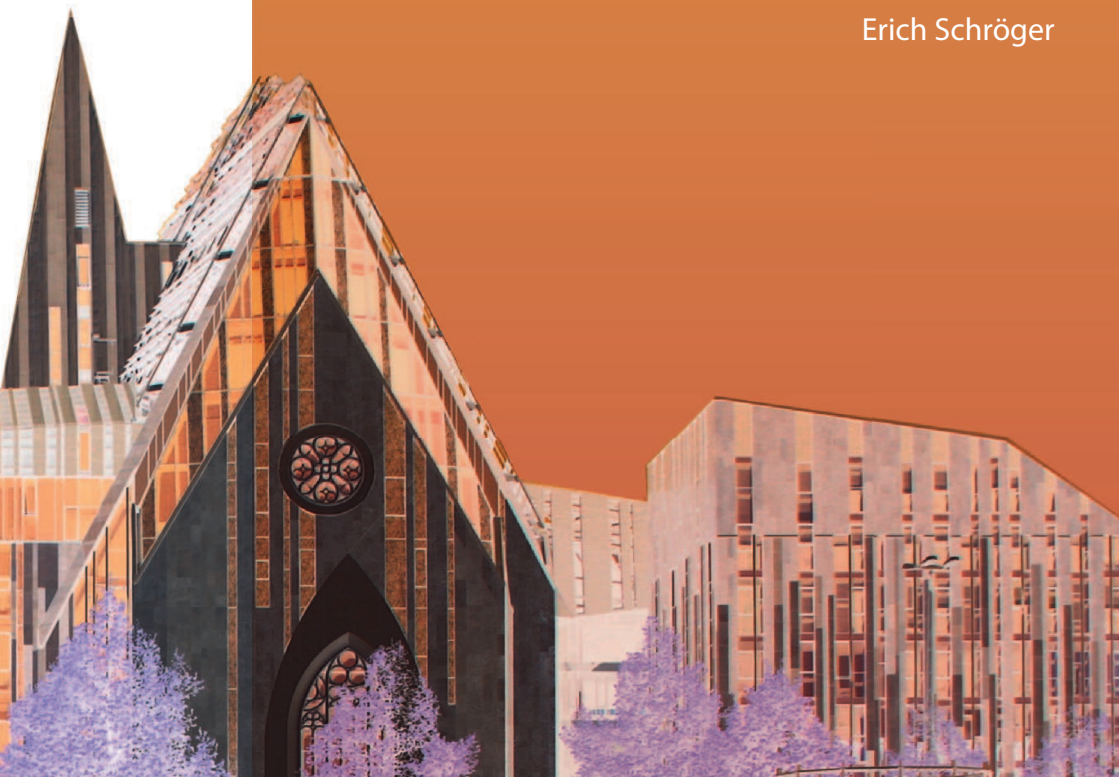
2015

MMN

Error Signals from the Brain

7th Mismatch Negativity Conference

Andreas Widmann
Johanna Steinberg
Alexandra Bendixen
Angela D. Friederici
Sabine Grimm
Thomas C. Gunter
Sonja A. Kotz
Dagmar Müller
Urte Roeber
Rudolf Rübsamen
Annekathrin Weise
Nicole Wetzel
Erich Schröger



Error Signals from the Brain

7th Mismatch Negativity Conference

Error Signals from the Brain

7th Mismatch Negativity Conference

Andreas Widmann
Johanna Steinberg
Alexandra Bendixen
Angela D. Friederici
Sabine Grimm
Thomas C. Gunter
Sonja A. Kotz
Dagmar Müller
Urte Roeber
Rudolf Rübsamen
Annekathrin Weise
Nicole Wetzel
Erich Schröger

UNIVERSITÄT LEIPZIG

MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliographie; detailed bibliographic data are available on the Internet at http://dnb.ddb.de .

Cover design: Sabine Grimm, MPI CBS Grafik & Multimedia
Cover photo: University of Leipzig/Randy Kühn
Printing: SDV Direct World GmbH
Printed in Germany

ISBN 978-3-00-050311-5

Preface

The MMN Conference has developed into an established, traditional meeting with a special focus on the brain's automatic, non-intentional encoding and representation of regularities and the detection of respective regularity violations. The first MMN Conference took place in Helsinki in 1998 (20 years after the discovery of MMN), followed by MMN meetings in Barcelona (2000), Lyon (2003), Cambridge (2006), Budapest (2009) and New York (2012).

In 2015, the MMN Conference takes place in Leipzig (organized by the University of Leipzig and the Max Planck Institute [MPI] for Human Cognitive and Brain Sciences). The University of Leipzig was founded in 1409 and hosted famous academics such as the mathematician Gottfried Wilhelm Leibniz, the philosopher Friedrich Nietzsche, and the father of German literature, Johann Wolfgang von Goethe. Interesting from the perspectives of cognitive neuroscience, psychiatry, and psychology: Paul Flechsig and Emil Kraepelin worked at the University of Leipzig; Ernst Heinrich Weber and Gustav Theodor Fechner developed psychophysics in Leipzig; and in 1879, Wilhelm Wundt founded the world's first Institute for Experimental Psychology in Leipzig. Already at that time, several behavioral and psychophysiological measures were used to study the human information processing system (cf. http://www.uni-leipzig.de/~psycho/wundt/viewerz.htm). Following this tradition, the MPI for Human Cognitive and Brain Sciences (originally named MPI for Cognitive Neuroscience) was established in 1994.

The MMN is an error signal of the brain that is elicited when a sensory (auditory, visual, somato-sensory) stimulus does not match an expected regularity of the sensory environment. It taps into important functions such as sensory memory, mental representations, perception, error signaling, novelty detection, neural adaptation, and prediction. MMN has been used in thousands of experiments in basic and applied (including clinical) research. Therefore the MMN can be regarded as the most influential error signal in cognitive neuroscience.

The 7th Mismatch Negativity Conference presents the state of the art in methods, theory, and application (basic and clinical research) of the MMN (and related error signals of the brain). Moreover, there will be two pre-conference workshops: one on the design of MMN studies and the analysis and interpretation of MMN data, and one on the visual MMN (with 20 presentations). There will be more than 40 presentations on hot topics of MMN grouped into thirteen symposia, and about 130 poster presentations. Keynote lectures by Kimmo Alho, Angela D. Friederici, and Israel Nelken will round off the program by covering topics related to and beyond MMN.

We welcome all conference participants in Leipzig, and we look forward to an interesting and inspiring meeting!

Erich Schröger on behalf of the local organizers

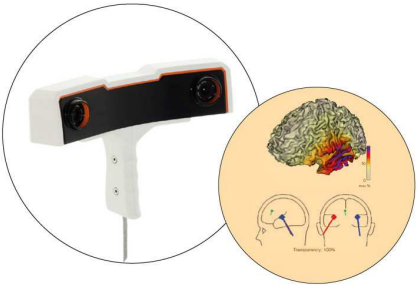
BRAIN PRODUCTS
Solutions for neurophysiological research

MES
FORSCHUNGSSYSTEME GMBH

EEG ERP Source Analysis Bundle

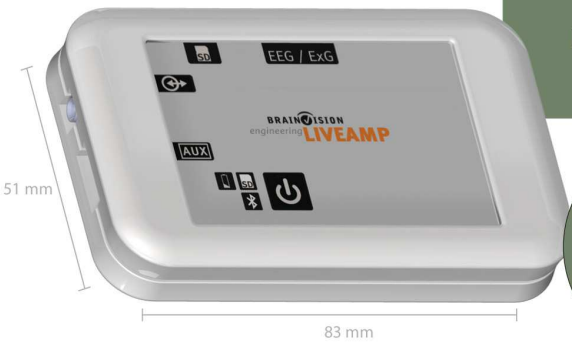
actiCHamp 64, CapTrak, BESA

64ch active EEG • Easy to use • Fast to apply
Easy optical electrode position digitization
Fully integrated • All you need to be at the cutting edge of EEG ERP Source Analysis



See us at Booth #A3!

LiveAmp



Wearable wireless amplifier • 56 grams
32 channels EEG (8 AUX capable)
Electrodes: passive/active/active dry
Built-in TTL trigger

Starting from 15.000 € incl. electrode cap and BrainVision Recorder

www.brainproducts.com
www.mesmed.de

Table of Contents

Conference Information

Organizers

Local organizers

Erich Schröger, Alexandra Bendixen, Angela D. Friederici, Sabine Grimm, Thomas C. Gunter, Sonja A. Kotz, Dagmar Müller, Urte Roeber, Rudolf Rübsamen, Johanna Steinberg, Annekathrin Weise, Nicole Wetzel, and Andreas Widmann.

Scientific committee

Kimmo Alho, Torsten Baldeweg, Alexandra Bendixen, Stefan Berti, Maria Chait, István Czigler, Sue Denham, Leon Deouell, Carles Escera, Catherine Fischer, Judith M. Ford, Angela D. Friederici, Marta Garrido, Marie-Hélène Giard, Sabine Grimm, Thomas C. Gunter, Christoph Herrmann, János Horváth, Minna Huotilainen, Thomas Jacobsen, Motohiro Kimura, Sonja A. Kotz, Nina Kraus, Teija Kujala, Manuel S. Malmierca, Daniel Mathalon, Patricia Michie, Dominique Morlet, Dagmar Müller, Risto Näätänen, Israel Nelken, Trevor Penney, Friedemann Pulvermüller, Urte Roeber, Rudolf Rübsamen, Dean F. Salisbury, Erich Schröger, Valerie Shafer, Yury Shtyrov, Johanna Steinberg, Elyse Sussman, Mari Tervaniemi, Juanita Todd, Laurel Trainor, Annekathrin Weise, Nicole Wetzel, Andreas Widmann, István Winkler, and Hirooki Yabe.

Getting to Leipzig

By air

Flughafen Leipzig/Halle (LEJ; Leipzig/Halle Airport) is approximately a 30 minute drive to the city center. Deutsche Bahn (http://www.bahn.de) S-Bahn trains run regularly between the airport station and Hauptbahnhof Leipzig (Leipzig main railway station). Alternative airport destinations include Berlin (about two hours from Leipzig by train), Frankfurt or Hannover (both about three and a half hours from Leipzig by train). Trains commute regularly between Leipzig and all three cities.

By rail

Deutsche Bahn (http://www.bahn.de) InterCity and InterCityExpress trains link Leipzig with almost all European cities. ❺ Hauptbahnhof Leipzig (Leipzig main railway station) is located directly in the center of Leipzig.

By road

You can reach Leipzig on highway A9 (Berlin–Nürnberg), A14 (Halle–Dresden), A38 (Göttingen–Leipzig), or A72 (Hof–Leipzig).

Conference venue and directions

The pre-conference workshops will take place at ❶ Städtisches Kaufhaus (Institute of Psychology, University of Leipzig), Universitätsstraße 16, 04109 Leipzig. Enter the door to the right of the yard gate (Treppenhaus D) and follow the signs to rooms Z005 and 133.

The conference opening including keynote lecture 1 and the welcome reception will take place at the ❸ Max Planck Institute for Human Cognitive and Brain Sciences (MPI CBS), Stephanstraße 1, 04103 Leipzig. The MPI is at 10–15 min walking distance from the city center. You can also take a tram (line 4 to Stötteritz, line 7 to Sommerfeld, line 12 to Johannisplatz, or line 15 to Meusdorf) and get off at the stop "Johannisplatz". Continue walking in the direction of the tram and take the second street on the right (Stephanstraße). The institute is immediately visible on the left-hand side at the next intersection.

The keynote lectures 2 and 3, symposia and poster sessions from Wednesday, September 9, to Friday, September 11, 2015 will take place at ❷ Hörsaalgebäude (lecture hall building, University of Leipzig), Universitätsstraße 3, 04109 Leipzig, in Hörsaal 3 and the Foyer, which are both on first floor.

The farewell party will take place in Gondwanaland at ❹ Zoo Leipzig, Pfaffendorfer Straße 29, 04105 Leipzig. The zoo is in 15–20 min walking distance from the city center. You can also take a tram (line 12 to Gohlis Nord) and get off at the stop "Zoo". You will find the entrance to Gondwanaland approximately 100 meters to the right of the main entrance of the zoo.

Conference office

The conference office will be open on Tuesday, September 8, 2015, from 09:00–10:00 at Städtisches Kaufhaus and from 17:00–21:00 at the MPI CBS. From Wednesday, September 9 to Friday, September 11, 2015 the conference office will be located in Hörsaalgebäude opposite Hörsaal 3. Opening hours will be from 09:00 until the end of the official program. Presentations can be uploaded in the conference office (at the latest half an hour before the presentation).

Please note that only cash can be accepted for on-site registrations. Also please note that access to the pre-conference workshops is only possible after registration through the electronic system on the webpage due to limited space.

Conference staff can be identified by conference t-shirts and colored name tags. Don't hesitate to contact them for assistance. Please wear your name tag during the conference.

A cloakroom will be available on the first floor of the Hörsaalgebäude during the official program.

Certificate of attendance

A certificate of attendance will be provided with the conference material when registering for the conference.

Important phone numbers

Emergency (ambulance, fire)	112
Police	110
Taxi	+49 341 4884

Internet access

Eduroam WiFi access will be available at Städtisches Kaufhaus (pre-conference workshops), MPI CBS (keynote lecture 1 and welcome reception) and Hörsaalgebäude (keynote lectures, symposia, poster sessions). At Städtisches Kaufhaus and Hörsaalgebäude you will also be able to connect to the *eduevent* WiFi network (SSID/network name: eduevent, PSK/password: Modellierung-2015, encryption: WPA2/AES, IP: DHCP, DNS: DHCP). *Eduevent* only provides http(s), pop3(s), imap(s), vpn, and ssh connections.

Information for presenters

Oral presentations

For presentations Microsoft Windows (PDF and Microsoft PowerPoint 2013) and OS X (PDF and Microsoft PowerPoint for Mac 2011) based PCs (incl. sound system) will be available. Please note that presentation with your own notebook/laptop computer will *not* be possible. Presentations can be uploaded at the conference office (at the latest half an hour before the presentation) or sent by email to mmn2015@uni-leipzig.de (at the latest the day before the presentation).

Poster

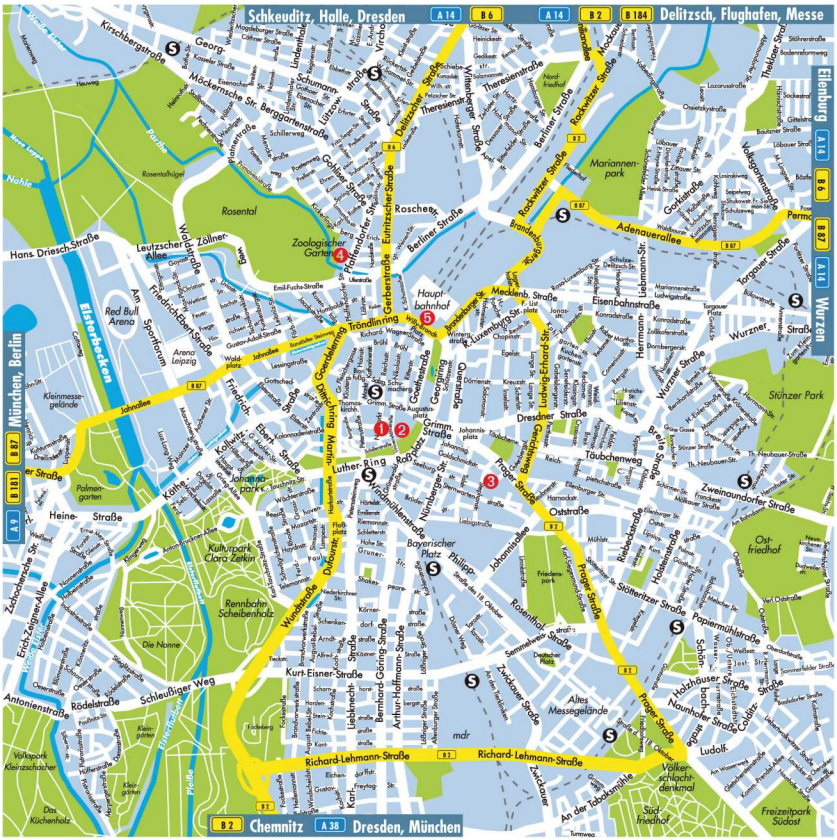
The maximal poster size is set at 900 mm width x 1200 mm height (portrait format). Posters can be put up at the morning of the day of the poster session and should be removed by the end of that day. Pushpins will be available at the poster boards. The badges next to the poster abstracts indicate the poster number (as you will find them on the poster boards) and the poster session in which the poster will be presented.

Maps

❶ *Städtisches Kaufhaus* (SKH; Institute of Psychology, University of Leipzig), Universitätsstraße 16, 04109 Leipzig (pre-conference workshops)

❷ *Hörsaalgebäude* (lecture hall building, University of Leipzig), Universitätsstraße 3, 04109 Leipzig (keynote lectures, symposia, and poster sessions)

❺ *Hauptbahnhof* (Leipzig main railway station)



❶ *Städtisches Kaufhaus* (SKH; Institute of Psychology, University of Leipzig), Universitätsstraße 16, 04109 Leipzig (pre-conference workshops)

❷ *Hörsaalgebäude* (lecture hall building, University of Leipzig), Universitätsstraße 3, 04109 Leipzig (keynote lectures, symposia, and poster sessions)

❸ Max Planck Institute for Human Cognitive and Brain Sciences *(MPI CBS)*, Stephanstraße 1, 04103 Leipzig (opening, keynote lecture 1, and welcome reception)

❹ *Zoo Leipzig*, Pfaffendorfer Straße 29, 04105 Leipzig (farewell party)

❺ *Hauptbahnhof* (Leipzig main railway station)

Catering

Small lunches of sandwiches, soups, desserts and soft drinks will be served at the conference venue. If you prefer to have lunch at a restaurant, please ask at the conference office for suggestions of one of the numerous places that are nearby. During coffee breaks soft drinks and snacks will be available. During poster sessions we will offer beverages and finger food. Catering is included in the registration fee.

Social program

Welcome reception

The welcome reception will be an informal get-together at the MPI CBS. Canapés and drinks will be offered. The welcome reception is included in the conference fee. If possible, please register in advance through the electronic system on the webpage. You can do so by modifying your existing registration.

Farewell party

Our farewell party will take place at *Gondwanaland* – a tropical island under a cupola roof within the fantastic setting of the Leipzig Zoo, which is internationally renowned for its biodiversity in its spectacular tropical area.

Starting at 19:00, we will undertake an exciting journey by boat on the jungle river Gamanile, going back in time through the Earth's history in the midst of the Gondwanaland rainforest. After the boat tour you will have the opportunity to explore this extraordinary habitat with its 500 different plant and animal species individually on a round tour. At around 20:00 a welcome drink and an exquisite buffet full of Asian culinary delights will be served surrounded by this exotic scenery. Of course there will be music, so we can hit the dance floor and celebrate an inspiring conference.

For organizational reasons we are only able to offer a very limited number of tickets for purchase on-site. Therefore, we highly encourage you to book your ticket through the electronic system on the webpage as soon as possible. You can do so by modifying your existing registration.

Acknowledgements

We are very grateful to the members of the Scientific Committee for important input defining symposia, selecting chairs, finding keynote speakers, reviewing all the abstracts, and giving helpful comments as well as to the members of the Travel Award Board, Alexandra Bendixen, Carles Escera, Motohiro Kimura, Dean F. Salisbury, and Juanita Todd, for their evaluation of the applications. Also, we are grateful to Kerstin Flake for her help with the cover design, to Moran Aharoni, Maria Bader, Nina Coy, Anna Marzecová, Florian Scharf, Mathias Scharinger,

Dagmar Schrödl, Dorit Thieme, Melanie Trümper and all student helpers for their assistance and invaluable help. The conference was supported by the sponsoring partners, MES Forschungssysteme GmbH, Brain Products GmbH, g.tec medical engineering GmbH, EASYCAP GmbH, Compumedics Germany GmbH, and a grant from the DFG (German Research Foundation, WE5026/2-1).

Sponsors and funding

Silver Sponsors

MES
FORSCHUNGSSYSTEME GMBH

BRAIN PRODUCTS
Solutions for neurophysiological research

g.tec
GUGER TECHNOLOGIES

Sponsors

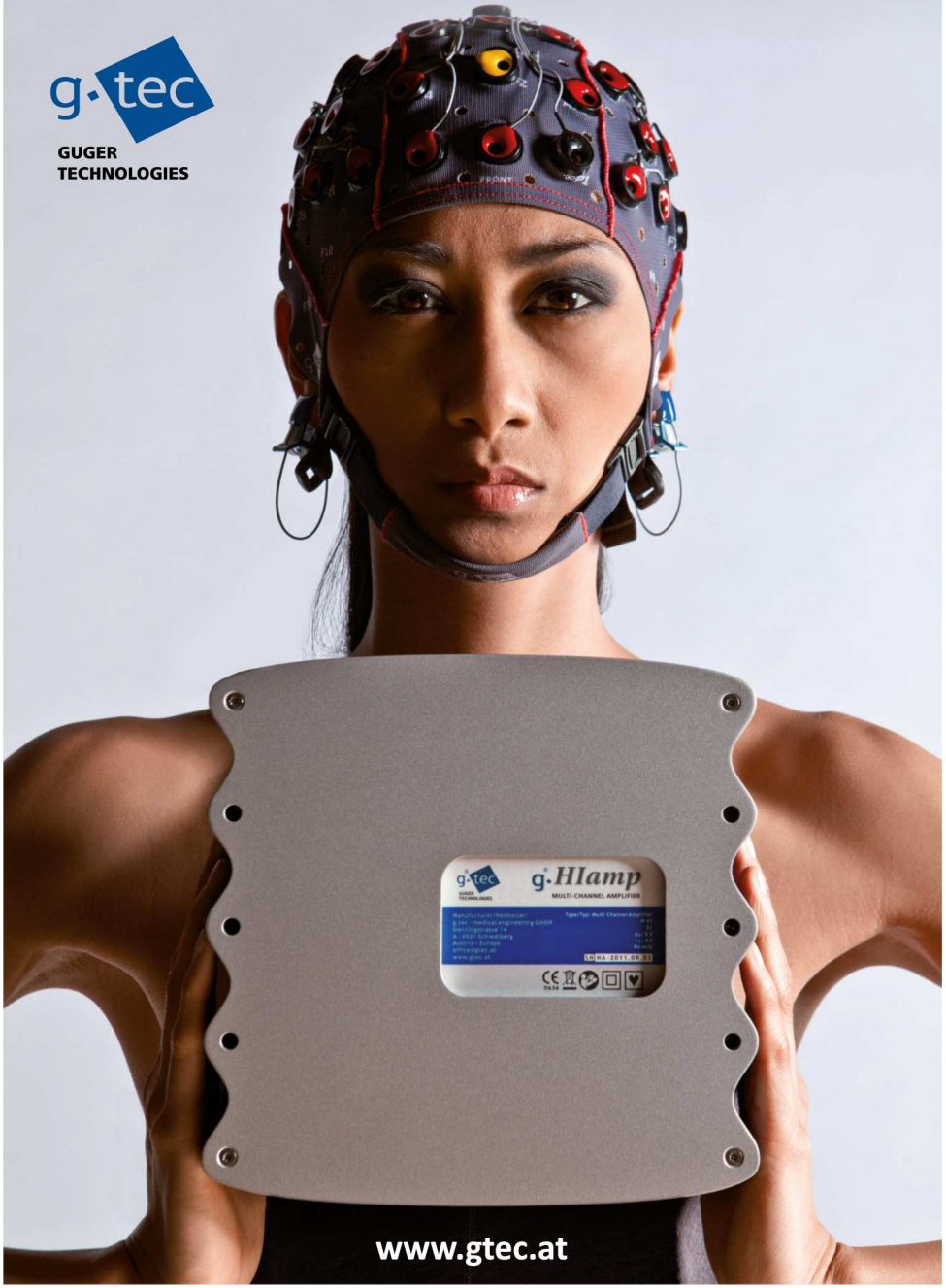
EASYCAP
EEG Recording Caps and Related Products

COMPUMEDICS
NeuroScan™

Funding

DFG

advanced biosignal acquisition, processing and analysis



www.gtec.at

Program

Overview

	Tuesday, September 8, 2015	Wednesday, September 9, 2015	Thursday, September 10, 2015	Friday, September 11, 2015
9:30		*Symposium 1:* When the brain errs (p. 113)	*Symposium 6:* MMN as a translational biomarker of psychosis (p. 122)	*Symposium 10:* Human language mechanisms as revealed by the MMN (p. 131)
10:00	*Pre-conference workshops:* Visual mismatch negativity (SKH Z005; p. 141) and Methodological aspects of MMN research (SKH 133; p. 149)			
10:30		Coffee break	Coffee break	Coffee break
11:00		*Symposium 2:* Development of auditory and speech processing in infants and children (p. 114)	*Symposium 7:* Fast dynamic encoding of the sound landscape (p. 125)	*Symposium 11:* Deviance detection along the auditory pathway (p. 133)
12:00		*Symposium 3:* Clinical applications: hearing and speech disorders (p. 117)	*Symposium 8:* Deviance-detection across modalities (p. 127)	*Symposium 12:* Aging (p. 135)
13:00		Lunch	Lunch	Lunch
14:30		*Symposium 4:* MMN, music, and life span (p. 119)	*Poster session 2* (p. 24)	*Symposium 13:* Computational models of MMN (p. 138)
15:30		*Symposium 5:* Attention, perception, and memory in scene analysis (p. 120)		*Poster session 3* (p. 27)
16:00			Coffee break	
16:30		Coffee break	*Symposium 9:* Past, present and future of the MMN (p. 130)	
17:00		*Poster session 1* (p. 20)		*Keynote lecture 3:* Kimmo Alho: Bottom-up triggered and top-down controlled attention to sounds (p. 32)
17:30				
18:00	Opening words (MPI CBS)			
18:30	*Keynote lecture 1:* Angela D. Friederici: Language: a uniquely human trait (MPI CBS; p. 31)	*Keynote lecture 2:* Israel Nelken: The representation of surprise in the auditory system: data and models (p. 32)		
19:00				Farewell party (Zoo)
19:30	Welcome reception (MPI CBS)			

Tuesday, September 8, 2015

Pre-conference workshop 1: Visual mismatch negativity

Tuesday, September 8, 2015, 10:00–17:00, Städtisches Kaufhaus, room Z005, p. 141
Chair: István Czigler & Gábor Stefanics

- *Jan Kremláček & Kairi Kreegipuu:* Visual mismatch negativity in clinical use
- *Motohiro Kimura & Gábor Stefanics:* Visual mismatch negativity, prediction, and its functional roles
- *István Czigler:* Methods in vMMN research (controlling attention, and adaptation)
- *Piia Astikainen & Marie Gomot:* Visual MMN to emotional faces and other higher-level stimuli
- *Anne Caclin & Davide Bottari:* Does the visual MMN develop independently of the auditory MMN? The case of deafness
- *Tom Campbell, Elke Lange, Alexander Sorokin, & Olga Sysoeva:* A form of visual mismatch negativity to color-deviant distractors disrupting visual search performance
- *Krisztina Kecskés-Kovács, Flóra Bodnár, István Sulykos, Domonkos File, & István Czigler:* The vMMN is sensitive to within category and between category effect when using a morphing method
- *Dagmar Müller, Katja Saupe, & Erich Schröger:* Predicting visual stimuli by auditory sequence regularities
- *István Sulykos, Krisztina Kecskés-Kovács, & István Czigler:* "What is it?" and "Where is it going?" Two questions in the language of the brain: the additivity issue of the visual mismatch negativity
- *George Stothart, Nina Kazanina, Andrea Tales, & Risto Näätänen:* The diagnostic and prognostic value of visual evoked potentials and vMMN in Alzheimer's disease and mild cognitive impairment
- *Fengyu Cong & Piia Astikainen:* Multi-way data decomposition and analysis for vMMN
- *Andres Neuhaus & Bob Vogel:* Comparing emotional and neutral visual mismatch negativity
- *Wei Wang, Danmin Miao, & Lun Zhao:* Automatic detection of configural processing of faces under non-attentional condition: a visual MMN
- *Tina Wentz:* Dynamic causal modelling for MMN

Pre-conference workshop 2: Methodological aspects of MMN research

Tuesday, September 8, 2015, 10:00–17:00, Städtisches Kaufhaus, room 133, p. 149
Chair: Alexandra Bendixen & Andreas Widmann

- *János Horváth:* MMN paradigms
- *Alexandra Bendixen:* MMN from a cognitive point of view
- *Yonatan Fishman:* The mechanisms and meaning of the mismatch negativity
- *Patrick May:* MMN Interpretation – the adaptation model
- *Leon Deouell:* Recording mismatch negativity and related potentials in neurological patients
- *Sabine Grimm:* Pre-MMN indicators of deviance detection

Opening words

Tuesday, September 8, 2015, 18:00–18:30, MPI CBS, Hörsaal

Erich Schröger & Risto Näätänen

Keynote lecture 1

Tuesday, September 8, 2015, 18:30–19:30, MPI CBS, Hörsaal, p. 31
Chair: Sonja A. Kotz

Angela D. Friederici: Language: a uniquely human trait

Wednesday, September 9, 2015

Symposium 1: When the brain errs

Wednesday, September 9, 2015, 9:30–10:30, Hörsaalgebäude, Hörsaal 3, p. 113
Chair: Iria SanMiguel & Markus Ullsperger

- *Floris de Lange:* How do prior expectations change sensory processing?
- *Markus Ullsperger:* Error signals and their weighting to guide adaptive behavior
- *Mike Cohen:* Midfrontal theta and response conflict: past and future

Symposium 2: Development of auditory and speech processing in infants and children

Wednesday, September 9, 2015, 11:00–12:00, Hörsaalgebäude, Hörsaal 3, p. 114
Chair: Valerie Shafer

- *Valéria Csépe, Linda Garami, Anett Ragó, & Ferenc Honbolygó:* The role of emerging templates in infants' speech perception
- *Eino Partanen:* Infant mismatch responses to complex auditory stimuli
- *Valerie Shafer, Tanja Rinker, Markus Kiefer, Nancy Vidal, Arild Hestvik, Hia Datta, & Yan Yu:* Neural indices of speech perception in bilingual children
- *Kaisa Lohvansuu, Jarmo Hämäläinen, Annika Tanskanen, Leena Ervast, Heikki Lyytinen, & Paavo Leppänen:* Atypically large brain response to deviant speech sounds in dyslexic children – compensatory effects on reading related skills?

