here, the ability of participants to detect changes between two consecutively-presented vibrotactile patterns presented on the fingertips of both hands or across the body surface were investigated. Not only was change detection impaired when a tactile mask was introduced between the two to-be-compared displays, but also when a visual mask was used instead. Similarly, failures of change detection were reported when the two to-be-compared displays were presented in different sensory modalities (vision and touch; i.e., crossmodal change blindness was observed). Finally, we also show that tactile change detection can be also impaired by the execution of a bodily movement during the presentation of the two to-be-compared displays. Taken as a whole, these results show that spatial information processing might play a critical role in people's awareness of both visual and tactile change.

Amodal multimodal integration

Marc O. Ernst[1], Massimiliano Di Luca[1], Wendy Adams[2]

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Recently it has been shown that congruent visual and haptic signals are integrated in a statistically optimal fashion. Spatial separation between the signals can preclude this integration. Here we investigate whether optimal integration occurs between an amodally completed visual stimulus and its haptic counterpart. Thus, we ask whether integration occurs despite the sensory information not being derived from the same spatial location. This may indicate that subjects inferred that the visually specified parts of the stimulus and the haptic information have a common cause and thus should be integrated. The visual stimulus was a disparity-defined bar that was partially occluded (amodal completion condition). The bar could also be touched behind the occluder using two fingers. Subjects' task was to discriminate the size of two successively presented bars using a 2-IFC paradigm, where one interval contained conflicting haptic and visual information. Performance in the amodal completion condition was not different from a condition in which the occluder was removed (visual- haptic condition). Both conditions were consistent with an optimal integration strategy. More interestingly, integration deviated from optimality when we introduced a slight modification to the visual stimulus – small gaps between the bar and the occluder (gap condition). This manipulation interfered with the amodal completion process and consequently subjects relied almost completely on the haptic information for discriminating the size of the bars. These findings suggest that visual and haptic information can be combined optimally even when visual information is not directly specified by sensory information, but results from amodal completion. In conclusion, it seems that the perceptual system determines when to combine visual and haptic information based on the likelihood the signals have of belonging to the same object (i.e. if there is a causal relationship between the signals) and not only on signal co- location.

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