Symposium 3: Clinical applications: hearing and speech disorders

Wednesday, September 9, 2015, 12:00–13:00, Hörsaalgebäude, Hörsaal 3, p. 117
Chair: Teija Kujala

- *Paavo Leppänen, Jarmo Hämäläinen, & Kaisa Lohvansuu:* Atypical responses generated in MMN-paradigms as brain signatures of reading difficulties
- *Anja Hahne:* Vowel length and stress pattern discrimination in young children with cochlear implants

- *Timothy Roberts:* Magnetoencephalographic correlates of auditory processing from tones to words: contributions to clinical language impairment

Symposium 4: MMN, music, and life span

Wednesday, September 9, 2015, 14:30–15:30, Hörsaalgebäude, Hörsaal 3, p. 119
Chair: Mari Tervaniemi

- *Stefan Elmer:* The specialists' brain: the advantage of using passive oddball paradigms as a window into auditory processing and neurocognition
- *Vesa Putkinen:* Do formal and informal musical activities accelerate the development of neural sound discrimination?
- *Paula Virtala, Minna Huotilainen, & Mari Tervaniemi:* Effects of age and music expertise on Western music chord processing

Symposium 5: Attention, perception, and memory in scene analysis

Wednesday, September 9, 2015, 15:30–16:30, Hörsaalgebäude, Hörsaal 3, p. 120
Chair: Elyse Sussman & Christoph Herrmann

- *Elyse Sussman:* Multi-tasking: influence of irrelevant sounds on target detection
- *Christoph Herrmann:* Brain oscillations are causal for cognitive processes
- *Ulla Martens & Thomas Gruber:* Contextual influences on object recognition – evidence from SSVEPs

Poster session 1

Wednesday, September 9, 2015, 17:00-18:30, Hörsaalgebäude, Foyer 1st floor

[1] *Márta Volosin, Sabine Grimm, & János Horváth:* Distraction versus task-set change: investigating the functional role of P3a elicited in oddball paradigms

[4] *Paniz Tavakoli & Kenneth Campbell:* P3a evidence of consciousness following acoustic change during REM sleep

[7] *Jessica de Boer, Sarah Gibbs, & Katrin Krumbholz:* Using adaptation to investigate the neural mechanisms of attention in the human auditory cortex

[10] *Dmitri Bryzgalov, Ivan Lazarev, Nikita Novikov, & Boris Chernyshev:* Errors in auditory condensation task are preceded by lower pre-stimulus alpha-band oscillations

[13] *Dominique Morlet, Perrine Ruby, Nathalie André-Obadia, & Catherine Fischer:* Improving the detection of voluntary processes in behaviorally unresponsive patients at bedside using an oddball paradigm

[16] *Dean F. Salisbury, Timothy K. Murphy, Kayla L. Ward, Brian A. Coffman, & Sarah M. Haigh:* Complex pattern MMN to extra identical tones in schizophrenia

[19] *Daniela Mannarelli, Caterina Pauletti, Daniela D'Agnano, Vincenzo Leuzzi, Nicoletta Locuratolo, Maria Caterina De Lucia, & Francesco Fattapposta:* Attentive vulnerability to levodopa therapy in ataxia-telangiectasia patients: a MMN study

[22] *Pascale Sandmann, Irina Schierholz, Christoph Kantzke, Alexandra Bendixen, Mareike Finke, Sabine Haumann, Thomas Lenarz, Reinhard Dengler, & Andreas Büchner:* Mismatch-negativity response in individuals with central auditory implants

[25] *Ana Olivares, Jorge Iglesias Fuster, Doris Hernández Barrios, Elena Cuspineda Bravo, Cecilia Pérez Gesen, Javier Sánchez López, Daymara del Río Bazan, & Calixto Machado Curbelo:* Residual cognitive functions in PVS patients by means of MMN paradigm using emotional content. Neural generators of remaining brain activity

[28] *Lilian Aline Weber, Andreea Oliviana Diaconescu, Christoph Mathys, André Schmidt, Michael Kometer, Franz Vollenweider, & Klaas Enno Stephan:* A computational single-trial analysis of MMN under ketamine

[31] *Tongran Liu:* Pre-attentive neural processes of unattended facial emotions in adolescents

[34] *Sari Ylinen, Alexis Bosseler, Katja Junttila, & Minna Huotilainen:* Prediction errors in word recognition and learning in young children

[37] *Caterina Piazza, Chiara Cantiani, Zeynep Akalin-Acar, Makoto Miyakoshi, April Ann Benasich, Gianluigi Reni, Anna Maria Bianchi, & Scott Makeig:* ICA derived cortical responses to auditory pitch and duration deviance in six-month-old infants

[40] *Judith Charpentier, Sylvie Roux, Emmanuelle Houy-Durand, Mathieu Lemaire, Joëlle Malvy, Frédérique Bonnet-Brilhault, Agathe Saby, & Marie Gomot:* Emotional prosodic deviance-detection in school-age children

[43] *Minna Huotilainen, Mari Katri Videman, Satu Pakarinen, Iina Ala-Kurikka, Taina Nybo, Sampsa Vanhatalo, Reina Roivainen, & Eija Gaily:* Auditory event-related potentials indexing memory and change-detection in newborn infants who were exposed to antiepileptic medication during the fetal period

[46] *Kristiina Kompus, Kairi Kreegipuu, Nele Põldver, René Westerhausen, Kenneth Hugdahl, & Risto Näätänen:* Resting-state glutamatergic neurotransmission is related to the peak latency of auditory MMN for duration deviants

[49] *Joan Liu-Shuang, Katrien Torfs, & Bruno Rossion:* Objective and rapid quantification of high-level visual impairment with fast periodic oddball stimulation in acquired prosopagnosia

[52] *Juanita Todd, Jade Frost, Kaitlin Fitzgerald, & István Winkler:* First-impression effects on mismatch negativity (MMN) amplitude extend to complex sequences

[55] *Jade Frost, Kelly McDonnell, Alexander Provost, & Juanita Todd:* Does sequence foreknowledge or concurrent task affect primacy bias in mismatch negativity (MMN)?

[58] *Domonkos File, Flóra Bodnár, Krisztina Kecskés-Kovács, István Sulykos, & István Czigler:* The role of stimulus complexity in various latency ranges of vMMN

[61] *Johanna Schaefer, Katarzyna Zarnowiec, Iria SanMiguel, Manuel S. Malmierca, & Carles Escera:* Predicting complex acoustic contingencies in the human auditory brainstem

[64] *Burkhard Maess, Erich Schröger, & Alessandro Tavano:* MEG/EEG evidence for prediction in the primary auditory cortex

[67] *Katja Junttila, Rika Takegata, Sari Ylinen, & Risto Näätänen:* The effects of frequency difference and ear-of-entry on auditory stream segregation and integration

[70] *Ana Pinheiro, João Pedrosa, Margarida Vasconcelos, Carla Barros, & Sonja Kotz:* Prediction error is reduced for angry vocalizations: insights from ERP and neural oscillations

[73] *Pekcan Ungan & Hakan Karsilar:* Is the level of passive attention entrained by the rhythm of stimulation?

[76] *Tomomi Fujimura & Kazuo Okanoya:* Emotional mismatch negativity elicited by Japanese kanji with different connotations

[79] *István Sulykos, Krisztina Kecskés-Kovács, & István Czigler:* "What is it?" and "Where is it going?" Two questions in the language of the brain: the additivity issue of the visual mismatch negativity

[82] *Ulrich Schall, Bernhard Müller, Christian Kärgel, & Onur Güntürkün:* Electrophysiological mismatch response recorded in awake pigeons from the avian functional equivalent of the primary auditory cortex

[85] *Patricia Michie, Lauren Harms, William Fulham, Markku Penttonen, Juanita Todd, Ulrich Schall, & Deborah Hodgson:* MMN-like and early deviance detection in two animal models of schizophrenia – maternal immune activation and NMDAR antagonism

[88] *Luise Wagner & Torsten Rahne:* Mismatch negativity (MMN) objectively reflects timbre discrimination thresholds in normal-hearing listeners and cochlear implant users

[91] *Paul M. Briley, Diana Omigie, & Katrin Krumbholz:* Stimulus-specific adaptation in the late auditory-evoked cortical potentials exhibits long memory and sensitivity to sequential stimulus relationships

[94] *Françoise Lecaignard, Olivier Bertrand, Sébastien Daligault, Anne Caclin, & Jérémie Mattout:* High-resolution reconstruction of auditory mismatch generators using fused EEG/MEG and group inversion

[97] *Annekathrin Weise, Erich Schröger, & János Horváth:* Higher-order auditory change detectors – support from behavioral and electrophysiological data

[100] *Alejandro Blenkmann, Holly Phillips, Srivas Chennu, James Rowe, Carlos Muravchik, Silvia Kochen, & Tristan Bekinschtein:* MMN distributed sources – evidence from human intracranial recordings

[103] *Jeff Hanna & Friedemann Pulvermüller:* MMN distinguishes rule-based and arbitrary processes in language

[106] *Jana Krutwig & Yury Shtyrov:* Language-attention interactions in neural processing of spoken words

[109] *Eino Partanen, Alina Leminen, & Yury Shtyrov:* Rapid and automatic formation of novel memory traces for visually presented unattended words: MEG evidence

[112] *Lilli Kimppa & Teija Kujala:* Association of rapid automatized naming and the MMN in dyslexic children

[115] *Faith Chiu & Jyrki Tuomainen:* The generation of speech-specific MMN: solutions from dynamic causal modelling

[118] *Yuchun Chang, Chia-Lin Lee, & Hans-Jörg Schmid:* Your Chinese is different from mine? Conventionalization of constructions as indicated by mismatch negativity

[121] *Leena Ervast, Jarmo Hämäläinen, Kaisu Heinänen, Kaisa Lohvansuu, Swantje Zachau, Mari Veijola, Matti Lehtihalmes, & Paavo Leppänen:* Stability of the MMN, P3a and LDN responses to auditory frequency change between two repeated measurements in typically developing 5- to 6-year-old children

[124] *Mirjam J.I. de Jonge:* Finding the origin of directionality effects in MMNs to phonetic contrasts

[127] *Mathias Scharinger & Alessandro Tavano:* Omission responses in speech are differentially modulated by speaking rate and attention

Keynote lecture 2

Wednesday, September 9, 2015, 18:30–19:30, Hörsaalgebäude, Hörsaal 3, p. 32
Chair: Sabine Grimm

Israel Nelken: The representation of surprise in the auditory system: data and models

Thursday, September 10, 2015

Symposium 6: MMN as a translational biomarker of psychosis

Thursday, September 10, 2015, 9:30–10:30, Hörsaalgebäude, Hörsaal 3, p. 122
Chair: Juanita Todd & Gregory Light

- *Steven Siegel:* MMN as a highly sensitive measure of subtle changes in NMDAR-mediated glutamate transmission in mice
- *Ulrich Schall:* Structural and functional brain correlates of at-risk mental state
- *Daniel Mathalon:* MMN, cortisol, inflammation, and gray matter loss in individuals at clinical high risk for psychosis
- *Gregory Light:* The "Other Side" of translational biomarker development: taking MMN out of academic labs and into real-world settings to improve our understanding and treatment of psychosis

Symposium 7: Fast dynamic encoding of the sound landscape

Thursday, September 10, 2015, 11:00–12:00, Hörsaalgebäude, Hörsaal 3, p. 125
Chair: Carles Escera & Sabine Grimm

- *Andreas Widmann, Nicole Wetzel, Ralf Engbert, & Erich Schröger:* Evoked gamma band and microsaccadic responses indicate fast deviance detection and sound categorization
- *Maria Chait & Nicolas Barascud:* How the brain discovers regularities in sound sequences
- *Maryam Aghamolaei, Katarzyna Zarnowiec, Sabine Grimm, & Carles Escera:* Functional dissociation between regularity encoding and deviance detection along the auditory hierarchy

Symposium 8: Deviance-detection across modalities

Thursday, September 10, 2015, 12:00–13:00, Hörsaalgebäude, Hörsaal 3, p. 127
Chair: Stefan Berti & Gábor Stefanics

- *Gábor Stefanics, Jakob Heinzle, & Klaas Enno Stephan:* The neural network underlying automatic visual change detection
- *Evangelos Paraskevopoulos, Anja Kuchenbuch, Sibylle Herholz, Panagiotis Bamidis, & Christo Pantev:* Musical training enhances automatic deviance detection within and across sensory modalities
- *Piia Astikainen, Saara Järveläinen, Sanni Koivula, Ina Tarkka, & Juho Strömmer:* Somatosensory mismatch response in young and elderly adults
- *Elia Valentini:* Processing of nociceptive deviant input in the brain: is there a real pre-attentive nociceptive-related mismatch response?

Poster session 2

Thursday, September 10, 2015, 14:30-16:00, Hörsaalgebäude, Foyer 1st floor

[2] *Aurélie Bidet-Caulet:* Dissociating the impact of unexpected salient sounds: increase in arousal versus attentional capture

[5] *Renee Symonds & Elyse Sussman:* What did you say? I wasn't paying attention: the impact of task-irrelevant sound processing on performance

[8] *Kazunari Ikeda:* Auditory selective attention in the auditory brainstem response, negative difference, processing negativity, and positive difference waves

[11] *Kertu Saar, Nele Põldver, Mai Toom, Annika Kask, Madli Uutma, Jüri Allik, Risto Näätänen, & Kairi Kreegipuu:* Visual mismatch negativity, working memory load and processing mode

[14] *Bernhard W. Müller, Christian Kärgel, Daniela Kariofillis, Jens Wiltfang, & Gudrun Sartory:* The effect of cognitive training on the mismatch negativity in schizophrenia

[17] *Sarah M. Haigh, Brian A. Coffman, Timothy K. Murphy, Christiana Butera, & Dean F. Salisbury:* Complex pattern-deviant detection in schizophrenia

[20] *Elisa Ruohonen, Jari Kurkela, & Piia Astikainen:* Intact pre-attentive processing of sound intensity in depression as revealed by mismatch negativity

[23] *Shuntaro Itagaki, Takashi Matsuoka, Tetsuya Shiga, Kazuko Kanno, Michinari Nozaki, Satoko Asano, Yusuke Osakabe, Norikatsu Itou, Masayuki Hikita, Shin-ichi Niwa, & Hirooki Yabe:* Effect of methylphenidate in adult attention-deficit/hyperactivity disorder as reflected by MMN

[26] *Alexander Mainka, Annegret Leuner, Dirk Mürbe, & Anja Hahne:* Music perception in adult cochlear implant users

[29] *Fengyu Cong, Tapani Ristaniemi, & Heikki Lyytinen:* Filtering event-related potentials in time, frequency and space domains sequentially and simultaneously

[32] *Gábor Háden, Renáta Németh, Miklós Török, & István Winkler:* Mismatch response (MMR) in neonates: beyond refractoriness

[35] *Chiara Cantiani, Valentina Riva, Caterina Piazza, Roberta Bettoni, Massimo Molteni, Naseem Choudhury, Cecilia Marino, & April Ann Benasich:* Rapid auditory processing in Italian infants at risk for language and learning impairment

[38] *Marina Winkler, Claudia Männel, Angela D. Friederici, & Jutta L. Mueller:* Little grammar experts: 5-month-old infants' mismatch responses reveal the ability to process a triple center-embedding

[41] *Niki Vavatzanidis, Alexander Mainka, Dirk Mürbe, & Anja Hahne:* Perception of musical features in hearing impaired children after cochlear implantation

[44] *Nicole Wetzel, Erich Schröger, & Andreas Widmann:* Age differences in the processing of sound's novelty and information as reflected by ERPs, pupil size, and performance

[47] *Elvira Brattico, Marina Kliuchko, Mari Tervaniemi, & Marja Heinonen-Guzejev:* Impaired auditory discrimination of sound quality in noise sensitive individuals

[50] *Daniel Mullens, István Winkler, Karlye Damaso, Andrew Heathcote, Lisa Whitson, Alexander Provost, & Juanita Todd:* Prediction errors – Mismatch negativity (MMN) reveals how higher-level models govern error detection at lower levels

[53] *Annika Luckmann, Jacob Jolij, & Deniz Baskent:* Neurofeedback as a training tool for pitch discrimination

[56] *Stefan Dürschmid, Leon Deouell, Hermann Hinrichs, Hans-Jochen Heinze, & Robert T Knight:* High gamma frontal cortex activity dissociates predicted vs. unpredicted deviation: an intracranial EEG study

[59] *Martin Reiche, Andreas Widmann, & Alexandra Bendixen:* Pre-stimulus ERP-correlates of predictive auditory processing

[62] *Krisztina Kecskés-Kovács, Flóra Bodnár, Domonkos File, István Sulykos, & István Czigler:* The vMMN is sensitive to within category and between category effect when using a morphing method

[65] *Szonya Durant, István Sulykos, & István Czigler:* The interplay of the magno- and parvocellular visual pathways in visual MMN

[68] *Sijia Zhao, Marcus Pearce, Frederic Dick, & Maria Chait:* Sensitivity to the statistics of rapid, stochastic tone sequences

[71] *Milena Dzhelyova & Bruno Rossion:* Emotional face discrimination as revealed by electrophysiological periodic visual responses: an alternative to the vMMN approach

[74] *Simon Musall, Melek Durmaz, Florent Haiss, Bruno Weber, & Wolfger von der Behrens:* Laminar processing of sensory deviations in the somatosensory cortex

[77] *Yusuke Osakabe, Moeko Tanaka, Yuko Matsuki, Michinari Nozaki, Satoko Asano, Kazuko Kanno, Masayuki Hikita, Tetsuya Shiga, Norikatsu Itou, Shuntaro Itagaki, Takashi Matsuoka, & Hirooki Yabe:* The study of tone-frequency effect on EEG-MMN to duration change

[80] *Daryl Kelvasa, Jens Ahrens, & Jan-Niklas Antons:* The ventriloquist effect evokes changes in the early spatial processing of auditory stimuli as measured by the mismatch negativity

[83] *Jari Kurkela, Arto Lipponen, Miriam Nokia, Markku Penttonen, & Piia Astikainen:* Passive exposure to speech sound features enhances cortical plasticity revealed by mismatch response in rats

[86] *Javier Nieto, Guillermo V. Carbajal, & Manuel S. Malmierca:* Genuine deviance detection occurs in the inferior colliculus (IC) of the anaesthetized rat

[89] *Marina Kliuchko, Peter Vuust, Petri Toiviainen, Mari Tervaniemi, Brigitte Bogert, & Elvira Brattico:* Effects of active vs. passive exposure to a musical style: a MMN study with the musical multifeature paradigm

[92] *Manuel S. Malmierca, Blanca E. Niño-Aguillón, Javier Nieto, & Jonathan Fritz:* Neurons in the inferior colliculus of the rat respond to the unexpected omission of repeated stimuli

[95] *Stephen Provost & Lachlan Foster:* The relation between psychophysiological and behavioural measures of expectancy and prediction in a roving mismatch negativity paradigm

[98] *Natàlia Gorina Careta, Katarzyna Zarnowiec, Jordi Costa-Faidella, & Carles Escera:* Regularity encoding in the human auditory brainstem is enhanced by timing predictability of the upcoming sounds

[101] *Johanna Steinberg, Thomas Konstantin Jacobsen, & Thomas Jacobsen:* Repair or violation detection? Pre-attentive processing strategies of phonotactic illegality demonstrated on the constraint of g-deletion in German

[104] *Corinna Christmann, Stefan Berti, Claudia Steinbrink, & Thomas Lachmann:* Differences in sensory processing of German vowels and physically matched non-speech sounds as revealed by the mismatch negativity (MMN) of the human event-related brain potential (ERP)

[107] *Guglielmo Lucchese, Jeff Hanna, Anne Autenrieb, Natalie Miller, & Friedemann Pulvermüller:* Early and interactive stored-form (symbol) access and combinatorial (rule) processing in constructing constructions: a MMN study

[110] *Satoko Asano, Tetsuya Shiga, Yusuke Osakabe, Norikatsu Itou, Michinari Nozaki, Kazuko Kanno, Masayuki Hikita, Shuntaro Itagaki, Takashi Matsuoka, & Hirooki Yabe:* Temporal integration of speech sound probed with mismatch negativity

[113] *Sari Ylinen, Katja Junttila, Marja Laasonen, Paul Iverson, Heikki Lyytinen, & Teija Kujala:* Brain responses to foreign-language words are diminished in dyslexic children

[116] *Ferenc Honbolygó, Andrea Kóbor, & Valéria Csépe:* Processing of non-native prosodic information: a MMN study

[119] *Johan Sebastian Orozco Henao, Lina Marcela Henao Grisales, Jonathan Gallego, & Yamile Bocanegra:* New behavioral paradigm that generates event related potentials associated with language and action

[122] *Mariya Kharaman, Natalia Bekemeier, & Carsten Eulitz:* On the role of different acoustic-phonetic cues in encoding voicing in Russian and German: a cross-linguistic MMN study with native and non-native stop consonants

[125] *Andreas Højlund Nielsen, Line Gebauer, William B. McGregor, & Mikkel Wallentin:* Perceptual asymmetry effects on the MMR to Danish speech sounds

[128] *Brian A. Coffman, Sarah M. Haigh, Timothy K. Murphy, Kayla L. Ward, & Dean F. Salisbury:* Event-related potentials demonstrate deficits in auditory Gestalt formation and MMN in schizophrenia

Symposium 9: Past, present and future of the MMN

Thursday, September 10, 2015, 16:30–18:00, Hörsaalgebäude, Hörsaal 3, p. 130
Chair: István Winkler

- *Risto Näätänen, Carles Escera, Erich Schröger, Juanita Todd, & István Winkler:* Past, present, and future of the MMN

Conference participants are encouraged to submit short statements to István Winkler in advance (for details, see p. 130).

Friday, September 11, 2015

Symposium 10: Human language mechanisms as revealed by the MMN

Friday, September 11, 2015, 9:30–10:30, Hörsaalgebäude, Hörsaal 3, p. 131
Chair: Friedemann Pulvermüller & Thomas Jacobsen

- *Friedemann Pulvermüller:* The MMN as an index of spoken language processing: what's new? (Introduction)
- *Alina Leminen, Suzanne Hut, Laura Hedlund, Lilli Kimppa, Miika Leminen, & Yury Shtyrov:* Acquisition of novel word-forms by adult language learners
- *Jeff Hanna, Yury Shtyrov, John Williams, & Friedemann Pulvermüller:* Can the MMN measure proficiency in a second language?

- *Yury Shtyrov:* Automatic neural discrimination of lexical information in unattended visually presented words

Symposium 11: Deviance detection along the auditory pathway

Friday, September 11, 2015, 11:00–12:00, Hörsaalgebäude, Hörsaal 3, p. 133
Chair: Manuel Malmierca & Yonatan Fishman

- *Jennifer F. Linden:* Stimulus-specific adaptation, repetition suppression, and the MMN: bridging the gap with small-animal MEG
- *Iiro Jääskeläinen:* Adaptation, predictive coding, and perceptual objects in the human auditory system
- *Yoram Gutfreund:* Stimulus-specific adaptation: can it be a neural correlate of habituation?
- *Tomoyo Shiramatsu & Hirokazu Takahashi:* Cortical mapping of mismatch negativity in rat

Symposium 12: Aging

Friday, September 11, 2015, 12:00–13:00, Hörsaalgebäude, Hörsaal 3, p. 135
Chair: Claude Alain

- *Johanna Rimmele:* The role of temporal structure in the investigation of sensory memory and auditory scene analysis: a healthy-aging perspective
- *George Stothart & Nina Kazanina:* Auditory processing in ageing: evidence for the inhibitory deficit hypothesis
- *János Horváth, Márta Volosin, & Zsófia Anna Gaál:* Recovering from the sensory effects of auditory distraction: no difference between young and old adults
- *Claude Alain & Anja Roye:* Effects of age, noise and hearing loss on concurrent sound segregation

Symposium 13: Computational models of MMN

Friday, September 11, 2015, 14:30–15:30, Hörsaalgebäude, Hörsaal 3, p. 138
Chair: Marta I. Garrido

- *Melissa Larsen, Morten Mørup, Elvira Fischer, Hartwig Siebner, William Baaré, Thomas Werge, & Marta Garrido:* Modelling MMN in 22q11 deletion syndrome
- *Catherine Wacongne:* A neuronal model of predictive coding for MMN
- *Marta Garrido, C. L. James Teng, & Jason B. Mattingley:* MMN: a marker of statistical learning in the brain
- *Ryszard Auksztulewicz:* Disentangling sensory expectation and attentional modulation in the predictive coding framework

Poster session 3

Friday, September 11, 2015, 15:30-17:00, Hörsaalgebäude, Foyer 1st floor

[3] *Motohiro Kimura & Yuji Takeda:* Voluntary action modulates the processing of unattended rule-violating events indexed by visual mismatch negativity

[6] *Boris Chernyshev, Dmitri Bryzgalov, Ivan Lazarev, & Nikita Novikov:* Spontaneous attentional lapses are related to a rejection positivity-like ERP shift

[9] *Philipp Ruhnau, Thomas Hartmann, Erich Schröger, Nathan Weisz, & Annekathrin Weise:* Auditory distractors modulate oscillatory power prior to visual targets – the neural basis for impaired target detection?

[12] *Zeynep Oeztan, Artur Matysiak, Peter Heil, & Reinhard König:* Effects of deviant predictability on MMN-like MEG responses in oddball paradigms

[18] *Miriam Cornella, Sumie Leung, Amaia Hervàs, Jordi Costa-Faidella, Isabel Rueda, & Carles Escera:* Regularity encoding in autism spectrum disorders: brainstem responses to repeated amplitude-modulated sounds

[21] *Tetsuya Shiga, Sho Horikoshi, Itaru Miura, Keiko Kanno-Nozaki, Kazuko Kanno, Yusuke Osakabe, Michinari Nozaki, Satoko Asano, Masayuki Hikita, Norikatsu Itou, Shuntaro Itagaki, Takashi Matsuoka, & Hirooki Yabe:* Relationship between MMN and monoamine metabolite levels in schizophrenia: preliminary results of cross-sectional and longitudinal studies

[24] *Jana Zweerings, Klaus Mathiak, Arnim Johannes Gaebler, & Mikhail Zvyagintsev:* Frontal dysfunction in patients with major depression revealed by an auditory mismatch paradigm: an fMRI investigation

[27] *Holly Phillips, Alejandro Blenkmann, Laura Hughes, Tristan Bekinschtein, & James Rowe:* Hierarchical frontotemporal networks in MMN: dynamic causal modelling of MEG supported by human intracranial EEG

[30] *Richard Rosch, Karl Friston, & Torsten Baldeweg:* Effects of NMDAR antagonism on mismatch negativity and repetition suppression

[33] *Benjamin Weismüller, Renate Thienel, Anne-Marie Youlden, Ross Fulham, Michael Koch, & Ulrich Schall:* Psychophysiological correlates of developmental changes in healthy and autistic boys

[36] *Elena Kushnerenko, Przemyslaw Tomalski, & Derek G Moore:* Detection of violation in two streams: a feasibility study in 6-9 months old infants

[39] *Satu Pakarinen, Iina Ala-Kurikka, Anna Jääskeläinen, Kaija Mikkola, Vineta Fellman, & Minna Huotilainen:* Large auditory evoked potentials to rare emotional stimuli in preterm infants at term age

[42] *Elizabeth Dinces & Elyse Sussman:* Impaired auditory processing with aging

[45] *Marina Vasileva:* Specific characteristics of mismatch negativity in pre-term and full term infants

[48] *Annika Kask, Nele Põldver, Kertu Saar, Liina Juuse, Jüri Allik, Risto Näätänen, & Kairi Kreegipuu:* Automatic processing of schematic faces depending on their gaze direction and eyebrow angle: relations with depression and anxiety

[51] *Benedikt Ehinger, Peter König, & José Ossandón:* Prediction errors of visual content across eye movements and their modulation by inferred information in the blind spot

[54] *Jade Frost, Alexander Provost, István Winkler, & Juanita Todd:* Does primacy bias in mismatch negativity (MMN) diminish with repeated exposure to sound sequences?

[57] *Françoise Lecaignard, Olivier Bertrand, Jérémie Mattout, & Anne Caclin:* Implicit learning of predictable sound sequence modulates mismatch responses at different levels of the auditory hierarchy

[60] *Zhuxi Yao, Yi Yuan, Tony Buchanan, Kan Zhang, Jianhui Wu, & Liang Zhang:* Stronger autonomic stress responses are associated with better post-error adjustment in special police cadets

[63] *Ekaterina Petropavlovskaia, Lidia Shestopalova, Svetlana Vaitulevich, & Nikolay Nikitin:* Discrimination of auditory motion velocities: difference thresholds and mismatch negativity

[66] *Maria Bader, Erich Schröger, & Sabine Grimm:* Shifting pitch: time course of extracting regularities from unfamiliar complex sound patterns

[69] *Flóra Bodnár, Domonkos File, István Sulykos, Krisztina Kecskés-Kovács, & István Czigler:* The role of adaptation in the mechanisms underlying visual mismatch negativity

[72] *Bruno Rossion & Joan Liu-Shuang:* Fast periodic oddball stimulation in electroencephalography: an objective and sensitive alternative approach to the (v)MMN

[75] *Juho Strömmer, Piia Astikainen, Ina Tarkka, Tomi Waselius, Ville Kirjavainen, Saara Järveläinen, & Sanni Koivula:* Auditory and somatosensory mismatch responses in aging and their associations with neuropsychological and physical test scores

[78] *Johannes Frey, Mike Wendt, & Thomas Jacobsen:* Mismatch negativity for unattended changes in room acoustics is followed by additional negative deflections

[81] *Urte Roeber, Bradley N. Jack, Andreas Widmann, Erich Schröger, & Robert P. O'Shea:* Prediction of vision from invisible stimuli

[84] *Hirokazu Takahashi & Tomoyo Shiramatsu:* Learning-induced plasticity of mismatch negativity in rats

[87] *Stefan Berti, Corinna Christmann, & Thomas Lachmann:* Pre-attentive discrimination of instrumental timbre in non-musicians as mirrored by the mismatch negativity

[90] *Amineh Koravand, Pascale Martel-Lamothe, Gilles Comeau, & Laurel Trainor:* The effects of musical training on cortical auditory evoked responses in children with hearing loss

[93] *Javier Nieto & Manuel S. Malmierca:* Topographic distribution of stimulus-specific adaptation in the rat auditory cortex

[96] *Katarzyna Zarnowiec, Jordi Costa-Faidella, & Carles Escera:* Temporal regularity is encoded in the human auditory brainstem

[99] *Annett Schirmer, Nicolas Escoffier, Xiaoqin Cheng, & Trevor Penney:* Emotions attenuate the MMN elicited by changes in information rate

[102] *Arild Hestvik & Karthik Durvasula:* Temporo-spatial decomposition of MMN reveals underspecified phoneme representations

[105] *Yury Shtyrov & Maria Lenzen:* Lexical MMN effects are too late: automatic lexical ERP enhancement in the oddball paradigm is already present in P1

[108] *Alina Leminen, Laura Hedlund, Suzanne Hut, Lilli Kimppa, Miika Leminen, & Yury Shtyrov:* Automatic processing of morphosyntax by second language learners

[111] *Miika Leminen, Alina Leminen, Juuso Ojaniemi, Marja Laasonen, Teija Kujala, & Yury Shtyrov:* Dynamics of memory-trace formation for morphologically complex words in adults and children

[114] *Luigi Grisoni, Felix Dreyer, & Friedemann Pulvermüller:* Somatotopic semantic priming and prediction in the motor system

[117] *Kateřina Chládková & Paola Escudero:* Changes in MMR amplitude reflect fast phonetic learning in adult listeners

[120] *Kateřina Chládková, Rozmin Dadwani, Varghese Peter, & Paola Escudero:* Adult listeners' processing of indexical versus linguistic differences as reflected by the mismatch negativity

[123] *Arunraj Karuppannan, Vijaya Kumar Narne, M. K. Ganapathy, & Shivaprasad Beelgi:* Audiovisual speech perception of homophones using mismatch negativity

[126] *Eve Higby, Monica Wagner, Anne Gwinner, Tanja Rinker, & Valerie Shafer:* The influence of acoustic phonetics on the processing of complex consonant onsets

Keynote lecture 3

Friday, September 11, 2015, 17:00–18:00, Hörsaalgebäude, Hörsaal 3, p. 32
Chair: Erich Schröger

Kimmo Alho: Bottom-up triggered and top-down controlled attention to sounds

Keynote Lectures

Keynote lecture 1

Tuesday, September 8, 2015, 18:30–19:30, MPI CBS, Hörsaal
Chair: Sonja A. Kotz

Language: a uniquely human trait

Angela D. Friederici

Department of Neuropsychology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
friederici@cbs.mpg.de

Language develops as the brain matures. Newborns demonstrate impressive abilities in phonological learning. By the age of 5 months infants are able to learn phonologically coded syntactic non-adjacent dependencies. Although phonologically based learning is present early, it takes a long time before structurally complex sentences can be processed. It will be shown that the maturation of certain brain structures goes together with the development of particular syntactic abilities. In adults the language-related brain regions in the frontal and temporal cortex are connected via several fiber tracts. Ventrally located fiber tracts are taken to support semantic processing. Dorsally there are two tracts: one which connects the temporal cortex to the premotor cortex (PMC) assumed to support auditory-based phonological processes and another tract which connects the temporal cortex to Broca's area (BA 44), a region known to subserve the processing of syntactic hierarchy. Brain structural data from newborns demonstrate that the ventral connection supporting semantic processes is fully matured at birth, and thus is in place when word learning starts during the first months of life. Of the two dorsal pathways, however, only the pathway to PMC is mature at birth possibly providing the basis for phonologically based learning during early infancy. The pathway to BA 44, however, matures much later. The maturation of this pathway is directly linked to the processing of syntactically complex sentences across development. This indicates that certain milestones in language development can only be achieved once particular brain structures are fully matured.

Keynote lecture 2

Wednesday, September 9, 2015, 18:30–19:30, Hörsaalgebäude, Hörsaal 3
Chair: Sabine Grimm

The representation of surprise in the auditory system: data and models

Israel Nelken

The Edmond and Lily Safra Center for Brain Sciences, The Hebrew University of Jerusalem, Israel
israel@cc.huji.ac.il

Neurons in the auditory system, starting at least as early as the inferior colliculus (IC), show stimulus-specific adaptation (SSA) – the selective reduction in their responses to a repeated, standard, stimulus that doesn't generalize to other, deviant stimuli. Subcortical SSA is strong in the so-called non-lemniscal pathway, but is weak in the core, lemniscal pathway from the brainstem to auditory cortex. We know that subcortical SSA does not depend on cortical feedback. On the other hand, primary auditory cortex (A1), which shows a substantial amount of SSA, is mostly driven by lemniscal inputs that do not show SSA. This picture suggests that SSA is computed at least twice in the auditory system: once in the IC, and a second time in A1. To test this hypothesis, we studied the responses of neurons in IC, the medial geniculate body (MGB, the auditory thalamus) and A1 in response to a large number of tone sequences and complex sounds. Here I will describe these results and interpret them in the context of adaptation in narrowly tuned modules (ANTM) models, arguably the simplest class of models that show SSA. Such models predict deviant responses that are the same or smaller than the responses to the same sounds in the deviant alone configuration or when presented as part of 'control' sequences. Furthermore, because of the tonotopic organization of the auditory system, such models predict no SSA to appropriately balanced broadband stimuli. I will show that these predictions hold in IC and in MGB, but fail in A1. In particular, the responses to deviants in A1 are larger than expected by the level of adaptation of the afferent inputs, and neurons in A1 show SSA to particularly well-balanced broadband stimuli that fail to evoke SSA in IC and MGB. I will discuss our approaches for unraveling the circuit mechanisms in A1 that may underlie these results.

Keynote lecture 3

Friday, September 11, 2015, 17:00–18:00, Hörsaalgebäude, Hörsaal 3
Chair: Erich Schröger

Bottom-up triggered and top-down controlled attention to sounds

Kimmo Alho

Institute of Behavioural Sciences, University of Helsinki, Finland
kimmo.alho@helsinki.fi

Our functional magnetic resonance imaging (fMRI) studies, as well as those of other research groups, indicate that in addition to enhanced activity in the auditory cortex, task-irrelevant

physical changes in the auditory environment elicit activity in the parietal and frontal cortices. These activations are likely to be associated with bottom-up triggered, involuntary attention and they are paralleled by the mismatch negativity and P3a event-related potentials (ERPs) with their generators in the auditory and frontal cortices, and at least for the P3a, even in the parietal cortex. According to fMRI, top-down controlled, voluntary shifts of auditory attention are associated with activation of even wider cortical network involved largely also in maintaining attention to particular sounds. Moreover, our meta-analysis of fMRI studies showed that both pitch changes in a repeating sound and voluntary attention to tones with a particular pitch activate predominantly posterior auditory-cortex areas. However, as suggested by our fMRI and ERP studies, in some cases, processing of task-irrelevant sounds may be actively suppressed in the auditory cortex. This suppression might be controlled in a top-down manner by a fronto-parietal network involved also in voluntary division of attention.

Poster

Attention and distraction

Distraction versus task-set change: investigating the functional role of P3a elicited in oddball paradigms

1
P1

Márta Volosin[1], Sabine Grimm[2], & János Horváth[1]

[1]*Institute of Cognitive Neuroscience and Psychology, Research Center for Natural Sciences, Hungarian Academy of Sciences, Budapest, Hungary*
[2]*Institute of Psychology, University of Leipzig, Germany*
volosin.marta@ttk.mta.hu

The unfolding of involuntary attention change (distraction) is mostly investigated in paradigms, in which sequences of stimulus event-pairs are presented. Occasional variations of the first event elicit a series of event-related potentials (ERPs), which are interpreted as reflections of various distraction-related processes. It is widely accepted that the P3a ERP reflects an involuntary attention change. Recent studies, however suggest that P3a indexes processes related to task-set changes. Because in most studies the stimulus event-pairs are separated by a constant interval, P3a might be elicited because this constant separation allows participants to prepare for the task-relevant second event. The goal of the present study was to reveal the functional role of P3a in such paradigms by manipulating the opportunity for temporal preparation. We utilized a continuous stimulation paradigm in which 4-minutes long complex tones were presented. The pitch of these tones alternated between two levels, either rarely or frequently. The tones also contained silent periods of 10 or 100 ms duration (gaps) with the task to press one key for the short and another one for the long gaps while ignoring the glides. In the informative condition, 80 % of the glides were followed by a gap in exactly 400 ms, while in the uninformative blocks the presentation of glides and gaps was independent. Although negative ERPs (Nd and CNV) were elicited by glides in the informative condition suggesting a temporal preparation, a P3a enhancement was not found. These results are compatible with the notion that P3a reflects distraction-related processes.

2 P2 Dissociating the impact of unexpected salient sounds: increase in arousal versus attentional capture

Aurélie Bidet-Caulet

Brain Dynamics and Cognition, Lyon Neuroscience Research Center INSERM U1028, Bron, France
aurelie.bidet-caulet@inserm.fr

Studies investigating behavioral distraction have found inconsistent results with significant cost (see Escera et al. 2000; Escera et al. 2003 for reviews), or benefit (see Parmentier 2014 for a review) in reaction times to targets when preceded by a so-called distracting sound. These results suggest that distracting sounds would not only trigger a detrimental attentional capture but could also produce a facilitation effect. We investigated the impact of unexpected salient sounds on the processing of a target sound, by manipulating the delay between the two sounds. We could evidence that distracting sounds trigger several phenomena that produce opposite effects on the reaction time to a subsequent target: a cost by an attentional capture mechanism, and a benefit due to an increase in arousal. Moreover, the analysis of the event-related potentials revealed that (1) increasing task load in top-down attention reduces early processing of the distracting sound (N100 and early frontal P3), but not bottom-up attentional capture mechanisms indexed by the late P3 response, (2) the bottom-up attentional capture by distracting sounds on target processing results in a delayed latency of the N100 sensory response to target sounds mirroring increased reaction times. Further analysis showed that the early frontal P3 amplitude is related to the arousal content of the distracting sounds and may index the arousal increase triggered by these sounds. Therefore, this work provides evidence for different mechanisms triggered by unexpected salient sounds both at the behavioral and electrophysiological levels.

3 P3 Voluntary action modulates the processing of unattended rule-violating events indexed by visual mismatch negativity

Motohiro Kimura & Yuji Takeda

National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan
m.kimura@aist.go.jp

Visual mismatch negativity (vMMN) reflects the automatic processing of rule-violating events embedded in a visual stimulus sequence. To investigate whether the processing of rule-violating events embedded in an unattended visual stimulus sequence is determined in a bottom-up (i.e., stimulus-driven) manner, or can be modulated by top-down control, we examined the effects of the participant's voluntary action on visual MMN with a dual-task experimental design. As a primary task, the participants were required to detect a sudden change in the size of a central fixation point. As a secondary task, they were required to press one button frequently (about 90 %) and another button infrequently (10 %) in random order, which produced a visual stimulus sequence at unattended surrounding locations. Frequently-performed button presses triggered rule-conforming stimuli (81 %), but occasionally rule-violating stimuli (9 %; externally-generated rule violation). In contrast, infrequently-performed button presses triggered rule-violating stimuli (9 %; self-generated rule violation), but occasionally rule-conforming stimuli (1 %). The results showed that visual MMN was elicited by the externally-generated rule violation, but not by the self-generated rule violation. These results

suggest that the processing of rule-violating events embedded in an unattended visual stimulus sequence can be controlled in a top-down manner. This top-down control is considered to play an important role in cancelling out non-significant (i.e., predictable) rule violation that carries no new information and facilitating the selective detection of significant (unpredictable) rule violation that can carry new information.

P3a evidence of consciousness following acoustic change during REM sleep

4
P1

Paniz Tavakoli & Kenneth Campbell

School of Psychology, University of Ottawa, Canada
ptava069@uottawa.ca

Certain potentially relevant auditory stimuli occurring outside the focus of attention can trigger an attention switch from the task-at-hand to the distracting auditory event. Such attention capture may result in an "intrusion into consciousness", eliciting a positive-going event-related potential, P3a. This is thought to reflect processes related to the switching of attention and the subsequent conscious awareness of the auditory event. This study examined these processes during an unconscious state, natural sleep. Certain deviants can elicit a P3a, some during REM sleep. These studies employ oddball paradigms with lengthy testing times due to rarely occurring deviants. An "optimal" paradigm allows for time-efficient data collection (during REM sleep). The present study examined the processing of six deviants using the optimal paradigm. During wakefulness, only white noise and environmental sounds elicited a significant P3a. During stages N2 and N3, a small amplitude positive-component around the time of P3a was apparent following these stimuli. During REM, white noise and environmental sounds elicited a large amplitude positivity occurring around the same latency and amplitude as the waking-state P3a. The scalp distribution maps of these positivities was however different. In waking-state, its maximum was over centro-frontal scalp sites. During REM, the positivity was more widespread. Deviants not eliciting P3a in waking also did not elicit this positivity during REM. This suggests that processes related to the possible intrusion into consciousness remain active during REM, which may be crucial for survival. The brain regions activated by these highly relevant stimuli do, however, appear to be different in REM.

What did you say? I wasn't paying attention: the impact of task-irrelevant sound processing on performance

5
P2

Renee Symonds & Elyse Sussman

Neuroscience, Albert Einstein College of Medicine, Bronx, NY
renee.symonds@phd.einstein.yu.edu

Listening to a friend's voice in a noisy environment often requires you to attend to that stream of sound and selectively process it to the exclusion of others. The degree to which the ignored sounds are processed, however, is still debated. Historically, attention has been thought to preempt all but low-level processing of unattended sounds. Recent theories from vision, however, posit that unattended information may be processed only by resources 'left-over' once attended information has been analyzed. This suggests that the attended task may determine how and when unattended information is processed. In this study we tested the

hypothesis that automatic processing of unattended sounds interacts with task demands to determine performance. To test this, we held task demands constant and manipulated working memory load for task-irrelevant sounds. No change in task performance would be consistent with the theory that task-irrelevant processing is modulated by task demands. However, we found that subjects' performance decreased with increasing working memory load for task-irrelevant sounds. This suggests that automatic processing of unattended sound streams is not preempted by attention and instead competes with task demands for cognitive resources, leading to lower performance in the primary task.

6 P3

Spontaneous attentional lapses are related to a rejection positivity-like ERP shift

Boris Chernyshev, Dmitri Bryzgalov, Ivan Lazarev, & Nikita Novikov

Research and Study Group of Cognitive Psychophysiology, National Research University Higher School of Economics, Moscow, Russia
b_chernysh@mail.ru

Selective and rapid information processing within multiple sensory streams is crucial for adaptive behaviour. Event-related potential (ERP) studies have shown that top-down attentional modulation of relevant neural representations may evoke ERP voltage shifts within the 100–200 ms time window (Ross et al., Cereb. Cortex, 2010; Näätänen et al., Psychophysiology, 2011). Most of the studies in the field dealt with forced attentional manipulations, while the present study was focused on ERP correlates of spontaneous attentional lapses. We hypothesized that a positive ERP shift similar to the rejection positivity (Alho et al., Electroen. Clin. Neuro., 1987; Degerman et al., Eur. J. Neurosci., 2008) may be present during spontaneous failures to appropriately identify stimuli. The auditory condensation task was used: four target auditory stimuli that differed in two independent features were presented randomly with equal probability. Control procedures ensured that each of the stimulus features could be easily discriminated by all participants. Participants were instructed to respond to each stimulus by pressing one of the two buttons according to a rule based on stimulus feature conjunction, which is a much more demanding task compared with singe feature discrimination. The ERP within the P2 peak time window (150–200 ms) was shifted positively preceding failed responses (errors and response omissions) compared with correct responses. This effect resembles the rejection positivity and supports the hypothesis that information processing is reduced preceding erroneous responses and omissions; this is likely related to misallocation of attention due to competition between the task execution and other mental processes.

7 P1

Using adaptation to investigate the neural mechanisms of attention in the human auditory cortex

Jessica de Boer[1], Sarah Gibbs, & Katrin Krumbholz[1]

[1]*MRC Institute of Hearing Research, Medical Research Council, Nottingham, United Kingdom*
jdb@ihr.mrc.ac.uk

Single neuron recordings in auditory cortex have suggested that attention causes a sharpening of neural frequency selectivity (Fritz et al. 2003). In humans, neuroimaging studies have reported similar effects when using notched-noise masking to estimate cortical frequency

selectivity. There is a possibility, however, that these results were confounded by differences in attentional load between different masking conditions. Here, we tested the effect of selective attention on cortical frequency tuning directly, using an adaptation paradigm previously used in the visual system (Murray & Wojciulik 2004). In this paradigm, the feature selectivity of cortical neurons is assessed by measuring the degree of stimulus-specific adaptation of the gross evoked response as a function of the difference between the adapting stimulus and the subsequently presented probe stimulus. If attention causes an increase in neural selectivity, it would be expected that adaptation becomes more stimulus specific, that is, more strongly dependent on the adapter-probe difference. Tone-evoked auditory-evoked potentials (AEPs) were recorded from 23 participants performing a dichotic listening task. As expected, selective attention increased the amplitude of the N1 and P2, but not the P1, components of the AEP. The P2, but not the N1, exhibited a sharper frequency-specific release from adaptation under attention. These results support the view that neural sharpening mechanisms contribute to selective attention, particularly at higher stages of processing.

Auditory selective attention in the auditory brainstem response, negative difference, processing negativity, and positive difference waves

8
P2

Kazunari Ikeda

Center for the Research and Support of Educational Practice, Tokyo Gakugei University, Japan
kazunari@u-gakugei.ac.jp

In the attentional trace theory (Näätänen, 1982, 1990), a representation for an attention channel in audition was considered to be maintained at the auditory cortices. According to this theory, no representation for a perceptual channel should be established at the subcortical structures. The present study recorded the auditory brainstem response (ABR), negative difference (ND), processing negativity (PN), and positive difference (PD) waves during a dichotic listening task, and then examined whether these physiological measures represented perceptual channels in tasks. Twelve right-handed participants performed dichotic listening tasks in which standard ($p = .99$) and target tones to one ear had frequencies respectively at 0.5 and 0.6 kHz while those stimuli to the other ear at 1 and 1.2 kHz (35 dB SL, SOA 180–320 ms). Each participant received two dichotic combinations; (1) 0.5 kHz to the left and 1 kHz to the right, (2) 1 kHz to the left and 0.5 kHz to the right. In a control condition, participants viewed a silent DVD program and ignored the dichotic stimulation. Recording sessions revealing the explicit Nd were preferentially applied to data analysis. The ND, PN and PD were symmetrically found for the two dichotic combinations of sounds. A significant difference in the ABR between relevant and irrelevant conditions was found only for the 0.5 kHz to the left and 1 kHz to the right condition. The ABR difference between irrelevant and control conditions was absent. The present results suggest the difficulty to represent perceptual channels during dichotic tasks at the brainstem.

9 P3 Auditory distractors modulate oscillatory power prior to visual targets – the neural basis for impaired target detection?

Philipp Ruhnau[1], Thomas Hartmann[1], Erich Schröger[2], Nathan Weisz[1], & Annekathrin Weise[2,3]

[1]*Center for Mind/Brain Sciences, University of Trento, Mattarello, Italy*
[2]*Institute of Psychology, University of Leipzig, Germany*
[3]*Rotman Research Institute, Baycrest Centre, Toronto, Canada*
philipp.ruhnau@unitn.it

Rarely occurring novel sounds (distractors) often impair task performance, even when targets stem from another (e.g., visual) modality. To better understand the underlying neural mechanisms we analyzed the effect of distractors on neural activity in the pre-target period. MEG data were collected within an auditory-visual distraction paradigm, in which the visual target was preceded by either a standard or a distractor sound. Even though participants ignored the auditory input, the distractor but not the standard sounds impaired task performance. Distractors evoked mismatch negativity (MMNm) and P3a activity, indexing the brain's error signal to this sound and involuntary attention capture. Impaired target performance due to a preceding distractor was indicated by longer reaction times. The current results extend those previously published by re-examining the effects of the distractor on visual processing before the target occurs. The current approach is motivated by research showing that different brain states (indexed by different patterns in oscillatory activity) can influence stimulus processing. Accordingly, we investigated oscillatory power in the time window before the visual target when preceded by either standard or distractor. Interestingly, we found decreased power for distractors compared to standards in the upper alpha to beta range (14–26 Hz) with a posterior distribution. This suggests that auditory distractors change oscillatory patterns in visual areas before the visual target occurs. This could be the neural basis for the impaired visual task performance.

10 P1 Errors in auditory condensation task are preceded by lower pre-stimulus alpha-band oscillations

Dmitri Bryzgalov, Ivan Lazarev, Nikita Novikov, & Boris Chernyshev

Research and Study Group of Cognitive Psychophysiology, National Research University Higher School of Economics, Moscow, Russia
dbryzgalov@hse.ru

Performance errors in visual tasks caused by deterioration of the cognitive control may be related to an increase in the alpha-band power (for example, O'Connel et al., Eur. J. Neurosci., 2009), although this effect has not been studied within the auditory modality. In order to investigate EEG predecessors of attentional lapses in the auditory modality we used the modified condensation task. Participants (n = 47) were presented with four auditory tones, each having two distinct features: "low" or "high" (500 Hz or 2000 Hz sinusoidal signal), "noised" or "pure" (with or without broadband noise admixed). Participants were asked to press one or the other button depending on the conjunction of the two features. Frequent distractors (pure 400 Hz tones) were also presented along with four target stimuli. Pre-stimulus EEG power in the alpha range (8–13 Hz) was found to be reduced for erroneous responses compared with correct responses. Pre-stimulus alpha-band power gradually in-

creased within continuous sequences of distractor stimuli separating adjacent target stimuli. No performance-related changes in stimulus-locked ERPs were found. These findings demonstrate that under conditions of the auditory attentional task higher alpha-band power may be an index of increased rather than decreased level of cognitive control. This finding also points to the pre-stimulus EEG power as a better predictor of behavioral outcome compared with the stimulus-locked ERPs. Supported by HSE Basic Research Program.

Visual mismatch negativity, working memory load and processing mode

11 P2

Kertu Saar[1], Nele Põldver[1], Mai Toom[1], Annika Kask[1], Madli Uutma[1], Jüri Allik[1,2], Risto Näätänen[1,3,4], & Kairi Kreegipuu[1]

[1]*Institute of Psychology, University of Tartu, Estonia*
[2]*Estonian Academy of Sciences, Tallin, Estonia*
[3]*Institute of Behavioural Sciences, University of Helsinki, Finland*
[4]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
kertusaar@gmail.com

MMN is widely considered an attention-independent component of deviance detection. We are interested in how visual MMN to task-unrelated, unattended stimuli acts as a function of working memory occupancy and processing mode (visual or verbal). Our subjects performed several n-back tasks with different levels of working memory engagement (0-back – simply responding to a target, i.e. smaller cognitive load; or 2-back – continuously comparing the current stimulus to the one presented 2 steps back, i.e. bigger cognitive load) and varying stimulus types (schematic emotional faces or capital letters). Some letters were also simultaneously presented in the surrounding periphery with an oddball paradigm to elicit MMN. The deviant "T" was chosen to differ from standard "B" more visually and less verbally, the deviant "S" to differ less visually and more verbally. Both letters evoked significant vMMNs during all tasks with insignificant differences between different working memory loads. The MMN was, however, slightly smaller while the subject was performing a more visual central n-back task with face-stimuli, as compared to the somewhat more verbal version with letter-stimuli. That indicates a potential dependence of vMMN on the availability of visual processing resources. As expected, "T" (the visually more different deviant) also elicited a larger vMMN than "S", independent of the central task type. Thus, our results indicate that the elicitation of vMMN depends more on processing mode, rather than plain task load. More questions regarding the behavioral results and individual n-back strategies (visual, verbal) will be further addressed on the poster.

12 P3 Effects of deviant predictability on MMN-like MEG responses in oddball paradigms

Zeynep Oeztan[1], Artur Matysiak[1], Peter Heil[2], & Reinhard König[1]

[1]*Special Lab Non-invasive Brain Imaging, Leibniz Institute for Neurobiology, Magdeburg, Germany*
[2]*Department Systems Physiology of Learning, Leibniz Institute for Neurobiology, Magdeburg, Germany*
rkoenig@lin-magdeburg.de

The auditory mismatch negativity (MMN) is commonly the result of a mathematical operation performed off-line on sound-evoked responses in oddball paradigms measured with MEG or EEG, namely the subtraction of trial-averaged responses to frequent "standard" sounds from those to rare "deviant" sounds. We studied the effects of attention and/or stimulus predictability on MMN-like responses. In the repeated-tone-sequence paradigm, subjects listened to 100 identical tone sequences, each consisting of 27 standards and three deviants, with the deviants occurring at the same positions in all sequences. In the random-tone-sequence paradigm, the 300 deviants occurred pseudo-randomly across the 100 sequences. Responses were analyzed over a 400 ms time window commencing with stimulus onset. Evaluation of single subject data reveals that, in the random tone sequence paradigm, differences between waveforms elicited by standards and deviants were subtle whereas in the repeated-tone-sequence paradigm, they were pronounced beyond the M100 peak in most subjects, supporting the notion of an important role of attention and stimulus predictability in the generation of the waveform differences. Computation and comparison of grand mean waveforms across the two experimental conditions requires stabilizing and equalizing the variance of the waveforms. Application of the asinh-transform to MEG waveforms leads to the same homogeneous variance in all conditions and results in normally distributed data, thus, allowing regressions and parametric tests for statistical analyses and comparisons of data from different experimental conditions. Hence, we will also discuss the impact of the asinh-transform on the (statistical) analysis of our data. Supported by DFG (KO1713/10-1).

Clinical applications (incl. consciousness)

13 P1 Improving the detection of voluntary processes in behaviorally unresponsive patients at bedside using an oddball paradigm

Dominique Morlet[1], Perrine Ruby[1], Nathalie André-Obadia[2], & Catherine Fischer[2]

[1]*Brain Dynamics and Cognition, Lyon Neuroscience Research Center INSERM U1028, Bron, France*
[2]*Neurophysiology and Epilepsy Unit, Pierre Wertheimer Neurological Hospital, Hospices Civils de Lyon, Bron, France*
dominique.morlet@inserm.fr

In prolonged disorders of consciousness, patients show poor or non-existent interaction with the environment. Clinical assessment is powerless to assess the actual level of consciousness in these behaviorally unresponsive patients. Neuroimaging techniques have been recently used (fMRI or EEG) in an attempt to find evidence of brain signals reflecting covert conscious-

ness, where the conscious modulation of brain signal was obtained using paradigms requiring voluntary participation of the subject (perform mental imagery or count targets). We designed a new EEG paradigm for better detection of willful modulations of attention at the patient's bedside. A standard auditory oddball paradigm was used. First, the subjects passively heard the auditory stimuli. Then, subjects were required to focus their attention away from the stimuli using a mental imagery task (diverted attention) and finally the subjects were instructed to count auditory deviants (focused attention). Contrasting the condition of focused attention with a new condition of actively diverted attention, we expected an improved effect as compared with a classical active/passive contrast. Indeed, in 20 healthy subjects, the contrast between diverted attention and focused attention was larger than between passive listening and focused attention. Event-related responses to auditory standard and deviant stimuli were significantly modulated by attention manipulation, not only at the group level but also at the individual level, thus providing clinically useful markers of voluntary processes. Preliminary results show that this active paradigm can provide evidence of some conscious cooperation in unresponsive patients.

The effect of cognitive training on the mismatch negativity in schizophrenia

14 P2

Bernhard W. Müller[1], Christian Kärgel[2], Daniela Kariofillis[3], Jens Wiltfang[4], & Gudrun Sartory[3]

[1]*Clinic for Psychiatry and Psychotherapy, University of Duisburg-Essen, Germany*
[2]*Institute of Forensic Psychiatry, University of Duisburg-Essen, Germany*
[3]*Psychology, University of Wuppertal, Germany*
[4]*Clinic for Psychiatry and Psychotherapy, University of Göttingen, Germany*
bernhard.mueller@uni-due.de

The mismatch negativity (MMN) repeatedly has been shown to be impaired in schizophrenia. In the present study, the effect of auditory training (AUD, n = 14) on the MMN was compared to that of a visual-spatial training (VIS, n = 14) and a treatment as usual (TAU, n = 14) condition. Training consisted of ten 50 min sessions over two weeks. Assessments took place before and after training and at a two-month follow-up. They comprised clinical measures and MMN recordings to frequency and duration deviant stimuli. We found a significant main effect for type of stimulus deviance with a more negative MMN to frequency than duration deviants. Individual group comparisons showed moderately greater improvement in the VIS than TAU group with regard to the MMN to frequency deviants from pre to post training. In conclusion, we found no evidence for a change in MMN after a brief two-week auditory training in schizophrenia patients. There was, however, a moderate effect of visual spatial training increasing MMN to frequency-deviants. While this result awaits replication, it is conceivable that the visual-spatial training contributed to salience detection which may have resulted in an increased frequency MMN amplitude in patients with schizophrenia.

16
P1

Complex pattern MMN to extra identical tones in schizophrenia

Dean F. Salisbury, Timothy K. Murphy, Kayla L. Ward, Brian A. Coffman, & Sarah M. Haigh

Department of Psychiatry, University of Pittsburgh, PA
salisburyd@upmc.edu

Mismatch negativity (MMN) to simple stimulus parameter deviants is robustly reduced in schizophrenia. Stimulus-specific adaptation (SSA) models argue that MMN is an epiphenomenal sensory effect because neurons adapt to repetitive tones. Hence deviant afferent activity is processed by non-adapted neurons, and MMN does not reflect deviation from a memory trace of past stimuli or a predictive model of stimulus patterns. The present experiment explored whether SSA was necessary to elicit MMN, and whether true novelty detection MMN was reduced in schizophrenia. A single tone complex pattern paradigm used the gestalt principle of proximity to form implicit groups of 5 stimuli (330 ms SOA, 800 ms ITI). Pattern models predict that MMN will be elicited by an occasional 6th tone. SSA models predict no MMN, as the same tone would necessarily activate adapted neurons. Subjects passively underwent a pitch-deviant and duration-deviant simple MMN task and extra tone complex MMN task while actively watching a silent movie. Simple MMN at FCz was significantly reduced in patients for pitch deviants ($p < .05$), and for duration deviants ($p < .05$). Analysis of activity to the complex pattern deviant revealed a large late MMN-like deviance-related negativity between 320 and 470 ms. This response was significantly reduced in schizophrenia ($p < .01$). Simple MMN is reduced in schizophrenia. The complex pattern MMN occurs later, and is reduced in schizophrenia. True novelty detection as reflected in complex MMN is impaired in schizophrenia, and cannot reflect deficient SSA.

17
P2

Complex pattern-deviant detection in schizophrenia

Sarah M. Haigh, Brian A. Coffman, Timothy K. Murphy, Christiana Butera, & Dean F. Salisbury

Department of Psychiatry, University of Pittsburgh, PA
haighsm@upmc.edu

The neural mechanisms that generate mismatch negativity (MMN) are debated, yet MMN is being assessed as a possible biomarker for schizophrenia (SZ). In SZ, MMN is smaller to stimulus deviants that differ in simple physical characteristics such as pitch. This suggests that auditory cortex is affected in SZ, but it is unclear whether it reflects deficits in stimulus adaptation, novelty detection, or both. MMN is also elicited by complex-pattern deviants, which cannot be due to non-adapted cells. We measured MMN to complex-pattern deviants to assess novelty detection in SZ and healthy controls (HC). Eight tones differing in 0.5 kHz steps were used in a standard zig-zag ascending pitch pattern (1, 2, 1.5, 2.5, 2, 3, 2.5, 3.5 kHz tones), with two final tone deviants: 2.5 kHz (repeat), or 4 kHz (jump). Subjects watched a silent video, and were presented with 80 % standard patterns, 10 % repeat- and 10 % jump-deviants. HC ($n = 23$) produced a late MMN-like negativity (400–500 ms after stimulus-onset) that was significantly larger than in SZ ($n = 23$) to both the repeat ($p = .038$) and jump-deviant ($p = .014$). The topography and source of the activity was consistent with a typical MMN response. The MMN from a complex deviant cannot be argued to be due to adaptation because there was no repeated tone to drive adaptation, and the MMN was too late to be con-

taminated by a larger N1 response to novelty. SZ did not produce a late-MMN to the repeator the jump-deviant suggesting deficits in novelty detection.

Regularity encoding in autism spectrum disorders: brainstem responses to repeated amplitude-modulated sounds

18
P3

Miriam Cornella[1], Sumie Leung, Amaia Hervàs, Jordi Costa-Faidella, Isabel Rueda, & Carles Escera[2]

[1]*Department of Psychiatry and Clinical Psychobiology, University of Barcelona, Spain*
[2]*Institute for Brain, Cognition and Behavior (IR3C), University of Barcelona, Spain*
mcornella@ub.edu

Children with Autism Spectrum Disorders (ASDs) often show atypical sensitivity to auditory stimulation and exhibit difficulties in the processing of auditory information. However, little is known about the underlying mechanisms yielding to atypical auditory processing in these children. In this study, we aimed at characterizing how repetitive stimulus presentations modulate the frequency following response (FFR) of the auditory brainstem in children diagnosed with ASD, a response that reflects the neural phase-locking to the periodic features of a sound. To test this, we used a roving standard paradigm consisting of 10 pure tones, each with different carrier frequencies and a common amplitude modulation of 380 Hz. Each tone was repeated 8, 10 or 12 times with a constant stimulus onset asynchrony (333 ms). Electroencephalographic recordings were obtained from 17 children with ASD and 18 matched typically developing (TD) children (age range 6.5–12 years). We found that in children with ASD, the FFR power amplitude to the AM frequency increased with stimulus repetitions, while a suppression of the power amplitude was observed in TD children ($p = .024$, RM-ANOVA). Additionally, the increase of FFR power amplitude with repetition correlated with the severity of auditory hypersensitivities. These findings suggest that the ability to reduce the brainstem representation of repetitive stimuli is altered in children with ASD and is associated with the existence of auditory sensitivities in these children.

Attentive vulnerability to levodopa therapy in ataxia-telangiectasia patients: a MMN study

19
P1

Daniela Mannarelli[1], Caterina Pauletti[1], Daniela D'Agnano[2], Vincenzo Leuzzi[2], Nicoletta Locuratolo[1], Maria Caterina De Lucia[1], & Francesco Fattapposta[1]

[1]*Neurology and Psychiatry, Sapienza University of Rome, Italy*
[2]*Paediatrics, Child Neurology and Psychiatry, Sapienza University of Rome, Italy*
daniela.mannarelli@uniroma1.it

Ataxia-telangiectasia (AT) is caused by mutations in the ATM gene. The neural phenotype of AT includes progressive cerebellar neurodegeneration, which results in ataxia, oculocutaneous teleangiectasias, immunodeficiency, recurrent infections and proneness to cancer. No therapies are available for this disease. Experimental studies on mice showed severe degeneration of tyrosine hydroxylase-positive, dopaminergic nigro-striatal neurons, and their terminals in the striatum. The aim of the current study was to investigate the effects of the levodopa therapy on motor and attentional performance in AT patients using clinical and psychophysiological evaluation. Three young AT-patients (age: 12 years) underwent a neuro-

logical evaluation and a MMN recording in basal condition (T0) and at two times points after levodopa therapy (at 4 weeks: T1; at 8 weeks: T2). MICARS and UPDRS-III scales were administered in order to assess clinical disability. MMN parameters (for three different acoustic deviants: frequency, duration and intensity) were evaluated. During the levodopa therapy, we observed a progressive reduction in latencies and an increase in amplitudes for all deviants. UPDRS-III values significantly improved after 8 weeks of L-dopa therapy. Our data suggest that levodopa treatment significantly improves motor performance in AT-patients. Additionally, pre-attentive auditory discrimination deficits appear to be ameliorated after levodopa therapy. These results induce us to hypothesize the presence of a dopaminergic dysfunction likely related to an involvement of the subcortical networks in AT-subjects as suggested by experimental studies. Moreover, from a clinical point of view, this evidence supports the potential role of levodopa in the treatment of patients with ataxia-telangiectasia.

20 P2

Intact pre-attentive processing of sound intensity in depression as revealed by mismatch negativity

Elisa Ruohonen, Jari Kurkela, & Piia Astikainen

Department of Psychology, University of Jyväskylä, Finland
elmaruoh@student.jyu.fi

Depression is associated with abnormal cognitive processing of emotional information which has also been shown in mismatch negativity (MMN) studies to both visual and auditory emotional stimuli. Recent research suggests that this processing bias occurs already at the basic visual feature processing level as indexed by visual mismatch negativity. In the auditory modality there is some evidence that the loudness dependence of the auditory evoked potentials may be associated with depression. However, there are no reports of studies applying intensity mismatch negativity paradigm in depressed participants. To that end we compared event-related potentials elicited in oddball condition for sound intensity changes in depressed and non-depressed participants. In one stimulus block the standard sound was 60 dB and the deviant sound 80 dB and in the other stimulus block the assignment was reversed. Differential responses were extracted from two time windows for the analysis: at 90–140 ms (N1) and at 150–200 ms (MMN) post-stimulus interval. At the earlier time window the loud stimulus as a deviant stimulus elicited larger negative amplitudes than the silent standard stimulus. When sound intensities for the standard and the deviant stimuli were reversed, no differential response was elicited. At the later time window negative-polarity differential response was elicited similarly in both stimulus blocks. There were no group differences in the brain responses and they showed no correlations with BDI-score. The results suggest that change detection of basic auditory processing of intensity is intact in depression.

Relationship between MMN and monoamine metabolite levels in schizophrenia: preliminary results of cross-sectional and longitudinal studies

21 P3

Tetsuya Shiga, Sho Horikoshi, Itaru Miura, Keiko Kanno-Nozaki, Kazuko Kanno, Yusuke Osakabe, Michinari Nozaki, Satoko Asano, Masayuki Hikita, Norikatsu Itou, Shuntaro Itagaki, Takashi Matsuoka, & Hirooki Yabe

Department of Neuropsychiatry, Fukushima Medical University, Japan
tetsuya3@fmu.ac.jp

Mismatch negativity (MMN) deficit has been repeatedly demonstrated in schizophrenia, and may be associated with an impaired N-methyl-D-aspartate (NMDA) receptor function. Although it is known that the dopamine receptor don't modulate MMN over the short term, it is unclear whether the dopamine system affects MMN in the long term. Therefore, we explored the correlation between MMN and plasma monoamine metabolites in schizophrenia patients in cross-sectional and longitudinal studies. Experiment 1: We collected blood samples in 18 schizophrenia patients and recorded duration-MMN to right-ear stimuli in this cross-sectional study. Correlations between MMN and levels of plasma dopamine and serotonin metabolites were explored. Experiment 2: 14 schizophrenia patients were enrolled into this longitudinal study. The antipsychotic drugs of all patients were switched to other antipsychotics for the improvement of clinical symptoms or side effects. Duration-MMN to the right-ear stimuli and dopamine and serotonin metabolites level were measured before and 4 months after the switching and the correlations between the change in MMN and changes in monoamine metabolite levels were explored. In experiment 1, a significant negative correlation between the amplitude of MMN and plasma levels of dopamine metabolites was observed. Plasma serotonin metabolite levels were not correlated with MMN. In experiment 2, we found no correlation between the changes in MMN and the changes in dopamine and serotonin metabolites level. The strong blockade of dopamine receptors in schizophrenia may attenuate MMN over the long term. However, larger sample size is required in future studies in this area.

Mismatch-negativity response in individuals with central auditory implants

22 P1

Pascale Sandmann[1], Irina Schierholz[1], Christoph Kantzke[1], Alexandra Bendixen[2], Mareike Finke[3], Sabine Haumann[3], Thomas Lenarz[3], Reinhard Dengler[1], & Andreas Büchner[3]

[1]*Department of Neurology, Hannover Medical School, Germany*
[2]*Department of Physics, Chemnitz University of Technology, Germany*
[3]*Department of Otolaryngology, Hannover Medical School, Germany*
sandmann.pascale@mh-hannover.de

Auditory brainstem implants (ABI) and auditory midbrain implants (AMI) are designed for electrical stimulation within the cochlear nucleus or the inferior colliculus to partially compensate for hearing loss in patients with neural deafness. However, only a small number of ABI/AMI patients are able to understand speech without lip reading. The goal of our EEG study was to contribute to a better understanding of how electrical stimulation of the auditory brainstem/midbrain relates to cortical responses and hearing abilities in these individuals. Specifically, we aimed to assess the question whether a mismatch negativity (MMN) response

can be observed in ABI/AMI patients. We used a MMN paradigm to examine AMI (n = 2) and ABI (n = 5) patients who were presented with a sequence of standard sounds (p = .68; 440 Hz; 400 ms) and four infrequent deviant sounds (each p = .08). The deviant sounds differed from the standard sounds either in frequency (increment; two levels) or duration (decrement; two levels). Further, in a control block we presented the four deviant sounds in succession which allowed comparing the event-related potentials (ERPs) to physically identical sounds between the MMN and the control block. First results revealed a high degree of variability in ABI and AMI patients regarding behavioral discrimination ability and ERPs. Despite this variability, we found N1-ERPs in all patients. Further, we observed a MMN response in some ABI- and AMI patients, suggesting that the MMN can be used as an objective index of auditory discrimination ability in these individuals.

23 P2

Effect of methylphenidate in adult attention-deficit/hyperactivity disorder as reflected by MMN

Shuntaro Itagaki, Takashi Matsuoka, Tetsuya Shiga, Kazuko Kanno, Michinari Nozaki, Satoko Asano, Yusuke Osakabe, Norikatsu Itou, Masayuki Hikita, Shin-ichi Niwa, & Hirooki Yabe

Fukushima Medical University, Japan
itasyun@sj8.so-net.ne.jp

A number of studies have recently reported that patients with ADHD fail to exhibit alleviation of symptoms such as inattentiveness and impulsiveness even after childhood. One effective pharmacotherapy for ADHD is methylphenidate (MPD). However, judging the curative effect uses observation and a check list of changes in symptoms. An objective method for measuring effects is therefore necessary. Mismatch negativity (MMN) is automatically elicited by occasional deviations within a sequence of homogeneous (standard) sounds. Some MMN studies have been performed on infant ADHD. Sawada et al. (2010) reported improvement of the MMN amplitude in infant ADHD with MPD medication, whereas Winsberg et al. (1993) found no such change. No studies of MMN with adult ADHD have reported an effect of osmotic-release MPD. We therefore examined cognitive function change with MPD in adult ADHD by measuring MMN. Methods: Sixteen individuals with adult ADHD (nine men; mean age, 37 years) were recruited from outpatients treated at Fukushima Medical University according to the criteria of the DSM-IV and confirmed using Conners' Adult ADHD Diagnostic Interview for DSM-IV. All stimuli were 1000 Hz in frequency. Standard (80 %) stimuli were 100 ms, and deviant stimuli (20 %) were 50 ms in duration. We measured and compared MMN before and after treatment. No significant differences in peak amplitude or peak latency of MMN were seen. This result was similar to that of Winsberg for infant ADHD, but unlike the results of Sawada. The fact that this modality differed from preceding studies using frequency MMN needs consideration.

Frontal dysfunction in patients with major depression revealed by an auditory mismatch paradigm: an fMRI investigation

24
P3

Jana Zweerings, Klaus Mathiak, Arnim Johannes Gaebler, & Mikhail Zvyagintsev

Psychiatry, Psychotherapy and Psychosomatics, Medical School, RWTH Aachen, Germany
jzweerings@ukaachen.de

In the present study we employed functional magnetic resonance imaging to identify neural mechanisms underlying auditory mismatch processing in 25 patients with major depression (MD) and 25 matched control subjects in a modified auditory mismatch paradigm. In this paradigm 30 sec long standard and deviant blocks were alternately presented within an eight minute sequence. Standard blocks comprised standard stimuli only. In deviant blocks each second stimulus deviated from the standard tone either in frequency, duration, amplitude, location, or it contained a silent gap in the middle. In both groups, blocks with deviants led to an increase of activity in the auditory cortex and a deactivation in the visual system, indicating a resource allocation to the auditory domain during mismatch processing. In MD patients, deviant blocks led to a deactivation in the rostral part of the anterior cingulate cortex (ACC) and left inferior frontal cortex. Consequently, group differences emerged only at prefrontal sites. Dysfunction of the rostral part of the ACC is a well-documented finding in MD and essentially contributes to the affective symptomatology, in particular to rumination and sadness. Deactivation of the rostral part of the ACC during the presentation of deviant blocks may thus reflect an impaired resource reallocation and shift of attention to the auditory modality. In summary, our results suggest dysfunctional resource redistribution in patients with MD but find no evidence for a deficit in early sensory processing.

Residual cognitive functions in PVS patients by means of MMN paradigm using emotional content. Neural generators of remaining brain activity

25
P1

Ana Olivares[1], Jorge Iglesias Fuster[2], Doris Hernández Barrios[3], Elena Cuspineda Bravo[1], Cecilia Pérez Gesen[4], Javier Sánchez López[1], Daymara del Río Bazan[5], & Calixto Machado Curbelo[1]

[1]*Institute of Neurology and Neurosurgery, Havanna, Cuba*
[2]*Cuban Neuroscience Center, Havanna, Cuba*
[3]*Department of Psychology, University of Jyväskylä, Finland*
[4]*National Institute of Endocrinology Institute, Havanna, Cuba*
[5]*Hermanos Ameijeiras Hospital, Havanna, Cuba*
ana.olivares@infomed.sld.cu

Cognitive event-related potentials are more frequently obtained with more ecologic stimuli or having an emotional content. However, their functional mechanisms and neural bases remain unknown. The objective of this study was to determine and localize sources of residual electrical cognitive activities in persistent vegetative state (PVS) patients by using an auditory stimulation paradigm including subjects' own name (SON). A mismatch negativity (MMN) component using SON was reconstructed in 10 patients in PVS. The auditory paradigm was validated in 20 healthy volunteers matched by age and gender, using 32 EEG channels montage. MMN grand average was computed and electrical sources were estimated by means of the Bayesian model averaging (BMA) approach in all groups. BAEPs were recorded for hearing

assessment and clinical variables were evaluated for the PVS group. Results: The MMN component was observed in 4 PVS patients showing right lateralization. MMN major sources were localized in fronto-temporal and fronto-central cortical areas in healthy subjects. For patients, these sources were localized in residual functional cortical areas although PVS patients showed structures similar to the controls in response to emotional stimuli (recreated by SON). Regardless of VS duration, in some patients residual cognitive markers of central auditory processing of their own name appeared. These results suggest recovery of consciousness, with its consequent practical and ethical implications. MMN is a helpful tool in identifying the ability to recover from VS and a valid measurement of clinical improvement.

26 P2

Music perception in adult cochlear implant users

Alexander Mainka, Annegret Leuner, Dirk Mürbe, & Anja Hahne

Saxonian Cochlear Implant Center, TU Dresden, Germany
alexander.mainka@uniklinikum-dresden.de

A cochlear implant (CI) is a neuroprosthesis that directly stimulates the auditory nerve. Although the main focus of CI usage is the compensation of speech discrimination deficits, the study of musical features has elicited increasing scientific attention over the last years. This may be due to the fact that speech discrimination is ultimately depending on the discrimination of auditory parameters like rhythm, pitch or intensity which are easier to characterize in the terms of musical patterns than with speech based experimental settings. 36 CI users (19 women, 17 men; median age 53 years) and 36 matched normal hearing (NH) controls were tested with a modified multi feature musical paradigm (Vuust et al. 2011). We tested four deviant categories, namely pitch, timbre, intensity and rhythm. Both groups, CI users as well as normal NH controls, exhibited MMN effects upon several deviant stimuli. Interestingly, peak-latencies appeared to show only small differences across groups. By contrast, MMN amplitudes were larger in NH controls. The data demonstrate that CI users benefit from the electrical auditory input also in terms of their musical discriminatory abilities. However, they also show that there are certain limitations in auditory discrimination compared to normal hearing which may explain reduced musical appraisal in postlingually deafened CI users.

128 P2

Event-related potentials demonstrate deficits in auditory Gestalt formation and MMN in schizophrenia

Brian A. Coffman, Sarah M. Haigh, Timothy K. Murphy, Kayla L. Ward, & Dean F. Salisbury

Department of Psychiatry, University of Pittsburgh, PA
coffmanb@upmc.edu

Grouping of auditory percepts is necessary for interpretation of patterns. Schizophrenia patients have blunted responses to deviance from an established norm, such as reduced mismatch negativity (MMN). Here we compared auditory event-related potential (ERP) responses to complex patterns between schizophrenia patients (SZ; n = 25) and matched healthy controls (HC; n = 23). ERPs were measured in an auditory pattern in which the first 6 tones increased in pitch in 500 Hz steps, from 1.5 to 4 kHz, and the last 6 tones decreased in pitch (4–1.5 kHz). In 8 % of trials, the last 6 tones repeated the increasing pitch pattern of the first 6 tones. Stimuli were presented while participants watched a silent video. We observed a

large sustained negativity (SN) throughout the entire duration of each group that returned to baseline following completion of the trial. Relationship between SN and ordinal stimulus position was compared between SZ and HC.SN was sensitive to ordinal stimulus position ($p < .01$), with largest responses to first and final tones. HC had greater SN than SZ across the entire trial, though differences were greatest for first and final tones ($p < .001$). Additionally, a late MMN-like deviance-related negativity was found between 400–500 ms after stimulus onset that was also larger for HC than SZ ($p < .05$). These results suggest stronger set formation in HC than SZ. Deficits in auditory pattern processing may be relevant to clinical issues in SZ, such as conceptual disorganization. Future studies will examine relationships between SN and clinical measures.

Computational models

Hierarchical frontotemporal networks in MMN: dynamic causal modelling of MEG supported by human intracranial EEG

27
P3

Holly Phillips[1], Alejandro Blenkmann[2], Laura Hughes[1], Tristan Bekinschtein[3], & James Rowe[1]

[1]*Department of Clinical Neurosciences, University of Cambridge, United Kingdom*
[2]*Institute of Cellular Biology and Neuroscience, National Scientific and Technical Research Council/University of Buenos Aires, Argentina*
[3]*Department of Psychology, University of Cambridge, United Kingdom*
holly.phillips@mrc-cbu.cam.ac.uk

Neurocomputational models (Lieder et al. 2013) and dynamic causal modelling (DCM) of the MMN in EEG (Garrido et al. 2009) and MEG (Hughes et al. 2013) indicate a hierarchy of feedback sensory prediction and feedforward prediction errors between primary auditory cortex (A1), superior temporal gyrus (STG) and prefrontal cortex (PFC). However, such DCM for non-invasive MEG/EEG relies on optimisation of the forward model. We compared MEG and intracranial EEG (iEEG) recordings to see whether this frontotemporal message passing is evident across imaging modalities. We used an auditory MMN paradigm (Näätänen et al. 2004), alternating standard tones with deviant tones, differing by frequency, intensity, location, duration or a silent gap. We recorded MEG data in healthy adults and electrocorticography (ECoG) in patient candidates for epilepsy surgery, covering temporal and frontal cortices. We compared 12 dynamic causal models of networks among A1, STG and PFC and used Bayesian model selection to compare models. Results show matching models across the modalities, with evidence for modulated frontotemporal feedforward and feedback connections and internally-generated inputs to PFC. We show ECoG and MEG are complimentary methods that balance generalisation to larger populations (MEG) against precise anatomical localisation with direct recording of cortical field potentials (ECoG). They provide convergent evidence for the hierarchical interactions in frontotemporal networks and evidence for an internal input influencing prefrontal cortex.

28 P1

A computational single-trial analysis of MMN under ketamine

Lilian Aline Weber[1], Andreea Oliviana Diaconescu[1], Christoph Mathys[1,2,3], André Schmidt[4], Michael Kometer[5], Franz Vollenweider[5], & Klaas Enno Stephan[1,2]

[1]*Translational Neuromodeling Unit, ETH & University of Zurich, Switzerland*
[2]*Wellcome Trust Centre for Neuroimaging, University College London, United Kingdom*
[3]*Max Planck UCL Centre for Computational Psychiatry and Ageing Research, London, United Kingdom*
[4]*University of Basel, Switzerland*
[5]*Neuropsychopharmacology and Brain Imaging, University of Zurich, Switzerland*
lweber@posteo.de

While the MMN is frequently interpreted as an index of surprise or prediction error (PE), the exact neuro-computational processes generating it are still subject to debate. Here, we present computational analyses of single-trial EEG data using data from a previous MMN study contrasting placebo against the NMDA-R antagonist S-ketamine. For an auditory roving paradigm, we propose that the observer infers on two (hidden) causes of the sensory input: a matrix of transition probabilities between tones of different frequencies, and the volatility of this matrix. Using a Bayesian model of perception and learning (hierarchical Gaussian filter), we understand learning as hierarchically-coupled predictions whose update dynamics are controlled by the next higher level. We hypothesized that update signals during learning manifest as trial-wise variations in EEG signal amplitude, where the MMN as a difference signal emerges from higher PEs on deviant trials compared to standard trials. In a multiple regression of the trial-wise EEG signals of 14 participants, we found significant correlations of model estimates of PEs and surprise over fronto-temporal channels. Critically, the signalling of PEs was reduced under ketamine as compared to the placebo condition. These results support the notion that the deviant negativity component of the MMN encodes indices of PE and that neuronal mechanisms for encoding trial-wise PEs are sensitive to NMDA receptor antagonism. Our single-trial analysis allows for a far more fine-grained computational interpretation of the MMN than conventional ERP analyses, distinguishing between different types of PEs and surprise, and is easily applicable to other experimental designs.

29 P2

Filtering event-related potentials in time, frequency and space domains sequentially and simultaneously

Fengyu Cong[1], Tapani Ristaniemi[2], & Heikki Lyytinen[3]

[1]*Department of Biomedical Engineering, Dalian University of Technology, China*
[2]*Department of Mathematical Information Technology, University of Jyväskylä, Finland*
[3]*Department of Psychology, University of Jyväskylä, Finland*
cong@dlut.edu.cn

Event-related potentials (ERPs) in the context of electroencephalography (EEG) for the cognitive neuroscience are usually produced through averaging single-trials of preprocessed EEG, and then, the interpretation of underlying brain activities is based on the ordinarily averaged EEG. We find that randomly fluctuating activities and artifacts can still present in the averaged EEG data, and that constant brain activities over single trials can overlap with each other in time, frequency and spatial domains. Therefore, before interpretation, it will be beneficial to

further separate the averaged EEG into individual brain activities. We propose the systematic approaches including pre-process wavelet transform (WT), independent component analysis (ICA), and nonnegative tensor factorization (NTF) to filter averaged EEG in time, frequency and space domains to sequentially and simultaneously obtain the pure ERP of interest, particularly for mismatch negativity. Furthermore, WT is the preprocessing for ICA and NTF respectively in the time and in the time-frequency domains. WT-ICA is suitable for the individual-level data processing and filters ERPs in the time, frequency and space domains sequentially. The filtered ERP data by WT-ICA can be used for group-level data analysis. While, WT-NTF is appropriate for the group-level data processing and analysis, and filters ERPs in the time, frequency and space domains simultaneously.

Effects of NMDAR antagonism on mismatch negativity and repetition suppression

30
P3

Richard Rosch[1], Karl Friston[2], & Torsten Baldeweg[3]

[1]*Institute of Neurology, University College London, United Kingdom*
[2]*Wellcome Trust Centre for Neuroimaging, University College London, United Kingdom*
[3]*Centre for Developmental Cognitive Neuroscience, University College London, United Kingdom*
r.rosch@ucl.ac.uk

Deficiencies in generating an auditory mismatch negativity (MMN) were one of the earliest electroencephalographic (EEG) markers of brain dysfunction in patients with schizophrenia. These EEG features can be replicated pharmacologically with the N-methyl-D-aspartate (NMDA) receptor antagonist ketamine. More recent studies have furthermore shown a ketamine-induced impairment of context dependent modulation of the MMN at the prefrontal electrodes, consistent with a predictive coding account of mismatch negativity generation. Here, we report the effects of ketamine administration at two different doses on the auditory MMN in a double blind, crossover, placebo-controlled study in 16 healthy volunteers. Pure tones were presented in a roving paradigm, where each frequency is both a deviant stimulus (following a frequency change), before becoming a new standard after a few repetitions. This study design has two advantages: (i) deviants and standards do not differ in their physical properties, but only in their preceding auditory context, and (ii) it discloses the 'relearning' of new standards after frequency changes (i.e. repetition suppression). There is a significant effect of ketamine on the response to standard stimuli, consistent with a defective sensory learning of new standards. Using dynamic causal modelling for EEG, we estimated the underlying changes in directed, effective connectivity between the sources of the relevant frontotemporal network. This study replicates some of the findings from a previous, independent study, but further focusses on the ketamine-induced difference in repetition suppression when 'relearning' a novel standard. These results give a mechanistic account of pharmacologically induced neurophysiological changes in synaptic plasticity.

Development (infancy, childhood, adolescence, and aging)

31 P1 Pre-attentive neural processes of unattended facial emotions in adolescents

Tongran Liu

Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing, China
liutr@psych.ac.cn

Adolescence is an essential period for the neurodevelopment of social-emotional abilities, and the pre-attentive change detection of facial expressions is crucial for adolescent's social interpersonal communication. Two groups of participants (an adolescent group and an adult group) were employed with the emotional oddball task which contained one happy oddball condition (frequently presented neutral expressions [standard stimuli: probability of .8] were rarely replaced by happy expression [deviant stimuli: probability of .2]) and one fearful oddball condition (frequently presented neutral expressions [standard stimuli: probability of .8] were rarely replaced by fearful expression [deviant stimuli: probability of .2]). The event-related potential (ERP) technique was adopted to record participant's electrophysiological activities, and the visual mismatch negativity (vMMN) components indexing the neural automatic change detection processes of facial expressions were compared between the two age groups. The vMMN differences between the age groups are regarded to reflect the differences of automatic change detection to affective information between these two groups. The electrophysiological results showed that adolescents had greater vMMN amplitudes than adults in the fearful condition, and the adolescent group showed larger vMMN amplitudes to fearful faces than that to happy faces during 120–200 ms. During 230–320 ms, there were no age group-related differences in vMMN responses between the two groups. The present study supported that adolescents had better automatic change detection to fearful faces relative to adults and shed light on the neurodevelopment of automatic processes on social-emotional information.

32 P2 Mismatch response (MMR) in neonates: beyond refractoriness

Gábor Háden[1], Renáta Németh[1], Miklós Török[2], & István Winkler[1]

[1]*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary*
[2]*Department of Obstetrics-Gynaecology and Perinatal Intensive Care Unit, Military Hospital, Budapest, Hungary*
haden.gabor@ttk.mta.hu

In the adult auditory system, deviant detection and updating the representation of the environment is reflected by the event-related potential (ERP) component termed the mismatch negativity (MMN). MMN is elicited when a rare deviant stimulus is presented amongst frequent standard stimuli, deviating in some auditory feature. The same stimuli also elicit a similar discriminative ERP component in sleeping newborn infants (termed the mismatch

response: MMR). Both the MMN and the MMR can be confounded by responses generated by differential refractoriness of frequency-selective neural populations. Employing a stimulus paradigm designed to minimize this confounding effect, newborns were presented with sequences of pure tones under two conditions: In the oddball block, rare deviant tones (500 Hz; 10 %) were delivered amongst frequent standards (700 Hz; 90 %). In the control block, a comparison tone (500 Hz) was presented with the same probability as the deviant (10 %) along with the four contextual tones (700 Hz, 980 Hz, 1372 Hz, 1920.8 Hz; 22.5 % each). The significant difference found between the response elicited by the deviant and the comparison tone showed that the response elicited by the deviant in the oddball sequences cannot be fully explained by frequency-specific refractoriness of the neural generators. This shows that neonates process sounds in a context-dependent manner as well as strengthening the correspondence between the adult MMN and the infant MMR.

Psychophysiological correlates of developmental changes in healthy and autistic boys

33 P3

Benjamin Weismüller, Renate Thienel, Anne-Marie Youlden, Ross Fulham, Michael Koch, & Ulrich Schall[1]

[1]*PRC Translational Neuroscience & Mental Health Research, The University of Newcastle, Callaghan, Australia*
Ulrich.Schall@newcastle.edu.au

This study investigated neurodevelopmental changes in sound processing by recording mismatch negativity (MMN) in response to various degrees of sound complexity in 18 mildly to moderately autistic versus 15 healthy boys aged between 6 to 15 years. Autistic boys presented with lower IQ and poor performance on a range of executive and social function measures when compared to their healthy counterparts. We found that MMN in response to duration deviants was less lateralized in the clinical group whereas larger amplitudes correlated with advanced age, thus capturing neurodevelopmental changes. Larger MMN in response to speech-like sound deviants was associated with better verbal fluency and executive function performance, respectively, but did not reliably discriminate the two groups. Our findings suggest that MMN amplitudes do not differ between healthy and autistic boys and equally capture brain maturation and associated cognitive ability in both groups.

Prediction errors in word recognition and learning in young children

34 P1

Sari Ylinen[1], Alexis Bosseler, Katja Junttila[1], & Minna Huotilainen[1,2]

[1]*Institute of Behavioral Sciences, University of Helsinki, Finland*
[2]*Finnish Institute of Occupational Health, Helsinki*
sari.ylinen@helsinki.fi

Previous studies have suggested that in adults, word recognition is driven by predictions. Here we show that inferring predictions is crucial to language learning in children. We recorded auditory event-related brain potentials (ERP) to the same target syllables in isolation (e.g., [ka]) and within context (e.g., [ku][ka], together forming the word [kuk:a] 'flower'). As compared to the no context condition, the context condition was hypothesized to allow more efficient processing of the target syllables due to word-level predictive coding, which was

expected to enhance and accelerate ERP responses. In the context condition, the target syllables completed either a familiar ([kuk:a] 'flower') or an unfamiliar ([kuk:e] with no meaning) word form. Results showed that 12- and 24-month olds' electrophysiological brain responses to heard syllables were faster and more robust when the preceding word context predicted the ending of a familiar word. For unfamiliar, novel word forms, however, word-expectancy violation generated a prediction error response, the strength of which significantly correlated with children's vocabulary scores at 12 months. This suggests that predictive coding serves as the neural mechanism for both word recognition and early learning of novel word forms. We argue that language development is guided by the same prediction-based learning mechanism reported across domains in human and non-human animals.

35 P2 Rapid auditory processing in Italian infants at risk for language and learning impairment

Chiara Cantiani[1], Valentina Riva, Caterina Piazza, Roberta Bettoni, Massimo Molteni, Naseem Choudhury, Cecilia Marino, & April Benasich

[1]*Scientific Institute E. Medea, Albavilla, Italy*
chiara.cantiani@lanostrafamiglia.it

Infants' ability to discriminate between auditory stimuli differing in fundamental frequency and presented in rapid succession (i.e. rapid auditory processing [RAP] abilities) has been shown to be anomalous in infants at familial risk for Language and Learning Impairment (LLI) and to impact later linguistic skills (e.g., Choudhury & Benasich, 2011). This study represents the first attempt to investigate RAP in Italian infants at familial risk for LLI (FH+) for two acoustic features: fundamental frequency and sound duration, both embedded in a rapidly-presented acoustic environment. Early RAP skills of 24 FH+ Italian 6-month-olds and 32 control infants (FH–) were characterized via EEG/ERP using a double-deviant oddball paradigm. Outcome measures of expressive vocabulary were collected at 20-months-of-age via a parental questionnaire (Language Developmental Survey; Rescorla et al., 2014). Overall, the morphology of ERP responses differed for frequency vs. duration deviants. Group differences favoring FH- infants were identified: in FH+ infants, the latency of the N250 peak was delayed and the mean amplitude of the positive mismatch response was reduced, primarily for the frequency condition and within the right hemisphere. Moreover, both measures differentiating FH+ and FH- groups at 6-months-of-age were correlated with expressive vocabulary at 20 months. Overall, these results suggest that Italian infants with a first-degree relative affected by LLI show atypical auditory processing and preliminary longitudinal data suggests that RAP abilities in Italian infants predict later language skills.

Detection of violation in two streams: a feasibility study in 6–9 months old infants

36
P3

Elena Kushnerenko[1], Przemyslaw Tomalski[2], & Derek G Moore[3]

[1]*School of Psychology, University of East London, United Kingdom*
[2]*University of Warsaw, Poland*
[3]*University of Surrey, United Kingdom*
e.kushnerenko@gmail.com

The ability to segregate auditory streams is essential for efficient speech processing and, therefore, attainment in school. Previously, it has been reported that infants already at birth can segregate auditory information in separate streams and detect a violation in one of them (Winkler et al, 2003). In this study, we explored the possibility of simultaneous processing of two streams both containing deviant stimuli. The aim was twofold: 1) to test whether it is feasible to record reliable data for two paradigms at the same time, 2) to test infants' speech processing capacity in auditory distracting environment. Infants (6–9 months old) were tested with two paradigms either presented simultaneously (streaming) or separately (control). While we expected to obtain an ERP signature of mismatch detection in both streams at the group level, we also expected to reveal a differential ability to segregate auditory streams at individual level. We examined ERPs in response to videos of audio-visually matched and mismatched syllables /ba/ and /ga/ (Kushnerenko et al, 2008) presented together with an auditory oddball paradigm including pitch and white-noise deviants (Kushnerenko et al, 2007). Our results demonstrate that at the group level the detection of audiovisual mismatch in the streaming condition was decreased, although still present in individual infants; processing of the white-noise segment was not affected significantly, while processing of the pitch deviant resulted in change of polarity of mismatch response. The results suggest that in situation of auditory overload, a different mechanism might be involved in detecting acoustic violations in infants.

ICA derived cortical responses to auditory pitch and duration deviance in six-month-old infants

37
P1

Caterina Piazza[1,2], Chiara Cantiani[1], Zeynep Akalin-Acar[3], Makoto Miyakoshi[3], April Ann Benasich[4], Gianluigi Reni[1], Anna Maria Bianchi[2], & Scott Makeig[3]

[1]*Scientific Institute IRCCS E. Medea, Italy*
[2]*Politecnico di Milano, Bosisio Parini, Italy*
[3]*Swartz Center for Computational Neuroscience, University of California San Diego, La Jolla, CA*
[4]*Center for Molecular & Behavioral Neuroscience, Rutgers University, Newark, NJ*
caterina.piazza@bp.lnf.it

Several studies have suggested that the auditory mismatch response (MMR) elicited in infants is a predictor of later language skills (Choudhury & Benasich, 2011; van Zuijen et al. 2013). However, there is little knowledge of what brain source activities the infant MMR reflects (Näätänen et al., 2014) and independent component analysis (ICA) has not been used to address this issue. Scalp-channel averaged EEG and MMRs may sum volume-conducted contributions from many cortical source areas. ICA applied to the unaveraged EEG-data can be used to identify the complex spatiotemporal dynamics underlying the MMR, allowing

identification of the contributions of the cortical generators that contribute to the scalp averages (Rissling et al., 2014). We recorded 60-channel EEG-data in 34 typically developing six-month-old infants during a passive acoustic oddball paradigm involving 'standard' interspersed with occasional pitch- or duration-deviant tone-pairs. Adaptive-mixture-ICA (Palmer et al., 2008), applied to EEG-data produced an average of 56 (range: 51–59) independent components (ICs) per subject for which the 3-D brain location of the best-fitting equivalent dipole (or of two position-symmetric dipoles) could be estimated using a four-layer template infant head model. These brain-source ICs were clustered across subjects by equivalent dipole locations and ERP morphology. Results showed: 1) Multiple cortical areas contributed to the two deviance MMRs. 2) A dominant cluster, located near posterior cingulate cortex, displayed marked inter-subject variability. 3) ICs requiring dual-dipole models appeared relatively frequently. These results show the potential of the ICA method for deriving more detailed functional information about the MMR in infancy.

38 P2 Little grammar experts: 5-month-old infants' mismatch responses reveal the ability to process a triple center-embedding

Marina Winkler[1], Claudia Männel[1], Angela D. Friederici[1], & Jutta L. Mueller[2]

[1]*Department of Neuropsychology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany*
[2]*Institute of Cognitive Science, University of Osnabrück, Germany*
winklerm@cbs.mpg.de

Human grammar crucially involves the processing of hierarchical structures, for instance center-embeddings, which are known to be difficult to process in natural language, as well as in artificial grammar. With increasing depth of embedding, the difficulty to process such structures increases, leading to the assumption, that more than 3 levels of center-embedding (LCE) are not comprehensible. Recent research has shown extraordinary language learning abilities in very young infants. Neonates are able to learn dependencies between adjacent syllables, and infants as young as 3–4 months can process non-adjacent dependencies between syllables. Our recent research has shown that 5-month-old infants are able to process complex hierarchical rules involving 2 LCE. The aim of the present event- related potential study was to examine, whether 5-month-old infants are also able to process hierarchical rules with 3 LCE. Following the passive listening oddball paradigms of our previous experiments, we used sequences of auditory stimuli (pure sine tones) as oddball elements. The frequent standard sequences contained correct triple center-embeddings and the deviants contained positional violations to these rules. The results show infant mismatch responses, indicating that the infants successfully processed the underlying rules. Our experiment provides evidence that infants can process even such a complex hierarchical structure as a triple center-embedding between rapid non-linguistic stimuli. Further research is needed to examine whether these findings can be transferred to the linguistic domain.

Large auditory evoked potentials to rare emotional stimuli in pre-term infants at term age

39
P3

Satu Pakarinen[1], Iina Ala-Kurikka, Anna Jääskeläinen, Kaija Mikkola, Vineta Fellman, & Minna Huotilainen[1,2]

[1]*Finnish Institute of Occupational Health, Helsinki, Finland*
[2]*Institute of Behavioral Sciences, University of Helsinki, Finland*
satu.pakarinen@helsinki.fi

In this study, we evaluated the pre-attentive processing of linguistic and emotional information in preterm and term-born infants by recording auditory evoked potentials (aERP). Preterm (n = 9; mean birthweight 1395 g, range 930–1950 g; mean gestational weeks 30.4, range 26.7–33.3) and healthy, term-born control (n = 20; gestational weeks 38–42) infants were assessed at term age. The stimuli were presented in a multi-feature mismatch negativity (MMN) paradigm with a standard tone (50 %) and five different deviant stimuli (~ 9 %, each). In addition, three emotionally valenced rare stimuli (~ 1 %, each) were occasionally presented. The standard stimulus was a naturally recorded pseudo-word /ta-ta/, and the deviants were linguistically relevant variations (e.g., frequency and vowel change) whereas the rare stimuli were happy, angry, and sad utterances of the standard. Statistically significant discriminatory responses (rare-minus-standard aERPs) were recorded in both groups for all rare emotional sounds at 250–350 ms and at 450–550 ms post stimulus onset. The responses to the standard stimulus did not differ between groups. The discriminatory responses for all three emotional rare sounds were significantly ($p < .05$) larger in the preterm than in the control group at both time windows. Large aERPs to rare stimuli in preterm infants show that they discriminate between the emotional and the standard stimuli. That the responses were larger in the preterm than in the control group may result from postnatal learning and therefore enhanced sensory processing. On-going follow-up studies will clarify the behavioural significance of these findings.

Emotional prosodic deviance-detection in school-age children

40
P1

Judith Charpentier[1], Sylvie Roux[2], Emmanuelle Houy-Durand[3], Mathieu Lemaire[3], Joëlle Malvy[3], Frédérique Bonnet-Brilhault[3], Agathe Saby[4], & Marie Gomot[2]

[1]*UMR930 INSERM, Université François-Rabelais de Tours, France*
[4]*Centre Universitaire de Pédopsychiatrie, Centre Hospitalier Régional Universitaire de Tours, France*
judith-charpentier@hotmail.fr

Prosody conveys key information about the emotional state of a speaker and thus is a crucial clue that one's has to detect early to develop an efficient social communication. Mismatch negativity (MMN) is an effective way to study automatic detection of such clue. Larger amplitude for emotional MMN (eMMN) compared to neutral MMN (nMMN) has been reported in adults while in school-age children, the few studies showed a biphasic fronto-central eMMN but without any comparison with nMMN to assess the specific effect of emotional deviancy. This study addressed direct comparison of automatic change detection of neutral and emotional deviants with strictly controlled acoustic parameters across development. To this end, oddball and equiprobable sequences were presented to 8-year-old children (n = 10), 11-year-

old children (n = 10) and adults (n = 11). A biphasic response was found for nMMN in all groups and for eMMN in children. Latency of eMMN was shorter than latency of nMMN in adults and in 11-year-old children whereas no significant difference was observed in the youngest children. Similar amplitude was found between groups and conditions but MMN topographies appeared more posterior in children indicating a non-mature organization of the brain response to prosody deviancy. Faster deviancy detection for emotional stimuli was found in adults and in older children but not in 8-year-old children. This is congruent with young children's behavioral preference for speech content over prosody when they are facing contradictory clues. Altogether, these results indicate a late maturation of emotional prosody discrimination.

41 P2 Perception of musical features in hearing impaired children after cochlear implantation

Niki Vavatzanidis[1,2], Alexander Mainka[2], Dirk Mürbe[2], & Anja Hahne[2]

[1]*Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany*
[2]*Saxonian Cochlear Implant Center, TU Dresden, Germany*
niki.vavatzanidis@uniklinikum-dresden.de

Cochlear implantation is by now an established procedure that gives hearing impaired children access to the auditory world. Yet, we still know little about the auditory features that hearing impaired children actually perceive in the months following cochlear implantation and thus, on what means they have to process sound, speech and music. In previous MMN studies we focused on the perception of vowel length (Vavatzanidis et al., under review) and syllable stress pattern (Vavatzanidis et al., in preparation) right after cochlear implantation as they are important abilities for language acquisition. In the following study we turned to more basic auditory features that nevertheless are also crucial for music perception. We applied an adapted version of the musical multi-feature mismatch paradigm by Vuust et al. (2011) that tests pitch, timbre, intensity, rhythm and slide perception. With it, we tested 16 prelingually deaf children (9 girls; mean age at implant activation: 17 months, range: 7–39 months) at six and twelve months after they received a cochlear implant. First results show that timbre deviations are well perceived by the children after a year's experience of hearing, thus showing auditory sensitivity to basic musical features despite their delayed hearing onset.

42 P3 Impaired auditory processing with aging

Elizabeth Dinces[1] & Elyse Sussman[2]

[1]*Otorhinolaryngology, Albert Einstein College of Medicine, Bronx, NY*
[2]*Neuroscience, Albert Einstein College of Medicine, Bronx, NY*
edinces@montefiore.org

Aging adults often have difficulty understanding speech with multiple competing sound sources. For aging individuals without a sensorineural hearing loss, it is not well understood what type of impairments contribute to the inability to listen to one sound stream among many. This study investigated several levels of sound processing to determine what types of impairments may contribute to difficulty hearing a single sound stream among competing

sounds in aging individuals with normal hearing. Electrophysiologic and behavioral measures were obtained to assess the ability to segregate target sounds from competing background sounds. The data expose differences in auditory processing associated with normal aging.

Auditory event-related potentials indexing memory and change-detection in newborn infants who were exposed to antiepileptic medication during the fetal period

43 P1

Minna Huotilainen[1,2], Mari Katri Videman, Satu Pakarinen[1], Iina Ala-Kurikka, Taina Nybo, Sampsa Vanhatalo, Reina Roivainen, & Eija Gaily

[1]*Finnish Institute of Occupational Health, Helsinki*
[2]*Institute of Behavioral Sciences, University of Helsinki, Finland*
minna.huotilainen@helsinki.fi

Exposure to antiepileptic drugs in young animals can result in cognitive problems. In humans, an increased risk for cognitive dysfunction after fetal exposure to antiepileptic drugs has been reported in follow-up studies which are vulnerable for confounding factors. We recorded MMNs from 47 infants exposed to antiepileptic drugs during the fetal period. The treatment was with a single drug for 35 and with two or more for 12 mothers. Control infants were from mothers matched in age, education, and family background. The multifeature paradigm had a standard bi-syllabic pseudoword and frequency, intensity, vowel duration, consonant duration, and vowel identity deviants. In addition, three emotionally uttered versions of the pseudoword were presented as infrequently occurring novel sounds (happy, angry, sad). This paradigm allows the comparison of change-related responses with respect to the speech-relevant features as well as emotional-sound induced responses. The direct comparison of ERPs from the exposed group and from the control group showed differences in the frequency change detection and in the emotional responses between the two groups. The responses for the frequency changes and for the happy emotions were smaller in the exposed group than in the control group. The responses to the angry and sad emotions had a different response pattern in the exposed than in the control group. Different types of antiepileptic drugs and their doses should be studied separately to reveal possible differences in the effects. These data allow such comparisons to a small extent. More research is needed to confirm and extend the findings.

Age differences in the processing of sound's novelty and information as reflected by ERPs, pupil size, and performance

44 P2

Nicole Wetzel, Erich Schröger, & Andreas Widmann

Institute of Psychology, University of Leipzig, Germany
wetzel@uni-leipzig.de

The present study focuses on effects of novelty and information provided by task-irrelevant sounds on involuntary attention and distraction in children (aged 6–7 years) and adults. We presented an auditory-visual oddball paradigm while participants performed a visual categorization task. In an informative condition all sounds were followed by a visual target. Sounds were irrelevant for the visual categorization task, but predicted the occurrence of a target. In an uninformative condition only half of the sounds were followed by a target, that is, sounds

were uninformative with respect to the occurrence of a visual target. We measured ERPs, pupil dilation response (PDR), and reaction times (RT). Results revealed different effects of sound's novelty or informational content reflected by differences in the ERP components N1, P2, N2, the PDR, and the RT in subsequent trials between the age groups. Results demonstrate that several steps of the processing of new and informative but task-irrelevant sounds are not yet matured until the middle childhood. Importantly, effects of sound's novelty and information on the pupil size observed in both age groups indicate that brain mechanisms involved in pupil control are modulated by sounds' novelty and target-related information. Moreover, these effects are partly different between children and adults.

45 P3 Specific characteristics of mismatch negativity in pre-term and full term infants

Marina Vasileva

Biological Department, St. Petersburg University, Russia
marinajv@list.ru

The mismatch negativity component of auditory event-related potentials was studied in preterm and full term infants of the first month of life and adults. Acoustic stimuli with large deviance in passive oddball task were used. EEG data revealed distinctive features in morphology and specificity in parameters of infant mismatch responses (MMRs). Unlike the adult group, infant MMRs were greater in amplitude and longer in latency and were manifested in two positive peaks (full term group) and in one negative peak (pre-term group). A significant positive correlation was observed between infant's conceptual age and MMR amplitude, and significant negative correlation was found between infant's conceptual age and MMR latency. Results suggest specificity in the parameters of infant mismatch responses which may index maturational changes in auditory cortex at early ages.

Diagnostics and inter-individual differences

46 P3 Resting-state glutamatergic neurotransmission is related to the peak latency of auditory MMN for duration deviants

Kristiina Kompus[1], Kairi Kreegipuu, Nele Põldver[2], René Westerhausen, Kenneth Hugdahl, & Risto Näätänen

[1]*Bergen, Norway*
[2]*Institute of Psychology, University of Tartu, Estonia*
kristiina.kompus@psybp.uib.no

Mismatch negativity (MMN) has been suggested to be associated to glutamatergic neurotransmission, mediated by glutamatergic NMDA receptors. In this study we used magnetic resonance spectroscopy (MRS), a non-invasive brain imaging method which allows quantification of metabolites in vivo to examine the relationship between inter-individual variation of 1H-MRS-measured glutamate+glutamine (Glx) in the superior temporal gyrus, and MMN for duration and frequency deviants in 19 healthy young adults (9 male). The peak latency of the

duration-MMN peak was associated with Glx ($p = .0003$, $\eta^2 = .43$), with increased Glx level being associated to earlier peak of the duration-MMN ($r = -.63$). In contrast, the amplitude of the duration-MMN was not related to Glx. There was no significant relationship between Glx and the frequency-MMN. We conclude that the inter-individual variation in the glutamatergic neurotransmission affects the MMN response in healthy individuals.

Impaired auditory discrimination of sound quality in noise sensitive individuals

47
P2

Elvira Brattico[1], Marina Kliuchko[1], Mari Tervaniemi[1], & Marja Heinonen-Guzejev[2]

[1]*Institute of Behavioural Sciences, University of Helsinki, Finland*
[2]*Department of Public Health, University of Helsinki, Finland*
elvira.brattico@helsinki.fi

Individuals vary in their reactivity to sounds. Noise sensitivity has been isolated to describe the individual physiological and emotional reactivity to noise. Noise sensitive individuals (amounting to about 20–40 % of the population) show a predisposition to attend to sounds and perceive them negatively. The neural correlates of noise sensitivity are yet to be determined. Here we measured with magnetoencephalography and electroencephalography (MEG/EEG) 71 healthy adults without any peripheral hearing impairments (age range 19–51 years) while they were presented with the musical multifeature paradigm, eliciting six mismatch negativity (MMN) responses to sound feature changes inserted in a music-like environment. By combining MMN parameters with noise sensitivity scores assessed by a questionnaire, we studied the effects of noise sensitivity on neural discrimination abilities. Noise sensitivity selectively affected the MMN strength to timbre changes (but not to pitch, slide, intensity, location or rhythm changes), with weaker MMN responses to timbre deviants in individuals with high noise-sensitivity scores than those with low scores. These results encourage to examining idiosyncrasies of central auditory processing and discrimination in noise sensitive individuals.

Automatic processing of schematic faces depending on their gaze direction and eyebrow angle: relations with depression and anxiety

48
P3

Annika Kask, Nele Põldver, Kertu Saar, Liina Juuse, Jüri Allik, Risto Näätänen, & Kairi Kreegipuu

Institute of Psychology, University of Tartu, Estonia
annika.kask@hotmail.com

It has been shown that mood affects automatic perception of schematic emotional faces evoking smaller visual mismatch negativity (vMMN) at posterior sites for depressive participants as compared to controls (Chang et al., 2010). In our study, emotional processing was studied with induction of vMMN, using the optimal paradigm with several schematic faces (defined by mouth, eyebrow angles, and gaze direction) as deviant stimuli. In addition, subjective evaluations to stimuli and scores to self-reported questionnaires (on personality, positive and negative emotions, impulsivity, emotional feeling) were registered (n = 33). According to grand averaged vMMN curves and literature two intervals of vMMN were analyzed: 90–200 ms and 200–340 ms. The difference of the eyebrow angle and gaze direction proved to be important for subjective evaluations, but from the analysis of the EEG data no

significant differences were found in the amplitudes of the negative peaks. However, there seem to be some individual differences in processing of unattended emotional faces, especially the neutral deviant. Also, gaze direction proved to be a relevant characteristic, eyebrow angle on the other hand, did not. Positive or negative mood or personality did not elicit a significant relation to vMMN. The analysis showed a correlation between the tendency to be depressed or anxious and the size of vMMN. These results indicate that the more depressed and anxious individuals were, the smaller amplitude they produced, presumably because of a more narrow and focused processing of targets.

49 P1

Objective and rapid quantification of high-level visual impairment with fast periodic oddball stimulation in acquired prosopagnosia

Joan Liu-Shuang[1], Katrien Torfs, & Bruno Rossion

[1]*Face Categorization Lab, University of Louvain, Louvain la Neuve, Belgium*
joan.liu@uclouvain.be

Perceptual deficits are common in many neurological conditions, but their assessment can be hindered by many unrelated factors (e.g. attention, comprehension, motor impairments etc.). Hence, a method allowing for an objective, sensitive, and efficient quantification of perception would be highly valuable. In the recently developed fast periodic oddball paradigm, base stimuli appear at a fixed rate (F Hz) with oddball stimuli, differing on a dimension of interest, inserted at regular intervals (every nth stimulus, or F/n Hz; Liu-Shuang et al., 2014). Periodic EEG responses at the F/n Hz oddball frequency and harmonics (2F/n Hz, 3F/n Hz…) reflect the perceived mismatch between base and oddball stimuli. We tested this approach with PS, a well-described brain-damaged patient impaired at face individualisation. PS was first presented with sequences of base "object" stimuli at 6 Hz with periodically interleaved oddball "face" stimuli at 1.2 Hz (every 5th stimulus). In line with her preserved ability to detect faces, PS showed periodic oddball EEG responses within normal range. However, when "different" oddball face identities (B, C…) were inserted in sequences containing a repeated "same" base face identity (A; sequence structure: AAAABAAAACAA…, Liu-Shuang et al., 2014), significant oddball responses were found in all control (young & age-matched) participants but were absent for patient PS. These observations were obtained within 8–12 min of recording. Overall, our findings underline the value of the fast periodic oddball paradigm as a diagnostic tool for rapid and objective characterisation of visual discrimination in neuropsychology.

Error signals

Prediction errors – Mismatch negativity (MMN) reveals how higher-level models govern error detection at lower levels

50
P2

Daniel Mullens, István Winkler[1], Karlye Damaso, Andrew Heathcote, Lisa Whitson, Alexander Provost, & Juanita Todd[2]

[1]*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary*
[2]*Psychology, The University of Newcastle, Callaghan, Australia*
Juanita.Todd@newcastle.edu.au

First-impressions are known to impact decision-making and are attributed to assumptions we make that have prolonged effects on reasoning. We have observed similar phenomena (termed "primacy bias") affecting the amplitude of the mismatch negativity (MMN) component in the auditory evoked potential. Here we test whether this phenomenon can be explained by the formation of a confident-weighted first impression bias. In two studies participants were asked to focus attention on a silent movie and ignore auditory stimuli while we recorded evoked responses to sound sequences. Sequences consisted of concatenated segments alternating the sequential probabilities (roles) of the same two tones (frequent/predictable vs. infrequent/unpredictable). Primacy bias refers to the finding that the event-related brain potentials expected on the basis of transition statistics are only found for the segments in which the roles are identical to how they were first encountered, but not for segments with the reversed roles. Study 1 shows that this bias is initially prevented if there is no 1:1 mapping between sound attributes and roles, but it returns once the auditory system determines which properties provide the highest predictive value. Study 2 shows that confidence in this bias drops if assumptions about the temporal stability of the pattern are violated. Together, these results provide compelling evidence that, the context (here the large-scale structure of the sequences) affects these sensory first impressions. The results are compatible with hierarchical predictive coding theories, demonstrating how higher-level models govern error detection at lower levels.

Prediction errors of visual content across eye movements and their modulation by inferred information in the blind spot

51
P3

Benedikt Ehinger, Peter König, & José Ossandón

[1]*Institute of Cognitive Science, University of Osnabrück, Germany*
behinger@uos.de

The brain is proposed to operate through probabilistic inference, testing and refining predictions about the world. Here, we search for neural activity compatible with the violation of active predictions, learned from the contingencies between actions and the consequent changes in sensory input. We focused on vision, where eye-movements produce stimuli shifts that could, in principle, be predicted. We compared error signals to saccade-contingent changes of direct and indirect inputs, by contrasting the electroencephalographic (EEG) activity after saccades to a peripheral stimulus presented monocularly inside or outside the

blind-spot. In some trials the stimulus remained the same pre and post eye-movement but in others it was exchanged. The EEG was analyzed using univariate general linear models, corrected for multiple comparison using threshold-free cluster based methods. We observed early (< 250 ms) and late error signals (> 250 ms) after stimulus change, indicating the violation of sensory and associative predictions respectively. Remarkably, the late P3-like response was diminished for blind-spot trials. These results indicate that predictive signals occur across multiple levels of the visual hierarchy, based on generative models that differentiate between signals that originate from the outside world and those that are inferred.

52 P1 First-impression effects on mismatch negativity (MMN) amplitude extend to complex sequences

Juanita Todd[1], Jade Frost[1], Kaitlin Fitzgerald, & István Winkler[2]

[1]*Psychology, The University of Newcastle, Callaghan, Australia*
[2]*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary*
Juanita.Todd@newcastle.edu.au

The auditory system has exquisite capacity to extract patterning in sound. Patterns are used to infer likely characteristics of upcoming sounds and sounds that deviate from patterns automatically elicit the evoked-potential component known as mismatch negativity (MMN). MMN signals a prediction-error when sound does not match inferred characteristics and MMN should be largest when confidence in the underlying inference is high (i.e. when patterns are very stable). In simple sequences we have shown that inferences are subject to order-driven bias and in this study we demonstrate that this extends to more complex patterns. Participants watched a silent movie while sequences were presented over headphones. Sequences contained three tones varying on three dimensions: A = 1210 Hz, 60 ms, left location; B = 1110 Hz, 30 ms, right location; and C = 1000 Hz, 90 ms, centre location. Tones were organised into blocks such that two were common standards (p = .425 each) and one was a rare deviation (p = .141). Stable sequences contained 2430 tones organised into six blocks of 405 and unstable sequences contained 18 blocks of 135. The sound that was deviant rotated through A, B, C order across blocks. Significant MMN was elicited to all deviants and reached equal amplitude at maximum stability points in the sequences. However, MMN elicited to the first deviant (A) was largest overall due to growth in MMN amplitude and other deviants requiring longer periods of stability. The order-effect reveals persistent first-impression bias in which initial tone roles impact confidence in subsequent changes in sequence pattern.

53 P2 Neurofeedback as a training tool for pitch discrimination

Annika Luckmann[1], Jacob Jolij[2], & Deniz Baskent[1]

[1]*Otorhinolaryngology, University Medical Center Groningen, Netherlands*
[2]*Experimental Psychology, University of Groningen, Netherlands*
annikaluckmann@gmail.com

Neurofeedback is an online training method, in which neuronal oscillations, measured with EEG, are used to give real-time feedback to individuals. Through the real-time feedback, individuals can be trained to regulate brain activity to match specific cognitive states. Recent-

ly, neurofeedback has been found to induce perceptual learning in both the auditory (Chang et al, 2014) and visual domain (Shibata et al, 2011; Scharnowski et al 2012). In a pilot study we investigated whether a simple two-tone pitch discrimination paradigm can be used in a neurofeedback training study. Furthermore, we wanted to investigate whether EEG data could predict participants' conscious perception in the form of behavioral ratings. We tested 28 normal hearing young adults. Participants rated the perceived difference between a standard (150 Hz) and a deviant (either 150.5 Hz, 151 Hz, 151.5 Hz or 152 Hz). Analysis of single trials showed that both acoustic change complex (ACC) and P300 were visible in deviant trials. A regression analysis further indicated that it was possible to predict the participants' behavioral data from the EEG data. In the next step, we will implement the neurofeedback into the pilot paradigm, and change the focus to the mismatch negativity instead of the ACC by using a string of nine tones per trial to replicate effects found in Chang et al. Our hypothesis is that participant's discrimination thresholds will improve significantly between pre- and post-test, and that the test group will improve significantly compared to a control group.

Does primacy bias in mismatch negativity (MMN) diminish with repeated exposure to sound sequences?

54
P3

Jade Frost[1], Alexander Provost, István Winkler[2], & Juanita Todd[1]

[1]*Psychology, The University of Newcastle, Callaghan, Australia*
[2]*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary*
Jade.Frost@uon.edu.au

The ability of the auditory system to detect patterning in sound sequences enables the system to predict the most likely characteristics of sound in the environment whilst remaining sensitive to sounds that deviate from predictions. If a sound deviates from an active 'prediction model', an evoked potential component called mismatch negativity (MMN) is elicited. MMN reflects a prediction-error when a discrepancy between inferred and actual sound properties occurs and is thought to be confidence-weighted where the higher the confidence (i.e. when patterns are stable), the larger the MMN following pattern violation. Using the 'multi-timescale' paradigm, we have consistently shown that MMN is susceptible to order-driven bias dependent on initial tone roles. In this study we show that the bias remains even with repeated exposure to sound sequences. Participants heard four occurrences of either stable or unstable sequences over headphones. Both sequences contained 60 ms and 30 ms tones that alternated the role of standard (p = .875) and deviant (p = .125). In stable sequences, tone roles alternated every 2.4 min (480 tones per block; 420 standard tones, 60 deviant tones). In unstable sequences, tone roles alternated every 0.8 min (160 tones per block; 140 standard tones, 20 deviant tones). Results were consistent with primacy-bias: more confident predictions for stimulus configurations matching the one first encountered than the reversed one. Remarkably, first-deviant MMN remained large while second-deviant MMN reduced with repeated presentation. Rather than diminishing, the primacy bias pattern appears to intensify with repeated sequence encounters.

55 P1 Does sequence foreknowledge or concurrent task affect primacy bias in mismatch negativity (MMN)?

Jade Frost[1], Kelly McDonnell, Alexander Provost, & Juanita Todd[1]

[1]*Psychology, The University of Newcastle, Callaghan, Australia*
Jade.Frost@uon.edu.au

The auditory system accumulates evidence about regularity across varying timescales to model predictions about subsequent sound. The evoked-potential component mismatch negativity (MMN) is elicited upon detection of any pattern-deviation and reflects a 'prediction-error'. MMN amplitude is proportional to 'confidence' in underlying predictions; MMN is largest when patterns are very stable. Using a 'multi-timescale' paradigm, we have demonstrated that MMN amplitude does not faithfully reflect sequence stability but instead succumbs to a 'primacy bias' that is coupled to initial tone roles. In the paradigm participants hear two-tone sequences in which tones alternate roles of standard ($p = .875$) and deviant ($p = .125$). In stable sequences, roles alternate every 2.4 min (480 tones per block; 420 standards, 60 deviants). In unstable sequences, roles alternate every 0.8 min (160 tones per block; 140 standards, 20 deviants). Primacy bias refers to the observation that only MMN in the first stimulus configuration show the expected stability-modulation: stable > unstable. To date all multi-timescale paradigms have been presented while participants have no knowledge of the sequence structure and watch a silent movie. In this study, we attempted to disrupt the bias by modifying engagement of higher-level brain areas in monitoring longer-term patterns thought to underpin it. The primacy bias pattern did not occur when participants performed a demanding concurrent n-Back task (study 1) or were first informed about the sequence structure (study 2) before watching a silent movie. Our results are interpreted as evidence that engagement of higher-order brain areas is required to make predictions about patterning over longer timescales.

56 P2 High gamma frontal cortex activity dissociates predicted vs. unpredicted deviation: an intracranial EEG study

Stefan Dürschmid[1], Leon Deouell[2], Hermann Hinrichs[3], Hans-Jochen Heinze, & Robert T Knight

[1]*Neurology, Otto-von-Guericke University, Magdeburg, Germany*
[2]*Department of Psychology & The Edmond and Lily Safra Center for Brain Sciences, The Hebrew University of Jerusalem, Israel*
[3]*Magdeburg, Germany*
stefan.duerschmid@googlemail.com

Predictive coding theories imply that stimuli deviating from expectancy result in a prediction-error (PE) signal. Previous research on processing of auditory deviancy has capitalized on low frequency event-related components (LFs) as signatures of PE. However, local cortical neuronal activity (NA) is best indexed by higher frequency bands (high gamma: Hγ) activity. Utilizing the high temporal and spectral resolution of direct cortical recordings from subdural electrodes (ECoG), we compared the temporal patterns of LFs and Hγ. Subjects (n = 5) heard trains of task-irrelevant auditory stimuli in two conditions differing in the predictability of deviation from repetitive background stimuli (fully predictable vs. unpredictable deviants). Subjects were instructed to ignore the sounds and watch a visual slide show. Electrodes with

significant Hγ and/or LF increase over baseline were classified as task-active Hγ/LF channels. Principal component analysis (PCA) was used to identify consistent temporal patterns of Hγ/LF activation. Deviant stimuli elicited Hγ activity earlier in time than LFs. Critically, only frontal Hγ activity discriminated between fully predictable and unpredictable changes. Furthermore, Hγ activity occurring 100 ms before fully predictable deviants differed from activity before standards and unpredictable deviants. ROC analysis revealed that middle frontal cortex pre-stimulus activity predicts fully predictable deviants on a single trial level. In distinction, the inferior frontal cortex was sensitive to the increasing likelihood of deviants following long trains of standards in the unpredictable condition. We propose that prefrontal cortex plays a critical role in prediction of sensory input even when the auditory stimuli are task irrelevant.

Implicit learning of predictable sound sequence modulates mismatch responses at different levels of the auditory hierarchy

57
P3

Françoise Lecaignard, Olivier Bertrand, Jérémie Mattout, & Anne Caclin

Brain Dynamics and Cognition, Lyon Neuroscience Research Center INSERM U1028, Bron, France
francoise.lecaignard@inserm.fr

Within the framework of predictive coding, deviance processing is part of an inference process where prediction errors (the mismatch between incoming sensations and predictions established through experience) are minimized. In this view, the mismatch negativity (MMN) is a measure of prediction error. This provides new hypothesis on MMN modulation by experimental factors, whose testing could refine our understanding of the cognitive processes underlying mismatch responses. In particular, the MMN should decrease as the occurrence of a deviant stimulus becomes more predictable. We conducted a passive oddball EEG study and manipulated the predictability of deviance occurrence by means of stimulus sequences with different temporal structures. Importantly, our design departs from previous studies that compared violations of different time-scale regularities. Evoked responses revealed (1) a modulation of the MMN amplitude by deviance predictability as expected, and (2) an earlier deviance response (around 50 ms) that was also reduced with sound predictability. This twofold effect of predictability supports the view that both deviance responses reflect prediction errors and belief updates computed at different levels of the auditory hierarchy. Furthermore, as none of the participants had been aware of the sound sequence structure, we conclude that it could be encoded through an implicit learning process implemented within the hierarchy. We propose that large time-scale regularities could induce high-level predictions that modulate both the content and the precision of lower-level ones. Our findings hence substantiate predictive coding and provide formal constraints for emerging generative neurocognitive models of (mismatch) evoked responses in the brain.

58 P1

The role of stimulus complexity in various latency ranges of vMMN

Domonkos File, Flóra Bodnár, Krisztina Kecskés-Kovács, István Sulykos, & István Czigler

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
domonkos.file@gmail.com

In visual oddball studies a negativity emerges in the deviant-minus-standard difference wave within the 150–350 ms latency range. We investigated the processes underlying the negativity by applying additional control paradigms. Participants were instructed to play a videogame while windmill patterns were presented. Two oddball conditions with 6 and 12 vanes (V6 and V12) patterns (deviant $p = .1$) and two control conditions were applied. In the equal probability condition 10 windmill patterns that differed in the number of vanes were presented, and in a modified control condition there were 5 patterns ($p = .1$ and .225, respectively). An asymmetry appeared between the ERPs to the V6 and V12 patterns. V12 deviants elicited larger negativity than the V12 standard and V12 control both in an earlier (100–200 ms) and in a later (200–348 ms) latency range. No such effects emerged to the V6 pattern. Accordingly, memory representation was built from both the sequences of V6 and V12, but the V6 deviant did not break the V12 sequence, therefore no V6-related vMMN emerged. As a possible explanation, continuous presentation of V12 adapts the neuronal population responsible for V6 (in other words, representation of the more complex stimulus included the representation of the less complex stimulus). However, the continuous presentation of V6 did not adapt the cell population responsible for V12. In the earlier latency both stimulus specific adaptation (effect on the standard) and (genuine) vMMN (effect on the deviant) appeared on V12, whereas in the later range deviant V12 elicited (genuine) vMMN.

59 P2

Pre-stimulus ERP-correlates of predictive auditory processing

Martin Reiche[1], Andreas Widmann[2], & Alexandra Bendixen[1]

[1]*Department of Physics, Chemnitz University of Technology, Germany*
[2]*Institute of Psychology, University of Leipzig, Germany*
martin.reiche@physik.tu-chemnitz.de

The mismatch negativity (MMN) has been proposed to be associated with a predictive mechanism forming a model of the environment and testing incoming sounds for their compatibility with this model. The MMN is thought to reflect the outcome of that comparison or a model update. Most studies investigate the underlying processes in situations with almost perfect predictability. Yet predictability in natural signals is often compromised by uncertainty; hence the proposed predictive mechanism is only plausible if it can be shown to dynamically adapt to the certainty provided by the sensory context. We investigated this issue by experimental manipulations of certainty in an event-related potential (ERP) paradigm in which predictability was implemented via frequency repetition during passive listening. In two independent experiments, we systematically manipulated the certainty of predictive relations between tones across conditions using different parameters of (un)certainty, such as the overall proportion of valid predictions or the accuracy with which predictions can be made. Results show an ERP correlate of predictive processing size-dependent on predictive certainty in the sequence. In contrast to the MMN, which occurs after the onset of an event, we find that predic-

tion-related ERP-effects can be observed immediately before the onset of a sensory event. This suggests that the proposed predictive mechanism rapidly and flexibly adapts to the degree of certainty in the auditory sensory context. To exclude alternative explanations, we are currently assessing the replicability of this effect with higher and lower tone presentation rates.

Stronger autonomic stress responses are associated with better post-error adjustment in special police cadets

60 P3

Zhuxi Yao[1], Yi Yuan[1], Tony Buchanan[2], Kan Zhang[1], Jianhui Wu[1], & Liang Zhang[1]

[1]*Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences, Beijing, China*
[2]*Department of Psychology, Saint Louis University, MO*
zhangl@psych.ac.cn

High stress jobs require both appropriate physiological regulation and behavioral adjustment to meet the demands of emergencies. Here, we investigated the relationship between the autonomic stress response and behavioral adjustment after errors in special police cadets. Sixty-eight healthy male special police cadets were randomly assigned to perform a first-time walking on an aerial rope bridge to induce stress responses, or a walking on a cushion on the ground serving as a control condition. Next, the participants completed a go/no-go task to assess behavioral adjustment after false alarm responses. Heart rate measurements and subjective reports confirmed that stress responses were successfully elicited by the aerial rope bridge task in the stress group. The behavioral performance of the go/no-go task between the two groups did not reach any significance. However, greater heart rate increases during the treatments were positively correlated with post-error slowing in the subsequent go/no-go task for the stress group. No such correlation was found for the control group. These results suggest that special police cadets with stronger autonomic stress responses had better post-error behavioral adjustment.

Predicting complex acoustic contingencies in the human auditory brainstem

61 P1

Johanna Schaefer[1], Katarzyna Zarnowiec[1,2], Iria SanMiguel[1,2], Manuel S. Malmierca[4], & Carles Escera[2]

[1]*Department of Psychiatry and Clinical Psychobiology, University of Barcelona, Spain*
[2]*Institute for Brain, Cognition and Behavior (IR3C), University of Barcelona, Spain*
[4]*Auditory Neurophysiology Laboratory, Institute of Neuroscience of Castilla y León (INCyL), University of Salamanca, Spain*
johanna.schaefer@ub.edu

Higher level sensory processing is thought to be subject of cortical sensory areas. On the cortical level, our auditory system is capable of extracting abstract regularities within the acoustic environment. Here, we investigated whether the subcortical auditory system, specifically the brainstem, is capable of representing complex acoustic feature contingencies. We presented sequences of sinusoidal tones of different frequencies (low: 256 Hz, high: 441 Hz) and durations (short: 100 ms, long: 185 ms). Within the rule sequence the duration of the

preceding tone predicted the frequency of the upcoming tone, e.g. a short tone was followed by a low tone and a long tone was followed by a high tone (Bendixen et al., 2008). After at least 20 rule conforming tones (standards), a further tone violated the established rule (deviant). In a control condition (eraser), the same auditory stimuli without rule, that is, without feature contingency was presented. We recorded the electrophysiological responses (EEG) to these auditory stimuli, and assessed cortical auditory processing by the means of long latency responses, namely the mismatch negativity (MMN) and subcortical auditory processing by the means of brainstem responses, namely the frequency following response (FFR). In line with previous empirical findings, our preliminary results confirmed that rule violations elicited the MMN. Importantly, our results also seem to indicate significant differences in amplitude and power between FFR to deviant tones and FFR to standard and eraser tones. These results suggest that the auditory system extracts complex feature contingencies outside of the scope of cortical processing.

Memory and perception

62 P2 The vMMN is sensitive to within category and between category effect when using a morphing method

Krisztina Kecskés-Kovács, Flóra Bodnár, Domonkos File, István Sulykos, & István Czigler

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
kecskes.kovacs.krisztina@ttk.mta.hu

The aim of the study was to examine the event-related potential correlates of automatic face categorization processes. We supposed that the memory system underlying vMMN is capable of encoding categorial changes even if the eliciting stimuli are irrelevant to the ongoing task (the task was visual tracking). To this end, in a passive oddball paradigm we explored the sensitivity of vMMN to within category or between categories deviancies. The stimuli were morphed female and male faces. We created six female-male gender-morph pairs with morph software. In each of the pairs four morph-^level stimuli were chosen. In the within category comparisons, 100 % and 67 % female/male faces were presented in reverse control conditions, whereas in the between category comparisons, the stimuli were 67-67 % female and male morphs. To avoid the specific physical effect of single faces, six pairs of morphs were created. The electrophysiological data showed that the deviant faces elicited a posterior negativity relative to the frequent standard ones. These effects are regarded as vMMNs generated by automatic detection of sequential regularities. Furthermore, the vMMN component in the between category sequences was larger than the vMMN in the within category sequences, even if the between and within category distances were similar. The results indicate that female and male information are encoded by different neural populations. According to the results, gender perception at an early stage of face processing does not require attentional processes, i.e., face gender categorical coding is automatic.

Discrimination of auditory motion velocities: difference thresholds and mismatch negativity

63
P3

Ekaterina Petropavlovskaia[1], Lidia Shestopalova, Svetlana Vaitulevich, & Nikolay Nikitin

[1]*Group of Auditory Physiology, I. P. Pavlov Institute of Physiology, St. Petersburg, Russia*
petekat@yandex.ru

The sensitivity of the auditory system to the sound motion velocity is known to be a complex phenomenon which can be influenced by associated cues, such as distance and duration. The ability to discriminate the velocity of moving sounds was examined using psychophysical and electrophysiological methods. White noise bursts (100–1300 Hz, 200 ms duration) were dichotically presented to 11 human subjects. Abrupt displacement of the sound from the head midline to the left or right ear or gradual motion to the same distance at different velocities were simulated manipulating interaural time difference. Stimulus design minimized the impact of additional cues on the discrimination of the velocity per se. Difference threshold for gradual motion velocity measured using the standard 2AFC procedure combined with adaptive staircase method exceeded relative velocity increase of 50 %. Such a high threshold value could result from distance and duration cues being out of listeners' perception. Significant mismatch negativity (MMN) was elicited by the relative velocity increase of 38 %. The result suggested that MMN was more sensitive to velocity difference than the psychophysical measuring and less dependent on the additional cues. Abrupt displacement of the sound elicited stronger MMNs than gradual motion. Discrimination of abrupt and gradual motion estimated using 2AFC procedure hardly reached the 75 % threshold level. At the individual level MMN amplitudes did not correlate with any of the psychophysical measures obtained.

MEG/EEG evidence for prediction in the primary auditory cortex

64
P1

Burkhard Maess[1], Erich Schröger[2], & Alessandro Tavano[3]

[1]*MEG & Cortical Networks, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany*
[2]*Institute of Psychology, University of Leipzig, Germany*
[3]*Neuroscience, Max Planck Institute for Emprial Aesthetics, Frankfurt, Germany*
maess@cbs.mpg.de

Active theories of perception posit that the brain exploits sensory inferences based on stimulus expectancies to best model the current state of affairs in the world. Brain responses to omitted, but highly expected stimuli, have been shown to resemble to a degree the response to the actual stimuli, suggesting activation of deputy sensory cortices. We used human EEG (study 1: 17 participants) and MEG (study 2: 20 participants) to test the extent of response "resemblance", by directly comparing predictable vs. unpredictable deviant pure tones with their (rare) omissions. We observed nearly identical evoked responses to highly predictable stimuli and their omissions in the sensor space for EEG, and in the source space for MEG, locating the sources within the primary auditory cortices. Both responses were equally sensitive to an increase of the stimulus contrast: increase in magnitude of deviancy lead to an increase in evoked magnitude. Responses to unpredictable stimuli and their omissions differed significantly. We take this as evidence for a virtually perfect auditory prediction repre-

sentation by our auditory cortices, overriding the concept of "stimulus template", traditionally understood as an abstract or subsampled sensory representation.

65 P2 The interplay of the magno- and parvocellular visual pathways in visual MMN

Szonya Durant[1], István Sulykos[2], & István Czigler[2]

[1]*Royal Holloway, University of London, Egham, United Kingdom*
[2]*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary*
szonya.durant@rhul.ac.uk

Two main components of the visual system, the magnocellular (M) and parvocellular (P) pathways, have different characteristics such as spatial frequency selectivity, contrast and colour sensitivity and processing speed (fast M and slower P activity). A dissociation of responses has been shown according to whether M and P biased stimuli are presented, using reaction times and fMRI. According to some theories (see e.g. Bar et al., 2006, Kveraga et al., 2007), the M system has a role in forming the gist of visual scenes. This process is fast and automatic, resulting in top-down control of fine-grade pattern analysis. VMMN is an early ERP component that may reflect pattern detection in the scene, which may provide ERP based correlates of this difference in contribution of the two streams. Additionally it should be able to reflect the latency differential that the slow integration time of fMRI can not. We investigated the relative contributions of the two systems to vMMN by presenting M and P biased standards and deviants in an unattended typical oddball stimulus. Low contrast, low spatial frequency Gabor patches were used to target the M system and high contrast, high spatial frequency the P. We found that P biased deviants paired with M biased standards result in a larger mismatch negativity with a different latency profile than in the reverse situation. We explain our results by investigating to what extent there is adaptation across the two types of stimuli and to what extent predictive processes are at play.

66 P3 Shifting pitch: time course of extracting regularities from unfamiliar complex sound patterns

Maria Bader, Erich Schröger, & Sabine Grimm

Institute of Psychology, University of Leipzig, Germany
maria.bader@uni-leipzig.de

We are able to implicitly learn abstract auditory regularities, e.g. regularities based on the relations between sound features, such as a melody played in different keys. The aim of the current study was to uncover the impact of such a "relative pitch code" on pattern regularity extraction in a roving paradigm. Presented sound patterns consisted each of six consecutive 50 ms segments of randomly chosen pitch. In order to compare the build-up of regularity representations, we introduced an absolute repetition condition, in which patterns were identically repeated (1–12 times), and a transposed condition, in which only the pitch relations of patterns were repeated, whereas the entire patterns were shifted up or down in pitch. During an EEG session, participants paid attention to the loudness of the stimuli, but not to the roving rule. A following active behavioral detection task ensured the behavioral detecta-

bility of pattern changes. Results indicate that pattern learning occurs rapidly as deviance-related components were present after only 2–3 pattern presentations. Markers of regularity encoding (repetition positivity) point to early differences in pattern regularity extraction, i.e. stronger matching in the absolute repetition condition. Nevertheless, at the stage of MMN, pattern change detection was comparable in strength and time course for both conditions. The P3a, however, differed markedly in latency and amplitude between conditions mirroring massive impairments in the active pattern change detection task in the transposed condition. Consequently, the impact of relative vs. absolute pitch regularities differs as a function of the processing stage.

The effects of frequency difference and ear-of-entry on auditory stream segregation and integration

67 P1

Katja Junttila[1], Rika Takegata, Sari Ylinen[1], & Risto Näätänen[1]

[1]*Institute of Behavioural Sciences, University of Helsinki, Finland*
katja.junttila@helsinki.fi

The auditory system constantly organises the sounds of auditory environment, integrating some sounds to the same auditory stream and segregating others to separate auditory streams. We investigated the effects of frequency difference and ear-of-entry on auditory stream integration and segregation. We recorded event-related potentials (ERP) while presenting the participants with tone pairs consisting of low and middle tone or middle and high tone in a repetitive sequence. To investigate the effect of frequency, the low, middle, and high tones were separated by 2, 7, or 16 semitones in three separate conditions. To investigate the effect of ear-of-entry, we compared the binaurally presented 7 semitone condition with ear-of-entry difference condition and mixed ear-of-entry condition. In ear-of-entry difference condition the low tones were presented to the right ear, the middle tones to both ears, and the high tones to the left ear. In mixed ear-of-entry condition the low, middle, and high tones were presented randomly to the right, to the left, or to both ears. Two types of deviant stimuli were used: omitting the second tone of a pair could serve as a deviant when the streams were integrated and frequency change in the middle tone could serve as a deviant when the streams were segregated. The results showed that large frequency difference promotes stream segregation whereas smaller frequency differences lead to stream integration. The organisation of streams was alternating between integration and segregation in ear-of-entry difference condition. The streams were segregated when the ear-of-entry was mixed.

Sensitivity to the statistics of rapid, stochastic tone sequences

68 P2

Sijia Zhao[1], Marcus Pearce[2], Frederic Dick[3], & Maria Chait[1]

[1]*UCL Ear Institute, University College London, United Kingdom*
[2]*School of Electronic Engineering and Computer Science, Queen Mary University of London, United Kingdom*
[3]*Birkbeck-UCL Centre for NeuroImaging, Birkbeck College, University of London, United Kingdom*
sijia.zhao.10@ucl.ac.uk

Accumulating MMN work suggests that the human brain is remarkably sensitive to patterns in sound. However, much of this research has focused on deterministic patterns. This study

investigated what statistics of random sequences are acquired by listeners, the time-scales associated with these processes and the underlying brain mechanisms. The paradigm measured listeners' ability to detect transitions (changes in statistics) within stochastic, 50 ms tone-pip sequences. The sequences were too rapid for conscious scanning thus tapping automatic statistical learning processes. Response measures were hit-rates and response-time (how much information, in terms of number of tone-pips, was accumulated by listeners before making a response) and were compared with an ideal-observer model. Tone frequencies were drawn with replacement from a fixed pool of 20 values between 200–2000 Hz. The basic signal was a random sequence of these values (alphabet size = 20; RAND20). In experiment 1 we measured sensitivity to reduction in alphabet size (RAND20 to RAND2, RAND5 or RAND10), demonstrating that performance declines monotonically within this range. In experiment 2 we focused on transitions from RAND20 to RAND10 while varying the statistics of the RAND10 sequence so tones are drawn from the 10 highest frequencies (RAND10_H), 10 lowest values (RAND10_L), 10 middle values (RAND10_M), 10 edge values (5 highest & 5 lowest; RAND10_E), or sampled equally from the entire range (RAND10_A). Performance revealed tuned sensitivity to the mean, variance, and step-size between elements of random sequences. MEG/EEG data, reflecting brain response dynamics evoked by these sequences will be reported.

69 P3

The role of adaptation in the mechanisms underlying visual mismatch negativity

Flóra Bodnár, Domonkos File, István Sulykos, Krisztina Kecskés-Kovács, & István Czigler

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
bodnar.flora@ttk.mta.hu

The vMMN, a negative ERP component in the 120–300 ms latency range, considered as an "error signal" is elicited by deviant stimuli that violate sequential regularity. The processes underlying vMMN are ambiguous, because stimulus-specific adaptation adds up with the "genuine" mismatch. We investigated the contribution of adaptation to the vMMN. Irrelevant windmill stimuli were presented sequentially with different numbers of vanes (6 and 12), while the participants were playing a video game. Two main conditions were applied, an oddball condition, and an adaptation condition with long adaptor stimuli, followed by different test stimuli. As control conditions, homogenous sequences were presented; in these sequences the test stimuli were identical to the adaptor. In the adaptation sequences average duration of the adaptors matched with the average of the summed duration of the standards between two deviants. We compared ERPs to physically identical test stimuli from the heterogeneous and homogenous sequences, and the ERPs to the deviant and standard of the oddball sequences. Deviant minus standard difference potentials of the oddball emerged in two latency ranges; earlier (100–180 ms) and later (200–220 ms) posterior negativities. In the adaptation condition, only the early difference was present (100–180 ms). In the early range, the amplitudes of the adaptation-related and the oddball-related difference waves didn't differ from each other. Based on our results, we propose that the earlier difference can be considered as stimulus-specific adaptation effect, whereas the later difference reflects "genuine" mismatch, related to the violation of sequential regularities.

Prediction error is reduced for angry vocalizations: insights from ERP and neural oscillations

70
P1

Ana Pinheiro[1], João Pedrosa[2], Margarida Vasconcelos, Carla Barros[2], & Sonja A. Kotz[3]

[1]*School of Psychology, University of Minho, Braga, Portugal*
[2]*Braga, Portugal*
[3]*Department of Neuropsychology, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany*
ana.pinheiro@psi.uminho.pt

The capacity to predict what should happen next is a central aspect in perception. In the context of social communication, the effective prediction of auditory inputs that may include emotional information conveyed through the speaker's voice is critical. However, it is still unclear how the perceived salience of vocal stimuli affects sensory prediction and the detection of sensory deviance representing a prediction error. This question was probed using a combined event-related potential (ERP) and time-frequency approach. Short neutral, angry and happy vocalizations were presented both as standard and deviant stimuli to 20 healthy college students in a passive listening oddball paradigm. Participants were instructed to watch a silent movie and to ignore the sounds. The mismatch negativity (MMN) was analyzed. Furthermore, wavelet analysis of single trial data was performed to estimate phase synchrony (phase-locking factor; PLF) of the early auditory-evoked gamma-band response to each type of vocalization. MMN amplitude was reduced and PLF was increased for angry compared to neutral and happy vocalizations. These findings confirm that the brain is tuned to detect vocal changes and that deviance detection is modulated by stimulus salience. A reduced prediction error response to angry vocalizations may diminish the need to adjust an internal model and represent an economy of processing resources in the absence of any negative consequences following stimuli with aversive content.

Emotional face discrimination as revealed by electrophysiological periodic visual responses: an alternative to the vMMN approach

71
P2

Milena Dzhelyova & Bruno Rossion

Institute of Research in Psychology, Univeristy of Louvain, Louvain la Neuve, Belgium
milena.dzhelyova@uclouvain.be

Being able to read social information is vital for an individual. A wealth of social cues is provided by the face, particularly emotional expressions. To address the question of how the brain discriminates emotional faces, we recorded electroencephalogram from 18 participants during a fast periodic oddball paradigm (Liu-Shuang et al., 2014), which provides an objective, implicit and robust quantifiable measure of visual discrimination. The same face with a neutral expression was presented at a rate of 5.88 Hz during an 80 s sequence. Every five faces, the same face but displaying an emotional expression of fear, disgust or happiness (in different sequences), was presented, resulting in a sequence NNNNFNNNNFNNNNF (e.g., neutral-fear oddball sequence). The oddball 1.18 Hz (5.88 Hz/5) response and its harmonics (e.g., 2f = 2.36 Hz) were used to measure emotional face discrimination. This emotional face discrimination response was observed bilaterally at occipito-temporal sites. Furthermore, inverting the faces significantly reduced the brain response over the occipito-temporal regions for

the oddball frequency, suggesting that it reflected high level processes related to the emotional faces. A time domain analysis revealed several subsequent components discriminating neutral from emotional faces rather than a single MMN: a positivity, peaking at 120 ms; a negativity, peaking at 170 ms and another positivity, peaking at 250 ms after stimulus onset. These observations highlight the power of the fast periodic oddball paradigm to understand high-level visual discrimination responses such as facial expression or other social cues of faces.

72 P3 Fast periodic oddball stimulation in electroencephalography: an objective and sensitive alternative approach to the (v)MMN

Bruno Rossion & Joan Liu-Shuang

Face Categorization Lab, University of Louvain, Louvain la Neuve, Belgium
bruno.rossion@uclouvain.be

The MMN is a response elicited by a stimulus that does not match the regularity of the environment. In the visual modality at least, this "change detection" component is highly variable across studies and individual participants, and is thus difficult to define objectively and quantify. We present an alternative approach to record neural responses to visual stimulation changes: fast periodic oddball stimulation (FPVS). This approach relies on the periodicity of visual stimulation and the elicited periodic response in the EEG. A stimulation sequence of base stimuli (e.g. picture of face A) is shown at a rapid rate of F Hz and oddball stimuli (e.g. faces B, C…) are introduced every nth base stimuli (F/n Hz, n>2). With complex images, discrimination between base and oddball stimuli is indexed by a periodic EEG response at the F/n Hz oddball frequency and harmonics. FPVS allows the measurement of both fine-grained within-category (e.g. face A vs. face B; Liu-Shuang et al., 2014) and coarse between-category (e.g. objects vs. faces, Rossion et al., 2015) differentiation, without trials subtraction. Moreover, periodic responses occur at experimentally-defined frequencies, they are immune from background EEG noise and quantified directly. Thus, reliable data can be acquired in a few minutes of recording only and with minimal attentional/task demands, making FPVS an ideal tool to measure and quantify visual discrimination in different populations (i.e. typical adults, infants, children, patients etc.).

MMN across modalities

73 P1 Is the level of passive attention entrained by the rhythm of stimulation?

Pekcan Ungan[1] & Hakan Karsilar[2]

[1]*Biophysics, School of Medicine, Koc University, Istanbul, Turkey*
[2]*Department of Psychology, Koc University, Istanbul, Turkey*
pekungan@gmail.com

There are studies reporting larger amplitudes for mismatch negativities (MMNs) recorded with constant inter-stimulus intervals (ISIs) than those with randomized ISIs. This would indicate an advantage of rhythmicity in a stimulus sequence for the passive attention mechanism.

However, there are others reporting similar or larger amplitude MMNs recorded with randomized ISIs. To clarify this issue, we tested the hypothesis that the level of passive attention is so entrained by the rhythm of stimulation that it is maximized around the expected occurrence times of rhythmic standards. Standard 1000 Hz tone-pips were presented with 800 ms ISIs. On average, every 7th standard was randomly replaced by a deviant stimulus which differed either in pitch (1200 Hz), or timing (ISI = 500 ms), or in both. Event-related responses to standard (RS) and three deviant stimuli [pitch (RP), timing (RT), and pitch & timing (RPT), respectively] were recorded from reading subjects, and the waveforms of the MMNs to on-time and early pitch deviances were calculated as follows as grand averages: "MMN (800 ms) = RP–RS" and "MMN (500 ms) = RPT–RT". The MMN (800 ms) elicited by pitch deviances occurring at times suggested by standard ISIs and the MMN (500 ms) elicited by substantially earlier pitch deviances were found to have similar amplitudes. Taking the MMN amplitude as an index for the level of passive attention and assuming the additivity of MMNs to changes in different auditory dimensions, this finding speaks against the hypothesis that the level of passive attention is entrained by the rhythm of stimulation.

Laminar processing of sensory deviations in the somatosensory cortex

74
P2

Simon Musall[1], Melek Durmaz[2], Florent Haiss[3], Bruno Weber[4], & Wolfger von der Behrens[2]

[1]*Brain Research Institute, University of Zurich, Switzerland*
[2]*Institute of Neuroinformatics, University of Zurich & ETH Zurich, Switzerland*
[3]*Institute of Neuropathology, RWTH Aachen, Germany*
[4]*Institute of Pharmacology and Toxicology, University of Zurich, Switzerland*
wolfger@ini.uzh.ch

Stimulus-specific adaptation (SSA) has been proposed as a potential mechanism to separate behaviorally relevant features from a stream of continuous sensory information and as a potential contributor to the generation of mismatch negativity (MMN). However, the mechanism giving rise to SSA and its effect on sensory perception is unknown. To address these issues, we investigated the behavioral implications of SSA in a deviance detection paradigm and characterized neural responses to deviant stimuli in rat somatosensory cortex. We trained rats to detect single-whisker deviant stimuli and found that detection performance was strongly enhanced when deviants differed in multiple features (identity of deflected whisker, deflection direction or deflection velocity) from background stimulation. Likewise, changes in different stimulus features also evoked robust SSA in single neurons in somatosensory cortex. Surprisingly, SSA was weakest in the input layer IV and significantly stronger in the supra- and infragranular layers, implying that a major part of SSA is generated within the cortex. This was corroborated by a late sensory response, occurring in a subpopulation of layer IV neurons roughly 200 ms after stimulus offset and exibiting true deviant detection properties. Our study provides the first behavioral evidence for enhanced perception of rare deviant stimuli, characterized by a set of specific stimulus features. Moreover, we found that deviant responses are actively amplified within cortex, especially in the supragranular layers. These results demonstrate the functional importance of cortical SSA and strongly implicate deviance detection as a feature of intracortical stimulus processing.

75 P3 Auditory and somatosensory mismatch responses in aging and their associations with neuropsychological and physical test scores

Juho Strömmer[1], Piia Astikainen[1], Ina Tarkka[2], Tomi Waselius[1], Ville Kirjavainen[1], Saara Järveläinen[1], & Sanni Koivula[1]

[1]*Department of Psychology, University of Jyväskylä, Finland*
[2]*Department of Health Sciences, University of Jyväskylä, Finland*
juho.strommer@jyu.fi

Aging-related alterations in event-related potentials (ERPs) reflect changes in neural plasticity that, in turn, are assumed to relate to changes in cognitive processing, such as decline in processing speed and inhibitory control. However, the detrimental effects of aging on pre-attentive sensory processing may not be similar across sensory modalities. In two experiments, we recorded obligatory ERPs to sounds deviating in frequency and to electrical pulses deviating in the location in hand in analogous passive oddball tasks from 41 young (20–30 years) and 90 elderly (63–81 years) adults in order to investigate aging-related alterations in early sensory processing. In addition, the relationships between ERPs and measures of cognitive and physical capacity were studied. Aging-related amplitude decrease and latency shift of mismatch response (MMR) were found in both sensory modalities. Furthermore, an early somatosensory response (P50) was increased in amplitude in aged compared to young, possibly reflecting an aging-related decline in sensory gating. In aged, an early somatosensory MMR correlated positively with a principal components analysis-derived composite score of processing speed. The late somatosensory MMR, instead, correlated positively with cardiorespiratory fitness (walking speed and VO2max-estimate) in older adults, but no relationships to neuropsychological test scores were found. In sum, the present data revealed dissociation between somatosensory and auditory deviance detection in aging, and associations of somatosensory MMR with cognitive and physical test scores.

76 P1 Emotional mismatch negativity elicited by Japanese kanji with different connotations

Tomomi Fujimura[1] & Kazuo Okanoya[2]

[1]*National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*
[2]*The University of Tokyo, Japan*
t.fujimura@aist.go.jp

The ability to detect emotional change in the environment is essential for adaptive behavior. We investigated whether visual mismatch negativity (visual MMN) reflected emotional change in a temporal context. Twenty-five participants viewed visual sequences of Japanese kanji with different emotional connotations while event-related potentials (ERPs) were recorded. The visual sequences were constructed from positive or negative standards with two types of deviants. One was emotionally incongruent with the standard (i.e. positive deviants for negative standards and negative deviants for positive standards). The other was emotionally congruent with the standard but had a different configuration from the standard (i.e. negative deviants for negative standards and positive deviants for positive standards). Participants were asked to respond to changes in color of characters that were irrelevant to emotional change in the sequence. We found that the emotionally incongruent and congruent

deviants elicited greater occipital negativities than the standards at 100–200 ms. At a latency of 200–260 ms, the occipital negativity was significantly greater for the emotionally incongruent deviants than for the standards. In addition, at a latency of 300–360 ms, the emotionally incongruent deviants elicited significantly greater negativity than the standards. These results suggest that the visual MMNs at 200–260 ms and 300–360 ms reflect emotional change in a sequence while the visual MMN at 100–200 ms reflect the changes in the visual features of the stimuli, rather than the emotional connotations. The visual MMN can reflect emotional connotations carried by Japanese kanji.

The study of tone-frequency effect on EEG-MMN to duration change

77
P2

Yusuke Osakabe, Moeko Tanaka, Yuko Matsuki, Michinari Nozaki, Satoko Asano, Kazuko Kanno, Masayuki Hikita, Tetsuya Shiga, Norikatsu Itou, Shuntaro Itagaki, Takashi Matsuoka, & Hirooki Yabe

Department of Neuropsychiatry, Fukushima Medical University, Japan
osakabe@fmu.ac.jp

When an infrequent sound occurs among frequently repeated sounds even in the absence of attention, a negative component of event-related potential (ERP) known as mismatch negativity (MMN) is elicited. MMN may be established as a clinical measure to evaluate cognitive function in the future, but its reliability must first be confirmed. It is not known what kind of influence tone-frequency of stimuli has on duration MMN. The goal of the present study was to examine whether the tone-frequency changes duration MMNs or not. The stimuli were delivered to 9 healthy men (aged 22–32 years) via left earphone. The deviant stimuli (80 dB, 50 ms) were presented at a probability of 10 %, while the standard stimuli (80 dB, 100 ms) were presented at a probability of 90 %. We delivered 6 conditions, each comprising different tone-frequencies (500 Hz, 1,000 Hz, 1,500 Hz, 2,000 Hz, 2,500 Hz and 3,000 Hz). Stimulus onset asynchrony was 500 ms. During experiments, participants were watching self-selected silent videos. Definite MMNs were elicited in all conditions. There were no statistically significant differences in MMN between each condition. These findings may show that the tone-frequency does not affect duration MMN.

Mismatch negativity for unattended changes in room acoustics is followed by additional negative deflections

78
P3

Johannes Frey, Mike Wendt, & Thomas Jacobsen

Experimental Psychology Unit, Helmut Schmidt University/ University of the Federal Armed Forces Hamburg, Germany
Johannes.Frey@hsu-hh.de

Changes in room acoustics provide important clues about the environment of sound source-perceiver systems. Thereby, for example, indicating changes in the reflecting characteristics of surrounding objects. In the current study the detection of auditory irregularities, brought about by a change in room acoustics, was investigated. Therefore, a passive oddball protocol with participants watching a movie (silent with subtitles) was used. Acoustic stimuli with differing room acoustics were presented via headphones as standard and deviant stimuli. Stimuli were created by modelling rooms of different sizes, keeping values of basic auditory

dimensions constant, such as pitch, duration, loudness and perceived sound source location. Stimulus duration was 600 ms. In experiment 1 complex stimuli were used. The stimuli encompassed three short (120 ms) sinusoidal tones, resulting in three onsets peaks during each stimulus. Deviant stimuli elicited a mismatch negativity (MMN) and two negative deflections corresponding to the onset peaks. In experiment 2, stimuli with the same duration (600 ms) and only one sinusoidal tone were used. Again, a MMN was observed for deviant stimuli with different room acoustics. This MMN was followed by an additional negative deflection. These results extend previous work demonstrating the automatic detection of acoustic irregularity brought about by changes in room acoustics. These findings further support the hypothesis that unattended changes in room acoustics elicit a MMN, as well as subsequent negative deflections after these changes are elicited.

79 P1

"What is it?" and "Where is it going?" Two questions in the language of the brain: the additivity issue of the visual mismatch negativity

István Sulykos, Krisztina Kecskés-Kovács, & István Czigler

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
sulykos.istvan@ttk.mta.hu

We investigated the relationships of visual mismatch negativity (vMMN) generators during the processing of double deviancies in case of various elementary features. Theories of independent, modular mechanisms suppose that the vMMN signal is aggregated from multiple deviations. This is because the deviant-related response is generated by independent brain electrical activities to the single deviations. In contrast, interactive processes would result in super- or sub-additive responses. In a series of five experiments, we compared the effects of two separate deviant features with the joint effect of these two features. The stimulus dimensions were orientation (O), movement direction (MD) and spatial frequency (SP). The stimuli (patterns of Gabor-patches) were delivered in passive oddball paradigms. O-SF double deviants elicited sub-additive vMMN, irrespective of whether the stimulation were static (experiment 1) or dynamic (experiment 2). Contrarily, MD-O double deviants elicited additive vMMN (experiment 3). However, in the latter experiment, the onsets of O and MD deviancies were asynchronous (the O deviancy preceded the MD deviancy) while in experiment 1 and 2, the deviancies occurred simultaneously. Therefore, the following two experiments were designed in such a way that the MD deviancy was either concurrent with (experiment 4) or followed by (experiment 5) the SF deviancy. In both cases, the vMMN to double deviants were additive again. As the robust results of the studies show, deviant-related processing of movement direction is independent of the deviant-related processing of orientation and spatial frequency, while the latter two are mutually dependent.

The ventriloquist effect evokes changes in the early spatial processing of auditory stimuli as measured by the mismatch negativity

80
P2

Daryl Kelvasa[1], Jens Ahrens[2], & Jan-Niklas Antons[2]

[1]*Oldenburg, Germany*
[2]*Quality and Usability Lab, Technische Universität Berlin, Germany*
Daryl.Kelvasa@gmail.com

The ventriloquist effect arises when synchronous auditory and visual events occur with spatial discrepancy and the location of the visual event biases the perceived location of the auditory event. The mismatch negativity (MMN) has been shown to be effective in tracking changes in spatial location of both auditory and visual stimuli by examining peaks of standard and deviant difference waves occurring within 200 ms after stimulus presentation. We present an audio-visual MMN experiment in which we attempt to induce an auditory MMN by shifting only the location of the visual stimulus. The standard condition consisted of visual and auditory stimuli originating from 0°, -10°, and 10°. The deviant condition held the auditory stimulus in the same location while shifting the visual stimuli to -20° and 20°, 10°, and 10° respectively. Auditory stimuli were presented by a software system for spatial audio reproduction that created two-dimensional virtual acoustic scenes and employed head tracking for added robustness. In addition, auditory and visual only conditions were collected to serve as comparisons to the audio-visual difference waves. An auditory MMN was successfully induced in the peripheral audio-visual condition, supporting other findings that cross-modal processing can elicit changes in the early pre-attentive processing of stimuli.

Prediction of vision from invisible stimuli

81
P3

Urte Roeber[1], Bradley N. Jack[2], Andreas Widmann[1], Erich Schröger[1], & Robert P. O'Shea[2]

[1]*Institute of Psychology, University of Leipzig, Germany*
[2]*Southern Cross University, Coffs Harbour, Australia*
urte.roeber@uni-leipzig.de

The human brain establishes predictive models encoding regularities in sensory input. For example, if we are stopped in a car at a traffic light and the indicator light of the car in front of us is blinking regularly, we form the prediction that it will continue to exist and to blink in the same way. Accordingly, we are not distracted by each blink of the indicator light, and we are able to attend to something else, such as a pedestrian crossing the road. However, when a prediction is violated (e.g. the indicator skips a blink), the predictive model has to be updated. An essential component of predictive models for visual information processing is that predictions are made even when objects are not consciously experienced (proto-objects). We review studies showing that the mismatch negativity (MMN; a well-established brain signature of prediction and prediction error) can be elicited by prediction-violating stimuli that are invisible from binocular rivalry suppression. The MMN is essentially identical to that when the identical stimulus is visible during episodes of binocular rivalry dominance. This suggests that predictive models for visual information processing are established, tested, and updated similarly for objects (visible) and for proto-objects (invisible).

MMN across species

82 P1 Electrophysiological mismatch response recorded in awake pigeons from the avian functional equivalent of the primary auditory cortex

Ulrich Schall[1], Bernhard W. Müller, Christian Kärgel, & Onur Güntürkün

[1]*PRC Translational Neuroscience & Mental Health Research, The University of Newcastle, Callaghan, Australia*
Ulrich.Schall@newcastle.edu.au

The neural response to occasional variations in acoustic stimuli in a regular sequence of sounds generates an N-methyl-D-aspartate receptor-modulated event-related potential in primates and rodents in the primary auditory cortex known as mismatch negativity (MMN). The current study investigated MMN in pigeons (Columba livia L) through intracranial recordings from Field L of the caudomedial nidopallium, the avian functional equivalent of the mammalian primary auditory cortex. Auditory evoked field potentials were recorded from awake birds using a low-frequency (800 Hz) and high-frequency (1400 Hz) deviant auditory oddball procedure with deviant-as-standard (flip-flop design) and multiple-standard control conditions. A MMN-like field potential was recorded and blocked with systemic 5 mg/kg ketamine administration. Our results are similar to human and rodent findings of a MMN-like event-related potential in birds suggestive of similar auditory sensory memory mechanisms in birds and mammals that are homologue from a common ancestor 300 million years ago or resulted from convergent evolution.

83 P2 Passive exposure to speech sound features enhances cortical plasticity revealed by mismatch response in rats

Jari Kurkela, Arto Lipponen, Miriam Nokia, Markku Penttonen, & Piia Astikainen

Department of Psychology, University of Jyväskylä, Finland
jari.kurkela@jyu.fi

Speech sound perception is not static but rather is modified by experience, thus enabling adaption to new situations. An ability to discriminate speech sound features is not unique to humans but exist for example in rodents. Passive exposure to sinusoidal sounds can improve rat's behavioral discrimination ability. However, there is no electrophysiological evidence on impact of passive exposure to brain plasticity. Mismatch negativity (MMN) response is a feasible tool to probe auditory perceptual learning in humans and it can be elicited in rats too. Here, we passively exposed two groups of animals to speech sound features for 12 hours per day for three consecutive days. Animals were exposed either to duration changes or tonal changes in vowel /a/ presented in oddball condition. After the exposure we recorded auditory evoked potentials on the auditory cortex by electrocorticogram (ECoG). The group of animals, which was exposed to duration changes, had enhanced amplitudes of mismatch response compared to naïve rats. While mismatch response was elicited in both trained and naïve groups for the 100 ms deviant sound (standard 200 ms), only trained animals showed mismatch response for the 150 ms deviant sound. Exposure to tonal changes had no observable

effect on LFPs. The results suggest that passive exposure to duration changes in speech sounds results in plastic changes in primary auditory cortex in adult rats.

Learning-induced plasticity of mismatch negativity in rats

84 P3

Hirokazu Takahashi & Tomoyo Shiramatsu

Research Center for Advanced Science and Technology, The University of Tokyo, Japan
takahashi@i.u-tokyo.ac.jp

In this study, we investigated how MMN is affected by acoustic saliency and valence of sound in anesthetized rats. Four groups of rats were investigated: (i) naïve control; (ii) exposed group; (iii) aversive conditioned group; (iv) and appetitive conditioned group. A surface microelectrode array was used to epipially map AEP in response to oddball tone sequences with 700 ms inter-tone interval. In the exposed group, a particular tone was passively presented without any outcome. In the conditioned groups, a conditioned stimulus (CS) tone was associated with either a foot shock or food reward. In the naïve control, changes from low-frequency standard tones to high-frequency deviant tones elicited larger MMN than those from high- to low-frequency tones. This result implies that MMN is affected by a spectrum in nature, where low frequency power is usually dominating. In the exposed group, we found that MMN to an exposed tone became smaller than in the naïve control, verifying that sounds with low appearance probability enhance MMN. In addition, both in the aversive and appetitive conditioned groups, MMN to CS tone became larger than in the exposed group, suggesting that MMN represent emotional saliency. Yet, because no difference was found between the aversive and appetitive groups, MMN might not encode emotional valence. Taken together, these results suggest that MMN represents acoustic saliency determined by both infrequency of sounds and saliency of outcomes.

MMN-like and early deviance detection in two animal models of schizophrenia – maternal immune activation and NMDAR antagonism

85 P1

Patricia Michie[1], Lauren Harms[1], William Fulham[2], Markku Penttonen[3], Juanita Todd[2], Ulrich Schall[5], & Deborah Hodgson[1]

[1]*Psychology, The University of Newcastle, Callaghan, Australia*
[2]*Medicine and Public Health, The University of Newcastle, Waratah, Australia*
[3]*Department of Psychology, University of Jyväskylä, Finland*
[4]*PRC Translational Neuroscience & Mental Health Research, The University of Newcastle, Callaghan, Australia*
pat.michie@newcastle.edu.au

Reduction in MMN is a robust finding in schizophrenia thought to reflect glutamate NMDAR hypofunction. We aimed to develop models of schizophrenia-related MMN impairments in rodents exposed to either a neurodevelopmental perturbation of maternal immune activation (MIA), a known risk factor for schizophrenia, or a pharmacological challenge, by administering an NMDAR antagonist (MK-801) known to reduce MMN in healthy individuals. Pregnant rats were administered the viral mimic, PolyI:C, to induce MIA, or saline, late in gestation. In adulthood, ERPs of male offspring were recorded to two oddball sequences (high- or low-pitch deviant), and a third sequence of randomly intermixed pitches that controlled for adap-

tation. Rats were tested on each sequence during three drug-free sessions, followed by three additional sessions after progressively escalating doses of MK-801 (0.1, 0.3, 0.5 mg/kg). Three early components, P13, N18 and P30, and two later broad negative peaks, N55 and N85 were identified. Adaptation-independent deviance-detection was observed in control (saline) rats for high, but not low pitch deviants on both early and late components. MK-801 dose-dependently increased deviance detection on early components, but reduced deviance detection for N55. MIA similarly increased deviance detection on early components, but did not reduce deviance detection on N55. These findings indicate that we have established a rat model of MMN, evident in the late negative peak, N55, which exhibited sensitivity to NMDAR antagonists similar to human MMN. However, we also identified an unexpected increase in deviance detection in early ERP components in response to both MIA and an NMDAR antagonist.

86 P2 Genuine deviance detection occurs in the inferior colliculus (IC) of the anaesthetized rat

Javier Nieto, Guillermo V. Carbajal, & Manuel S. Malmierca

Auditory Neurophysiology Laboratory, Institute of Neuroscience of Castilla y León (INCyL), University of Salamanca, Spain
javier.nietodiego@gmail.com

Some neurons in the IC show a larger response to tones when presented as deviants than when presented as standards using an oddball paradigm, i.e., they show stimulus-specific adaptation (SSA). The response to the deviants could not only remain unaffected, because of its rarity due to a simple adaptation process, but also be enhanced by the fact that it breaks the regularity imposed by the standard, thus containing a component of genuine "deviance detection". This specific component has already been shown in numerous cases in human subjects using the "many standards control" (MSC) paradigm (Jacobsen and Schröger, 2001). Animal studies in primary auditory cortex, however are controversial. One study has reported deviance detection, mostly based on theoretical grounds (Taaseh et al., 2011). Others have failed to show genuine deviance detection (Fairley et al., 2010; Fishman and Steinschneider, 2012). We recorded single unit responses in the IC (45 recordings from 14 neurons) and selected one or more pairs of frequencies using the oddball paradigm and the MSC with varying frequency spacing. The preliminary results show that on average, neurons responded more strongly to the same tone when presented as deviant than in the context of the MSC, specifically for the high frequency (F2, $p = .005$, paired t-test) of the pair, but not for the low (F1). Hence, our results demonstrate the presence of genuine deviance detection at the level of the IC. Supported by the Spanish MINECO (BFU2013-43608-P) and JCYL (SA343U14)

Music

Pre-attentive discrimination of instrumental timbre in non-musicians as mirrored by the mismatch negativity

87 P3

Stefan Berti[1], Corinna Christmann[2], & Thomas Lachmann[2]

[1]*Institute for Psychology, Johannes Gutenberg University Mainz, Germany*
[2]*Center for Cognitive Science, University of Kaiserslautern, Germany*
berti@uni-mainz.de

There is growing evidence for music-specific networks within the human brain. In this context, most studies have focused on the role of pitch, while neglecting the role of timbre. One problem when applying complex sounds to the logic of the standard oddball paradigm is that it is hard to evaluate whether an observed effect of a particular 'higher order' feature (like timbre) of the stimulus is due to this feature or solely due to the complexity of the stimulus in general. In order to test how instrumental timbre is processed on the level of pre-attentive sensory processing, we applied complex instrumental sounds (i.e., saxophone or clarinet) and spectrally rotated versions of these sounds in a passive oddball paradigm. The spectrally rotated counterpart of the instrumental sound preserves the complexity as well as the spectral information of the sound but lacks timbre. Natural and rotated sounds were applied in different conditions. In each condition, clarinet and saxophone sounds served either as standards or as deviants in different blocks. Fourteen young adults without special musical training participated in the study. Both stimulus types (natural and rotated sounds) elicited a MMN with comparable amplitudes but the latency was shorter for the natural compared to the spectrally rotated sounds. These results indicate that timbre is more efficiently processed by the human brain than equally complex sounds without timbre. Moreover, our findings support the idea of music-specific networks within the human brain.

Mismatch negativity (MMN) objectively reflects timbre discrimination thresholds in normal-hearing listeners and cochlear implant users

88 P1

Luise Wagner[1] & Torsten Rahne

[1]*Otolaryngology, University Hospital Halle (Saale), Germany*
luisewagner89@gmx.de

For cochlear implant (CI) users timbre discrimination is still challenging. This study focuses on psychoacoustical and electrophysiological measures of individual discrimination of single timbre dimensions in 15 normal hearing listeners and 15 CI users. Just noticeable differences (JNDs) in temporal envelope modulation and spectral distribution of complex tones were measured in an adaptive three-alternative forced-choice procedure. For both timbre dimensions two tone pairs were computed, one above and one below the individual JND. With these tone pairs, four randomly arranged oddball paradigms were presented and the EEG was recorded. MMN was present in all normal hearing listeners and CI users when the timbre difference was above the individual JND, but not when below JND. We conclude that the timbre perception skills of NH listeners and CI users in particular can be assessed timbre dimension specifically with psychoacoustic measurements and MMN recordings. MMN occur-

rence reflects the individual JND for temporal envelope modulation and spectral distribution differences and can be used as a clinical tool to monitor auditory-verbal therapy after CI surgery.

89 P2 Effects of active vs. passive exposure to a musical style: a MMN study with the musical multifeature paradigm

Marina Kliuchko[1], Peter Vuust[2,3], Petri Toiviainen[3], Mari Tervaniemi[1], Brigitte Bogert[1], & Elvira Brattico[5]

[1]*Institute of Behavioural Sciences, University of Helsinki, Finland*
[2]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
[3]*Royal Academy of Music, Aarhus, Denmark*
[4]*Department of Music, University of Jyväskylä, Finland*
[5]*Helsinki Collegium for Advanced Studies, University of Helsinki, Finland*
ms.klyuchko@gmail.com

The perceptual and neural discriminatory accuracy for musical sound features in musicians seems to be selectively influenced by the cognitive strategies used in practicing an instrument as well as by the stylistic features of the practiced music. In the present study, we aimed to investigate the neural effects of preference for practicing or merely listening to a musical style on auditory discrimination in a large sample of subjects. We recorded MEG/EEG data of 110 subjects assigned to five groups depending on their musical expertise and musical style practiced (assessed with questionnaires): non-musicians, amateur musicians, rock/pop musicians, jazz musicians, and classical musicians. Subjects were presented with the no-standard multi-feature paradigm, which measures in a short time six different mismatch negativity (MMN) responses to sound feature changes inserted in a musical context. Results confirmed previous findings of enhanced MMN responses to musical feature changes in musicians as compared to non-musicians and amateurs. Furthermore, musicians differed from each other in neural discrimination of pitch, pitch sliding and timbre changes depending on the musical style they practiced. In turn, non-musicians and amateurs who preferred to listen to jazz music and were familiar with it showed smaller MMN to pitch sliding, which is a jazz-specific sound feature. The reversed pattern (enhanced MMN to slide) was obtained in professional jazz musicians. Our results suggest that actively practicing a musical style by regular playing an instrument is crucial for developing functional adaptation to the sound features of the preferred music, in contrast to just listening to it.

90 P3 The effects of musical training on cortical auditory evoked responses in children with hearing loss

Amineh Koravand[1], Pascale Martel-Lamothe[1], Gilles Comeau[2], & Laurel Trainor[3]

[1]*Audiology and Speech-Language Pathology Program, University of Ottawa, Canada*
[2]*School of Music, University of Ottawa, Canada*
[3]*Department of Psychology, Neuroscience & Behaviour, McMaster University, Ontario, Canada*
amineh.koravand@uottawa.ca

The main objective of present study was to explore the effect of piano lessons on the cortical auditory evoked potentials (CAEP) in children with normal and abnormal auditory function. It

has been documented that special auditory training and the quality of acoustic environments have complex impacts on the neural auditory system. On the other hand, the absence of early acoustic stimulation during optimum periods of central auditory system plasticity may prevent the normal maturation of the central auditory system. Twenty 4 to 9 year-old children with normal hearing (NH) and with hearing loss (HL; users of cochlear implant, CI, and/or hearing aids) participated in the study. CAEP were recorded in a passive oddball paradigm. Cortical auditory evoked responses, P1, N1, P2, N2, and MMN, were measured before and after six months of intensive piano training. Different patterns of results have been found; N1 and P2 deflection were absent in more children with CI compared to children with NH. Moreover, the N2 and MMN latency and/or amplitude values were different between the groups of participants. Larger N2 amplitude was found only in NH after the musical training. Findings indicated different patterns of cortical responses in children with CI and/or with hearing aid before and after musical training. Findings suggest that musical experience may have advanced the developmental trajectory only in children with NH and that 6 months of musical training may not be sufficient to compensate for the maturational delays in children with HL.

Neuronal models

Stimulus-specific adaptation in the late auditory-evoked cortical potentials exhibits long memory and sensitivity to sequential stimulus relationships

91
P1

Paul M. Briley, Diana Omigie, & Katrin Krumbholz[1]

[1]*Institute of Hearing Research, Medical Research Council, Nottingham, United Kingdom*
katrin@ihr.mrc.ac.uk

Auditory neural responses tend to be suppressed, or "adapted", by preceding stimuli, and the amount of adaptation tends greater when the current and preceding stimuli are the same than when they are different. Initially, this stimulus-specific adaptation (SSA) was thought of as a passive process of neural fatigue, to be contrasted with the active processes underlying the mismatch negativity (MMN), a scalp-recorded response to deviant, or "oddball", sounds. Subsequently, however, SSA was observed in single-neuron responses and evidence was found suggesting that single-neuron SSA shares many of the complex properties of the MMN. Here, we used special types of oddball sequences and analysis techniques to estimate the memory span, and investigate the properties, of SSA in the stimulus-driven deflections of the late auditory-evoked cortical scalp potentials in humans. Different deflections differed starkly in their adaptational properties. The earliest measured deflection, the P1, showed little evidence of SSA at all. For the latest deflection, the P2, SSA mostly depended on the short-term stimulus history and was consistent with the adaptational effects of each preceding stimulus separately, irrespective of any stimulus relationships. In contrast, for the middle deflection, the N1, SSA was mostly dependent on the longer-term stimulus history and seemed to be strongly influenced by sequential stimulus relationships. These results indicate that SSA in human auditory cortex represents a complex and multi-faceted phenomenon, which is unlikely to reflect a unitary causal mechanism.

92 P2 Neurons in the inferior colliculus of the rat respond to the unexpected omission of repeated stimuli

Manuel S. Malmierca[1], Blanca E. Niño-Aguillón[1], Javier Nieto[1], & Jonathan Fritz[2]

[1]*Auditory Neurophysiology Laboratory, Institute of Neuroscience of Castilla y León (INCyL), University of Salamanca, Spain*
[2]*University of Maryland, College Park, MD*
msm@usal.es

The omission of an auditory stimulus often elicits an omission MMN component, revealing the predictive activity of the auditory system. The goal of the present study was to investigate whether single neurons in the auditory midbrain respond to the omission of stimuli as found in human MMN. Responses of well isolated single units were recorded from the IC, using an oddball "omission" paradigm (10 % sounds pseudorandomly omitted from a regular train of pure tones or noise bursts) at various presentation rates. Importantly, the sequence of stimuli was also recorded to ensure that no sound artifact was producing these responses. In addition, several parameters including the number of consecutive omitted responses were manipulated. Finally, we also reversibly deactivated auditory cortex while recording in the IC. The results reveal the presence of some neurons in the IC cortex that showed a similar response to the sound and to (silent) omitted stimuli when presentation rates ≥ 8 Hz. Analysis suggests that 1) intrinsic neuronal properties may determine the best presentation rate of these responses, 2) the modulation of neuronal spontaneous activity by the sound may contribute to these "omission" responses, 3) that entrainment in the IC could be inherited from the auditory cortex in a top-down fashion. Our findings are in agreement with the temporal window of integration concept for the human auditory system (Yabe et al. 1997) and may explain the basic mechanisms that generate omission responses in the MMN literature. Supported by BFU2013-43608, JCYL (SA343U14), JCYL-fellowship (ERIDI2007-2013).

93 P3 Topographic distribution of stimulus-specific adaptation in the rat auditory cortex

Javier Nieto & Manuel S. Malmierca

Auditory Neurophysiology Laboratory, Institute of Neuroscience of Castilla y León (INCyL), University of Salamanca, Spain
javier.nietodiego@gmail.com

SSA is known to be a widespread property of neurons in the primary auditory cortex (AC; Ulanovsky et. al, 2003), but its anatomical distribution remains unexplored. The present study aims at characterizing the distribution of SSA in the rat AC. Multiunit activity to pure tone stimulation was collected across the whole AC of anesthetized rats under an oddball paradigm (deviant probability: 10 %, frequency contrast: 0.5 octaves, interstimulus interval: 300 ms). Stereotaxic coordinates were determined for each electrode penetration, and the limits between the putative fields were outlined for each animal using the characteristic frequency gradient as the main reference landmark. Our results show that SSA is topographically distributed throughout the AC (topological product statistic, $C = 0.32$, $p < .01$). Specifically, median CSI was lowest in the primary fields A1 (0.49) and AAF (0.56) and highest in secondary fields SRAF (0.75) and PAF (0.72) (Kruskal-Wallis test, $\boldsymbol{p} < 1e\text{-}6$). These differences

are present throughout the whole neural response, and are due to differential adaptation to the standard stimuli. Moreover, this adaptation was faster in secondary fields, where the response to the standard quickly reaches a steady state of virtually no response. In conclusion, A1 is confirmed to be the first station in the lemniscal auditory pathway where SSA is present, but neurons in the non-primary fields are much more sensitive to repetition as they completely filter out repetitive stimuli, thus enhancing the contrast between deviant and standard. Supported Spanish-MINECO(BFU2013-43608) and JCYL (SA343U14) to MSM and a JCYL-fellowship (ERIDI2007-2013) to JN.

High-resolution reconstruction of auditory mismatch generators using fused EEG/MEG and group inversion

94
P1

Françoise Lecaignard[1], Olivier Bertrand[1], Sébastien Daligault[2], Anne Caclin[1], & Jérémie Mattout[1]

[1]Brain Dynamics and Cognition, Lyon Neuroscience Research Center INSERM U1028, Bron, France
[2]MEG Department, CERMEP, Bron, France
francoise.lecaignard@inserm.fr

Deviant stimuli violating a regular auditory stream elicit the well-known mismatch negativity (MMN) whose psychophysiological underpinnings still remain debated. Recent findings in auditory deviance studies, namely earlier mismatch responses than the MMN (Escera et al, 2014) strengthen the view that deviance processing is achieved along the hierarchical auditory system. Spatially characterizing this hierarchy would benefit to the many fundamental and clinical approaches relying on mismatch responses. Therefore, localization methods combining fine spatial and temporal resolutions are required. In SPM software, source reconstruction from scalp recordings rests on Bayesian inference (Mattout et al, 2006) and has recently been enriched with two remarkable advances: group-level inference (Litvak et al, 2008) and fused EEG-MEG inversion (Henson et al, 2009). We combined those advances to locate early and late mismatch cortical generators elicited by frequency and intensity deviances. Bilateral sources in supratemporal cortex and inferior frontal gyrus were found for both features. Interestingly, a fine dissociation could be observed within the supratemporal plane: while intensity deviance activated the Heschl's gyrus (HG) for early and late responses, results using frequency deviance suggest activations starting within HG and progressively expanding anteriorly. Beside, using Bayesian model comparison, we show that fused inversion provides an increased spatial resolution compared to unimodal ones. Our findings provide empirical support for fused inversion using simultaneous EEG and MEG recordings. The fine spatial description of the auditory cortical hierarchy achieved here represents a crucial step prior to further hypothesis testing regarding the neurophysiological and computational mechanisms behind mismatch responses.

Other

95 P2 The relation between psychophysiological and behavioural measures of expectancy and prediction in a roving mismatch negativity paradigm

Stephen Provost[1] & Lachlan Foster

[1]*Health and Human Sciences, Southern Cross University, Coffs Harbour, Australia*
steve.provost@scu.edu.au

Perruchet (1985) reported that as the number of reinforced trials in an eye blink conditioning preparation increased participants' expectation that the next trial would be reinforced decreased. Simultaneously, however, conditioned eye blink responding was strengthened. These data are often cited as evidence for a discontinuity between explicit and implicit processes in learning. We wished to examine whether a similar discontinuity might exist in a MMN paradigm when the run-length of standards was sufficiently long for participants to begin to expect a deviant was likely. An auditory roving MMN procedure was employed with sequence lengths determined using a hazard function over short (2–3), medium (4–6) and long (7–24) runs. MMN measured at F4 in the 170–190 ms window was a linear function of sequence length. The amplitude of a component measured between 300 and 330 ms post stimulus onset showed evidence of a quadratic trend. RTs were also largely linearly related to run length, for both deviants and standards. However, closer examination of individual run lengths revealed some indication of an increase in RT to standards and a decrease to deviants at long run lengths (greater than 15 trials). Although this experiment failed to provide conclusive evidence for the discontinuity described by Perruchet it is possible that a change in the behavioural response occurs after a relatively large number of trials in the sequence and that the run lengths chosen here were simply not long enough for this effect to be detected. This possibility warrants further attention.

96 P3 Temporal regularity is encoded in the human auditory brainstem

Katarzyna Zarnowiec, Jordi Costa-Faidella, & Carles Escera

Department of Psychiatry and Clinical Psychobiology & Institute for Brain, Cognition and Behavior (IR3C), University of Barcelona, Spain
katarzyna.zarnowiec@ub.edu

The temporal regularity of sensory stimulation is of prime importance for our online behavior, as it helps to optimize detection and processing of incoming events. The mismatch negativity (MMN) of the human event-related potentials is elicited by violating a regular stimulus onset asynchrony (SOA) of auditory sequence. Importantly, deviance-related responses can be also found in the middle-latency response (MLR) range, circa 30–40 ms from the deviance onset. The aim of the study was to examine the effects of fine-grained violations in the rhythmic structure of auditory stimulation in the human brainstem using frequency-following responses (FFR). We presented amplitude-modulated sine waves (carrier frequency 2530 Hz, symmetrical triangle-wave modulation with frequency f0 = 390 Hz) in a multi-oddball paradigm. Standard stimuli were presented at a constant rate of 3.21 Hz (i.e. at multiples of 312 ms from the onset of experimental block), whereas 8 equiprobable deviants ($p = .16$) in order to break

the temporal pattern were presented at different phases of the presentation cycle, -π, -¾π, -½π, -¼π, ¼π, ½π, ¾π, π, i.e., with SOAs 156, 195, 234, 273, 351, 390, 429 and 468 ms, respectively. A sequence not entailing a rhythmic organization was used as a control condition. Our preliminary results showed that the FFR at the stimulus modulation frequency f0 differ significantly in its mean amplitude ($p = .008$) in oddball vs. control condition, suggesting that the human brainstem is able to encode the timing regularity of auditory landscape.

Higher-order auditory change detectors – support from behavioral and electrophysiological data

97
P1

Annekathrin Weise[1,2], Erich Schröger[2], & János Horváth[3]

[1]*Rotman Research Institute, Baycrest Centre, Toronto, Canada*
[2]*Institute of Psychology, University of Leipzig, Germany*
[3]*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary*
aweise@research.baycrest.org

Auditory changes are partly processed by dedicated change-detectors. Their activity can be indexed by the elicitation of the N1 and P2 event-related potentials (ERPs). Following this logic, distinct ERPs to first-order (i.e. constant-to-glide) frequency transitions provide evidence for first-order change detectors. However, evidence from ERP signatures for higher-order (i.e. glide-to-constant) transition detectors has remained sparse to date. This study aimed at elaborating the hypothesis that the asymmetry in ERP elicitation is not due to the complete lack of higher-order change detectors but due to their smaller number compared to first-order change detectors. To this end, electrophysiological and behavioral data were collected to the corresponding transitions in different blocks in a go/no-go paradigm. Each block utilized two types of sounds of equal probability, which did or did not contain a transition (e.g. 50 % constant-to-glide and 50 % constant-only or 50 % glide-to constant and 50 % glide-only). The rate of frequency change within the glide was varied in different blocks (i.e. 10 vs. 40 semitones per second) in order to increase the number of responding change detectors. Participants attended the sounds and were required to respond as fast as possible to the transition. The current data show distinct ERP signatures not only for first-order changes but, importantly, also for higher order changes when the frequency change rate of the glide was largest. This ERP result is accompanied by faster change detection on behavioral level. Thus, the current data support the proposed hypothesis and provide evidence for higher-order change detectors.

Regularity encoding in the human auditory brainstem is enhanced by timing predictability of the upcoming sounds

98
P2

Natàlia Gorina Careta, Katarzyna Zarnowiec, Jordi Costa-Faidella, & Carles Escera

Department of Psychiatry and Clinical Psychobiology & Institute for Brain, Cognition and Behavior (IR3C), University of Barcelona, Spain
natalia.gorina5@gmail.com

Repeated presentation of a stimulus leads to reduced neural activity to it, a phenomenon known as repetition suppression (RS). In the auditory domain, repetition suppression has

been observed in animal cortical and subcortical structures and in the human auditory cortex, and incidentally reported in the human inferior colliculus with fMRI. Moreover, timing regularity of the ongoing stimulation influences the encoding of the repetitive environment at the level of the auditory cortex. However, before auditory information reaches the cortex, it is deeply processed in the auditory brainstem, which has the ability to encode context-dependent information. This study was set out to investigate how a repetitive environment is encoded at the level of the auditory brainstem and ascertain whether the described influence of timing regularity on the auditory cortex can be also observed at earlier stages of the auditory hierarchy. Here we recorded the human auditory brainstem frequency following response (FFR) to consonant-vowel stimuli (/wa/) delivered in two timing conditions (predictable and unpredictable) among a six-talker babble background. In the predictable timing condition, stimuli were delivered with isochronous stimulus onset-to-onset intervals (366 ms) and in the unpredictable timing condition, onset-to-onset time varied randomly between 183 and 549 ms. Our results confirm that repetition suppression is observable at the level of the human auditory brainstem and demonstrate that timing predictability influences the brainstem response to repetitive sounds, eliciting a better and faster encoding of regularities.

99 P3

Emotions attenuate the MMN elicited by changes in information rate

Annett Schirmer, Nicolas Escoffier, Xiaoqin Cheng, & Trevor Penney

Department of Psychology, National University of Singapore
schirmer@nus.edu.sg

Much evidence indicates that emotions influence time perception. To better understand this influence, we explored whether and how emotions alter sensitivity to changes in the speed or rate at which sounds unfold. A surprise and a neutral vocalization were compressed to 378 ms and expanded to 600 ms to create "fast" and "slow" stimuli, respectively. There were two blocks comprising surprise stimuli only and two blocks comprising neutral stimuli only. For one block of each condition, fast sounds were deviants and slow sounds were standards, and for the other block the standard and deviant assignment was reversed. Participants were instructed to ignore the sounds and to read personal material they had brought for the study. Event-related potentials revealed an influence of speed and emotion on the mismatch negativity (MMN). The MMN was larger in the slow than the fast condition and larger for neutral than surprise vocalizations. The speed effect suggests greater priority for a sudden decrease rather than an increase in information rate. The emotion effect suggests that emotions impair the pre-attentive monitoring of how events unfold in time.

MMN distributed sources – evidence from human intracranial recordings

100 P1

Alejandro Blenkmann[1], Holly Phillips[2], Srivas Chennu[2], James Rowe[2], Carlos Muravchik[3], Silvia Kochen[1], & Tristan Bekinschtein[2]

[1]*Institute of Cellular Biology and Neuroscience, National Scientific and Technical Research Council/University of Buenos Aires, Argentina*
[2]*Department of Clinical Neurosciences, University of Cambridge, United Kingdom*
[3]*National University of La Plata, Argentina*
ablenkmann@gmail.com

In order to investigate MMN sources we recorded electrocorticography (ECoG) and/or stereo-electroencephalography (SEEG) in 14 patient candidates for epilepsy surgery, covering temporal, parietal, occipital and frontal cortices. We used three paradigms to evoke MMN potential. 1) an auditory MMN paradigm(Näätänen et al. 2004), alternating standard tones with deviant tones; performed by 13 patients. 2) four series of 5 complex tones (Bekinschtein et al, 2009), two using the same 5 sounds and two with the final sound swapped; performed by 6 patients. 3) a modification of the previous paradigm (Chennu et al 2013), where sequences were either monaural or interaural; performed by 7 patients. Channels with epileptic activity or noise were discarded, and a total of 683 channels were analyzed. Local average reference was used to improve signal from local sources compared to distant ones. MMN potentials were analyzed with paired t-test ($p < .01$ for a least 25 ms). The greatest amplitude MMN was located in the left Heschl gyrus, however no electrodes were recorded from the right Heschl gyrus for comparison. Furthermore, we found most consistent activations located in right hemisphere in the superior temporal gyrus, middle temporal gyrus, anterior central gyrus, inferior frontal gyrus, and superior parietal lobule. In the left hemisphere activations were located in superior temporal gyrus, middle temporal gyrus, anterior central gyrus, inferior frontal gyrus, middle frontal gyrus and superior frontal gyrus. These results reveal that MMN sources, evoked by different paradigms and found in different patients, are consistently distributed in a fronto-temporo-parietal network.

Speech and language (incl. deficits)

Repair or violation detection? Pre-attentive processing strategies of phonotactic illegality demonstrated on the constraint of g-deletion in German

101 P2

Johanna Steinberg[1], Thomas Konstantin Jacobsen[2], & Thomas Jacobsen[2]

[1]*Institute of Psychology, University of Leipzig, Germany*
[2]*Experimental Psychology Unit, Helmut Schmidt University/ University of the Federal Armed Forces Hamburg, Germany*
j.steinberg@uni-leipzig.de

Using the mismatch negativity (MMN) as a tool for assessing linguistic knowledge activation from long term memory, we investigated effects of language-specific categorical phonotactic

knowledge on pre-attentive speech processing. To this end, we presented illegal speech input that violated a phonotactic constraint in German called "g-deletion" while recording the EEG. Recent psycholinguistic research has reported on two different mechanisms to deal with phonotactic ill-formed speech input: early and automatic repair strategies or the detection of the violation due to a phonotactic evaluation process. In the present study, we aimed to extend previous findings of automatic processing of phonotactic violations and to investigate the role of stimulus context in triggering either an automatic phonotactic repair or a detection of the violation. The MMN was obtained in two identical cross-sectional experiments with speaker variation and 16 healthy adult participants each. Four pseudowords were used as stimuli, three of them phonotactically legal and one illegal. Stimuli were contrasted pair-wise in passive oddball conditions and presented binaurally via headphones. Phonotactically illegal stimuli were found to be processed differently compared to legal ones. Results indicate evidence for both automatic repair and detection of the phonotactic violation depending on the linguistic context the illegal stimulus was embedded in. These findings further strengthen the assumption that categorical phonotactic knowledge, as stored in long-term memory, is activated and applied even in the absence of attention and thus contribute to the general understanding of sub-lexical phonological processing.

102 P3

Temporo-spatial decomposition of MMN reveals underspecified phoneme representations

Arild Hestvik[1] & Karthik Durvasula[2]

[1]*Linguistics and Cognitive Science, University of Delaware, Newark, DE*
[2]*Linguistics, Michigan State University, East Lansing, MI*
hestvik@udel.edu

The theory of phonological underspecification (Halle, 1959; Hall, 2007) states that the phonemes that make up words in long-term memory are only coded for a subset of the articulatory features needed for pronounciation. Recent psychological support for underspecification comes from acquisition studies (Fikkert and Levelt, 2008) and ERP studies (Eulitz and Lahiri, 2004; Lahiri and Reetz, 2010). Our study tested a theoretical proposal by Iverson and Salmons (1995) that English voiceless stops are coded for a voicelessness feature in lexical representations, but that voiced stops are not coded (i.e. underspecified) for voicing specification. We tested this by utilizing the multi-standard MMN paradigm (Phillips et al., 2000), which causes a phonetic representation to be compared to a phonological representation, allowing us to test a fully specified feature matrix against a partially specified feature matrix. We present here both new data and a reanalysis of results presented at the previous MMN conference, by using difference waveforms as input to temporo-spatial PCA (Dien and Frishkoff, 2005; Dien, 2012); which captures spatial differences in topography of MMN for /d/ vs. /t/. As predicted by underspecification theory, we found a greater MMN to a phonetic oddball [d] in two multiple-standard MMN experiments (with and without attention to the stimuli). Furthermore, we predicted, and observed significant MMNs for both /d/ and /t/ in a single-standard MMN paradigm (but /d/ and /t/ MMNs were observed via ICA to have different spatial distributions). The results support a theory with underspecification at the phonological, but not phonetic level.

MMN distinguishes rule-based and arbitrary processes in language

103
P1

Jeff Hanna & Friedemann Pulvermüller

Brain Language Lab, Freie Universität Berlin, Germany
jeff.hanna@gmail.com

One of the fundamental theoretical questions in linguistics is delineating which aspects of language are whole units, and which aspects are combined according to rule-based processes, i.e. syntax. Recent work has used the MMN to shed new light on these long-standing theoretical disputes. This work exploits two patterns of results that have been established in the previous decade of linguistic MMN research: First, MMNs to deviant syllables or morphemes, which complete an existing word are stronger than MMNs to the same deviant when it forms a pseudoword instead. Second, MMNs to deviants, which render a sentence ungrammatical are stronger than MMNs to the same deviants in a grammatical context. This divergence, where errors of lexicality enhance MMNs and errors of grammaticality reduce them, allows us to explore ambiguous linguistic phenomena which could plausibly be handled by either whole-form storage system or rule-governed systems. In one case, we tested the status of derivational morphology. MMNs were elicited by derived German words "Sicherheit" (security) and "Sauberkeit" (cleanliness), as well as their incorrectly derived counterparts, *"Sicherkeit" and *"Sauberheit." We found that correctly derived words produced stronger MMNs than incorrectly derived, suggesting the former are accessed as whole-forms, and not combined in "real-time" from their constituent morphemes. In another case, we tested German separable verb-particle combinations (e.g. "bilden … ab"), where the prefix is separated from its root by some distance. MMN patterns indicated that despite this discontinuity between constituents, these verbs are still perceived as one unit.

Differences in sensory processing of German vowels and physically matched non-speech sounds as revealed by the mismatch negativity (MMN) of the human event-related brain potential (ERP)

104
P2

Corinna Christmann[1], Stefan Berti[2], Claudia Steinbrink[3], & Thomas Lachmann[4]

[1]*Center for Cognitive Science, University of Kaiserslautern, Germany*
[2]*Institute for Psychology, Johannes Gutenberg University Mainz, Germany*
[3]*Department of Psychology, University of Erfurt, Germany*
[4]*Center for Cognitive Science, University of Kaiserslautern, Germany*
christmann@cs.uni-kl.de

In most studies comparing the processing of speech versus non-speech sounds the complexity of both stimulus types has not been matched. As stimulus complexity has already been shown to have an influence on the auditory mismatch negativity (MMN), care should be taken to avoid this potentially confounding factor. In our study we compared processing of speech and non-speech by means of the MMN. For this purpose, the MMN elicited by German vowels was compared to those elicited by two non-speech stimulus types: spectrally rotated versions of the vowels, having the same stimulus complexity as the speech stimuli, and sounds based on the bands of formants of the vowels, representing non-speech stimuli of lower complexity compared to the other stimulus types, while preserving the most important frequencies of the speech sounds. This design allows controlling for effects of stimulus complexity when

comparing neural correlates of processing speech to non-speech. Deviants within a modified multi-feature design differed either in duration or spectral property (timbre) according to the German vowel system. Moreover, the difficulty to discriminate between the standard and the two deviants was controlled for each stimulus type by means of an additional active same-different discrimination task. Even though active discrimination scores were lowest in the vowel condition, vowels elicited a larger MMN compared to both non-speech stimulus types, supporting the concept of language-specific phoneme representations and the role of the participants' prior experience in auditory processing.

105 P3 Lexical MMN effects are too late: automatic lexical ERP enhancement in the oddball paradigm is already present in P1

Yury Shtyrov[1] & Maria Lenzen[2]

[1]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
[2]*RWTH Aachen, Germany*
yury.shtyrov@cfin.au.dk

Previous MMN research made a strong case for automatic and rapid access of word memory traces in the brain, seen as a specific enhancement of MMNs to meaningful words at ~150 ms. Recent evidence using non-MMN paradigms has, however, suggested an even earlier lexical access reflected in a word-specific enhancement of P1-type responses at ~60 ms (MacGregor et al, 2012). This raises the question of why previous MMN studies missed early lexical effects. Two principle possibilities exist. One (in line with the MacGregor results) is that repetitive stimulus presentation leads to habituation of P1 amplitudes, obliterating any neurolinguistic effects. The other lies with signal-processing procedures: whereas MMN analysis typically employs 20–40 Hz low-pass filter, P1 studies use a much higher range: a high-pass of > 10 and low-pass of > 70 Hz. To test this, we recorded EEG responses to a matched set of words and pseudowords in a typical lexical oddball paradigm known to elicit a robust word MMN enhancement, and subjected the data to P1-optimised analysis: bandpass filtered of 10–100 Hz and ICA artifact correction. We found that, for all response types – standards, deviants and subtraction ERPs – P1 responses, peaking at ~30 ms after stimulus recognition points, showed a significant amplitude increase for real words over acoustically matched pseudowords. The results suggest that the well-known lexical MMN enhancement is a secondary process preceded by first-pass lexical access already in the P1 range. With appropriate analysis techniques, MMN paradigms are well-suited to capturing both of these early neurolexical processes.

106 P1 Language-attention interactions in neural processing of spoken words

Jana Krutwig[1] & Yury Shtyrov[2]

[1]*Centre for Cognitive Neuroimaging, Donders Institute, Nijmegen, Netherlands*
[2]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
j.krutwig@donders.ru.nl

Previous studies indicated diverging patterns of ERP responses to meaningful and meaningless lexical materials: stronger MMN for words vs. pseudowords, and the opposite pattern (pseudowords > words) for N400 responses. Possible reasons include stimulation regime

(repetitive oddball stimulation vs. multiple unrepeated stimuli) and/or the level of attention on linguistic input (passive presentation vs. active tasks). To address this, we recorded MMNs to word and pseudoword stimuli, while participants attended to either these stimuli or to a nonlinguistic task. The results showed a MMN peaking at ~130 ms after the word recognition point, followed by a shift in the classical N400 window. In the early window, a strong effect of attention – larger MMN for attended than unattended stimuli – was localised to left-frontal sites. In right-frontal electrodes, however, we found an interaction between attention and lexicality: while word MMNs were relatively immune to attentional modulation, pseudoword responses increased with attention. In the N400 window, attention enhanced all responses. Furthermore, a contrast between pseudoword and word ERPs showed a typical N400 effect (pseudoword > word), present only in attend conditions. The results demonstrate a complex pattern of language-attention interactions in neural word comprehension processes. Early on, word responses appear more robust, while pseudoword ERPs are subject to stronger attention modulation. Later on, attention effects are more pervasive. We also show that N400 effects can be elicited in MMN designs, and are thus resilient to multiple stimulus repetition. They are, however, limited to attend conditions and therefore likely reflect top-down controlled processes in lexical access.

Early and interactive stored-form (symbol) access and combinatorial (rule) processing in constructing constructions: a MMN study

107
P2

Guglielmo Lucchese[1], Jeff Hanna[1], Anne Autenrieb[1], Natalie Miller, & Friedemann Pulvermüller[1]

[1]*Brain Language Lab, Freie Universität Berlin, Germany*
guglielmo.lucchese@fu-berlin.de

Combinatorial mechanisms and access to stored signs in the brain are indexed by the MMN that can be used for determining their time course and interaction. We probed 16 mini-constructions that were either well-formed [ich leide (= suffer), ich zeige (= show), wir schweigen (= keep silent), wir scheiden (= separate)]; ill-combined (*ich schweigen, *ich scheiden, *wir leide, *wir zeige); containing a pseudoword (ich schweide*, ich scheige*, wir leigen*, wir zeiden*); or containing a pseudoword and morphosyntactically ill-combined (*ich leigen*, *ich zeiden*, *wir schweide*, *wir scheige*). The storage and combination factors were orthogonally varied keeping the critical last syllables constant. Spoken phrases were presented in 2 blocks of a MMN multifeature paradigm with each pronoun as standard stimulus and the 8 verbs as deviants. Data from 23 subjects were analysed with repeated-measures ANOVAs. The ERPs showed a main effect of storage [$F_{(1,22)} = 4.6$, $p = .04$] 100 ms after last syllable onset, and an effect of combination varying across hemispheres [$F_{(1,22)} = 6.9$, $p = .01$] at 105 ms. Responses emerged at 270 ms for both ill-combined and pseudo-verb-containing strings. Double violations failed to elicit a response. This resulted in a significant interaction of the storage and combination factors [$F_{(1,22)} = 6.9$, $p = .01$]. Construction storage-related and combinatorial processes are indexed very early by different brain signatures resembling, respectively, the lexical and syntactic MMN. At a second stage interactive storage-related and combinatorial processing is evident, possibly reflecting the search for alternatives to incongruent stimuli, which may be aborted in the case of double violations.

108 P3 Automatic processing of morphosyntax by second language learners

Alina Leminen[1], Laura Hedlund[2], Suzanne Hut[2], Lilli Kimppa[2], Miika Leminen[2], & Yury Shtyrov[1]

[1]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
[2]*Institute of Behavioural Sciences, University of Helsinki, Finland*
alina.leminen@gmail.com

In our surroundings, we often encounter complex things, comprised of multiple subparts. A striking example of such a complexity is offered by language. Many words are complex, i.e. they have more than one meaningful element (morpheme), e.g. boys, boy+plural marker (inflection); boyish, boy+attenuator (derivation). Recent MMN findings (Leminen et al., 2013, Cortex) have shown that the brain automatically processes native language (L1) inflections by decomposing them into morphemes, while derivations are likely to form unitary representations. However, little is still known about the brain mechanisms responsible for the processing of complex words in a second language (L2). To investigate this issue, we presented L1 speakers, beginning and advanced L2 learners of Finnish with a balanced set of inflected and derived words and complex pseudowords (real stem+pseudosuffix), while recording EEG in a passive multi-feature paradigm. L1 speakers replicated the morphological MMN pattern that showed stronger responses for derived than for inflectional words, indicating the existence of full-form memory traces for derivations and decompositional parsing for inflected forms. Crucially, neither beginning nor advanced L2 learners showed such an effect, suggesting weaker memory circuits for L2 derived words and thus likely automatically decompose them into stem and suffix, similar to inflections. All groups showed a syntactic ERP pattern – a stronger response to pseudowords than to real words. We show that morphological parsing takes place already early on in L2 grammar learning, and even advanced L2 learners seem to continue using the parsing route for all types of morphological complexities.

109 P1 Rapid and automatic formation of novel memory traces for visually presented unattended words: MEG evidence

Eino Partanen, Alina Leminen, & Yury Shtyrov

Center of Functionally Integrative Neuroscience, University of Aarhus, Denmark
eino.partanen@helsinki.fi

To master a language and communicate effectively, we must acquire large vocabularies. During childhood, words are acquired rapidly, and novel words can be efficiently used already after some dozens of repetitions in active learning tasks. Word learning also occurs in adulthood, and, for spoken words, it can be traced neurophysiologically as a specific increase in oddball ERPs elicited by novel words with native-like phonology, occurring within minutes of passive repetitive exposure to them (Shtyrov et al., J Neursci 2010). It remains unknown, however, whether similar mechanisms exist in visual modality for learning new written words. To address this, we used MEG and a classical oddball paradigm to present visually, orthographically and phonologically matched known words and novel word forms ("pseudowords"), tachistoscopically displayed on the visual field periphery to subjects occupied by a central non-linguistic dual colour-detection task. We compared the differences between the temporal dynamics of MEG responses to known words and novel pseudo-words throughout the ~15 minute exposure time. We found a visual analogue of automatic rapid memory trace

formation for unattended pseudo-words: a rapid increase in early (~100 ms) perisylvian activation in response to novel deviant orthographic stimuli. Our results show, for the first time, rapid build-up of neural memory traces for new visually-presented words. The results suggest a common neural mechanism underpinning "fast mapping" of novel linguistic information, which is shared by auditory and visual modalities.

Temporal integration of speech sound probed with mismatch negativity

110 P2

Satoko Asano, Tetsuya Shiga, Yusuke Osakabe, Norikatsu Itou, Michinari Nozaki, Kazuko Kanno, Masayuki Hikita, Shuntaro Itagaki, Takashi Matsuoka, & Hirooki Yabe

Department of Neuropsychiatry, Fukushima Medical University, Japan
satoko@fmu.ac.jp

Deviant sounds occurring in a sequence of standard sounds, in the absence of attention, elicit an event-related potential known as mismatch negativity (MMN). Standard sounds are encoded in auditory sensory memory trace and processed as a single unit within 160–170 ms, where each unitary event stored is closely related to the temporal window of integration (TWI). The TWI of pure tone sound has already been reported. There are no reported correlations, however, between speech sounds and a temporal unit. It is well known that pure tone sounds are predominantly recognized in the right hemisphere, while speech sounds are recognized in the left. The goal of this study was to examine whether speech sounds were processed as a temporal unit like pure tone sounds, and if there were differences between right and left ear stimuli. Twenty-five healthy Japanese males participated. Stimuli consisted of the vowel /a/ spoken by a Japanese female, and the stimuli sequences were randomized from short standard sounds and three types of long duration deviant sounds. The stimuli were presented to both ears, separately. All bilateral stimuli induced definite MMN with similar peak latencies. The MMN peak amplitudes were gradually enhanced from the short to long duration deviant at Fz. No significant difference of peak amplitude at between T5 and T6 was observed. There were no differences in MMN between the right and left ear stimuli at Fz, T5 and T6. These findings also show that bilateral deviant speech sounds were processed equally as a temporal unit.

Dynamics of memory-trace formation for morphologically complex words in adults and children

111 P3

Miika Leminen[1], Alina Leminen[2], Juuso Ojaniemi[1], Marja Laasonen[3], Teija Kujala[1], & Yury Shtyrov[2]

[1]*Institute of Behavioural Sciences, University of Helsinki, Finland*
[2]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
[3]*Department of Phoniatrics, Helsinki University Central Hospital, Finland*
miika.leminen@helsinki.fi

Human ability to rapidly acquire new words is the basis of successful language learning and efficient communication. It has been shown that within minutes of passive listening, MMN amplitudes for monomorphemic words increase in adults, suggesting memory-trace formation for novel words. However, it is unknown what happens if the new word is built from two or more morphemes (i.e. complex words, such as, 'sing+er'). Is automatic rapid learning of

novel complex word forms possible, and, if so, are there differences between these processes in adults and children? To address this, we presented adults and typically developing 3 to 4-year-old children with derived and inflected words, along with novel complex pseudowords with real inflectional suffix. Acoustically, the suffix was identical in all stimuli. The results showed that after just 5 minutes of passive exposure, adult MMN responses to all complex stimuli declined, likely due to response habituation. This is in contrast with previous findings using monomorphemic stimuli that showed learning-related activation increase reflecting memory trace build-up. In children, however, MMNs for inflected and pseudo-complex forms were enhanced during this short exposure. This suggests automatic learning of complex forms in children's brain, which, strikingly, includes not only memory trace build-up for novel pseudowords, but also lexicalisation of existing inflectional forms. In sum, using MMN as a tool to probe memory trace formation in the brain, we here document different learning mechanisms for complex word acquisition in children and adults.

112 P1 Association of rapid automatized naming and the MMN in dyslexic children

Lilli Kimppa & Teija Kujala

Institute of Behavioural Sciences, University of Helsinki, Finland
lilli.kimppa@helsinki.fi

The association of the MMN to phonological changes in speech and performance in rapid automatized naming (RAN), a measure sensitive for dyslexia, is yet to be determined. To address this, we recorded 9 to 12-year-old dyslexic and fluent reading controls' MMNs to changes in a spoken three-syllabic pseudo-word and tested the RAN with colour, number, letter, object, number-letter, and colour-number-letter naming tasks. We recorded MMNs for vowel identity, duration, and frequency changes at the middle and final syllables of the pseudo-word while subjects were ignoring or attending to the sounds. Individual RAN scores were entered in stepwise multiple regression. In dyslexics, the significant predictors of MMN amplitudes for duration and frequency deviants in the ignore condition were the RAN times of colour, letter, number and object naming tasks. In the attend condition, only frequency and vowel identity MMNs at the final syllable were predicted by the RAN times. The longer the naming time, the smaller was the amplitude. In contrast, the association between RAN and MMN amplitudes was not as strongly present in controls; only the letter naming time positively predicted the duration deviant amplitude at the middle syllable in the attend condition. Conversely, the naming times in number, letter and number-letter tasks served as negative predictors of vowel identity MMN amplitude at the final syllable in the ignore condition. These results indicate that slowness in rapid naming is related to weaker neural discrimination of changes embedded in complex words indexed by the MMN in dyslexic children.

Brain responses to foreign-language words are diminished in dyslexic children

113
P2

Sari Ylinen[1], Katja Junttila[1], Marja Laasonen, Paul Iverson, Heikki Lyytinen, & Teija Kujala[1]

[1]*Institute of Behavioral Sciences, University of Helsinki, Finland*
sari.ylinen@helsinki.fi

Dyslexia is manifested as reading impairment, which is thought to result from compromised processing of phonological units. The impairment is not restricted to reading, however: dyslexic readers often have difficulties also in second-language (L2) learning. By comparing MMN responses to familiar and unfamiliar spoken L2 items between Finnish 9 to 11-year-old dyslexic readers and typically-reading control children, we aimed to determine whether the processing of spoken L2 words is compromised in dyslexia and whether this is due to sublexical or lexical processing. We also determined, how the activation of brain representations is linked with cognitive measures that are typically impaired in dyslexia, such as reading and rapid naming. The L2 deviant stimuli were 'she', 'shy', and pseudoword 'shoy'. Corresponding native-language equivalents used as controls were pseudoword 'sii' and words 'sai', and 'soi'. The results showed that as compared with typical readers, dyslexic readers' MMN responses were diminished for the most frequent L2 word 'she'. In contrast, no differences between the groups were found in MMNs for the other items, ruling out the possibility that dyslexic readers processing difficulty was sublexical in nature. Rather, the diminished responses for the familiar L2 word are interpreted to reflect dyslexic readers' compromised lexical representations. The MMN amplitudes for the L2 word 'she' were also found to negatively correlate with reading scores, implying that compromised activation of L2 lexical representations is closely linked with literacy skills.

Somatotopic semantic priming and prediction in the motor system

114
P3

Luigi Grisoni, Felix Dreyer, & Friedemann Pulvermüller

[1]*Brain Language Lab, Freie Universität Berlin, Germany*
grisoniluigi@zedat.fu-berlin.de

The recognition of action-related sounds and words activates motor regions and reflects the semantic grounding of these symbols in action information. Furthermore, modality-preferential motor cortex even exerts a causal influence on sound perception and language comprehension. However, proponents of classic symbolic theories dispute the motor system's role in the semantic processing of meaningful stimuli, but attribute meaning to an amodal semantic system instead. To clarify whether the motor system carries genuine semantic processes, we used multi-channel event-related potentials (ERPs) to investigate priming effects manifest at the neurophysiological level between action sounds and spoken words semantically related to face or leg actions. To direct subjects' attention away from the sounds, a distraction-oddball design was used and the mismatch negativity (MMN) to rare "deviant" mouth- and leg-related action words ("kiss" and "kick") was recorded in the context of frequent "standard" mouth- or leg related-action sounds ("whistle", "footstep") or non-action meaningful sound ("water drop"). Event-related potentials revealed that action-related words produced significantly larger stimulus-evoked and predictive brain responses when presented in body-part-incongruent context (i.e. "kiss" in footstep sound context; "kick" in whistle

context) than in body-part-congruent context, a pattern consistent with semantic priming. The main cortical generators of the semantic priming effect were localized in motor cortex and followed a somatotopic pattern. As our results show neurophysiological manifestations of semantic priming in the motor cortex, they prove genuine semantic processing in the motor system and thus semantic grounding in a modality-preferential system of the human brain.

115 P1 The generation of speech-specific MMN: solutions from dynamic causal modelling

Faith Chiu & Jyrki Tuomainen

Speech, Hearing and Phonetic Sciences, University College London, United Kingdom
faith.chiu.11@ucl.ac.uk

To further elucidate the neural basis of speech perception – specifically whether the MMN response reflects speech-specific processing – we used pure tones, speech, and spectrally rotated speech as stimuli. Rotated speech is an acoustic manipulation which preserves the acoustic complexity of the original speech signal but renders it unintelligible. The main focus of the study was on the potential difference between speech and rotated speech in the effective connectivity of auditory areas as revealed by dynamic causal modelling using the same modelling approach as Schofield et al. (2009. Speech and pure tone stimuli used in the passive listening task were obtained from Schofield et al. Rotated speech stimuli were produced by low-pass filtering the speech stimuli at 3500 Hz before performing spectral rotation. Preliminary results indicate that the DCM solution to spectrally rotated speech differs from both the speech and pure tone conditions, particularly between speech and rotated speech conditions. Especially, the strength in backward connections between left Heschl's gyrus and left superior temporal gyrus is lower in the rotated speech condition. Backward connections are top-down and connect infragranular to agranular layers (cf. Kiebel et al., 2007). We speculate that predictive coding in the rotated speech condition does not access speech categories. The results suggest that acoustic complexity is a necessary but not a sufficient condition to trigger pre-attentive speech-specific (phonetic) processing. These results are in line with studies which have previously investigated the effect of intelligibility in speech processing (Rosen et al., 2011).

116 P2 Processing of non-native prosodic information: a MMN study

Ferenc Honbolygó, Andrea Kóbor, & Valéria Csépe

Brain Imaging Centre, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
honbolygo.ferenc@ttk.mta.hu

Prosodic features of speech contribute to the process of extracting words from the continuous speech input: For example word stress can mark word boundaries. Previous findings suggest that word stress patterns may have long-term representations in a pre-lexical form that can be used by lexical acquisition processes in segmenting speech. We suppose that these representations are language specific and therefore are activated only by stress related acoustic features of a specific language. In the present study, we investigated the language

specific nature of these stress templates measuring event-related brain potential responses. In a passive oddball paradigm, Hungarian participants heard trisyllabic pseudowords, while we recorded the brain's electrical activity with a 128 channel EEG system. Pseudowords were stressed on one of the three syllables and were presented with either Hungarian or German pronunciation. Results showed that pseudowords stressed on the second or third syllables pronounced in Hungarian elicited two mismatch negativity (MMN) components, one related to the first syllable and another one related to the additional stress, while those pronounced in German elicited a single MMN, related to the additional stress. The lack of the MMN to the missing stress in the German condition might imply that stress templates were not activated by foreign words, and without these the processing of missing stress on the first syllable was absent. These findings support our hypothesis that the processing of stress relies on language specific long-term representations.

Changes in MMR amplitude reflect fast phonetic learning in adult listeners

117
P3

Kateřina Chládková[1] & Paola Escudero[2]

[1]*Amsterdam Center for Language and Communication, University of Amsterdam, Netherlands*
[2]*MARCS Institute, University of Western Sydney, Surry Hills, Australia*
k.chladkova@uva.nl

This study examined whether phonetic learning occurs automatically after a short exposure to a statistical distribution of speech sounds. We assessed the amplitude of the mismatch response (MMR) before and after 9 minutes of unattended distributional training. During training, twenty Spanish listeners were exposed to a bimodal distribution of sounds on the first-formant (F1) dimension: half of them listened to a distribution with a trough at low F1 values, and the other half with a trough at high F1 values ("low-boundary" and "high-boundary" groups, respectively). A pre-attentive oddball paradigm was presented before and after training: the standard had an F1 value representative of the Spanish /i-e/ boundary, and two deviants had values of Spanish /i/ "i-deviant", and /e/ "e-deviant" (note that in training the standard, i-deviant, and e-deviant all had the same probability of occurrence). If listeners learned from the bimodal distributions they heard in training, the trained boundary locations should affect their pre-attentive discrimination of stimuli at post-test. Specifically, for the low-boundary group, standard and e-deviant should be perceived as one category and i-deviant as the oddball, while for the high-boundary group, e-deviant should be the oddball. Difference waves were computed as post-test minus pre-test responses to physically identical stimuli, and MMR quantified as the average absolute amplitude between 100 and 200 ms after stimulus-onset. As predicted, i-deviant yielded larger MMR than e-deviant for the low-boundary group, and vice versa for the high-boundary group. This demonstrates that adults successfully learn to discriminate non-native vowel contrasts after short distributional training.

118 P1 Your Chinese is different from mine? Conventionalization of constructions as indicated by mismatch negativity

Yuchun Chang[1], Chia-Lin Lee[2], & Hans-Jörg Schmid[3]

[1]*Graduate School Language & Literature, Ludwig-Maximilians-Universität München, Germany*
[2]*Graduate Institute of Linguistics & Department of Psychology, National Taiwan University, Taipei, Taiwan*
[3]*Institute of English Philology, Ludwig-Maximilians-Universität München, Germany*
Y.Chang@lipp.lmu.de

Over the past decades, grammarians have extensively debated over whether grammar in the cognitive system is innate, i.e., intact from experience, or emergent, i.e., shaped by repeated exposure to usage events and linked to linguistic units' degrees of conventionalization in the speech community. This study compares mismatch negativity responses to constructions conventionalized in a specific speech community (the local churches) but not in the general society in Taiwan (namely community-specific constructions), with responses to constructions conventionalized both in the specific speech community and the general society in Taiwan (namely community-general constructions), among members in the specific speech community and outsiders in the general society. In doing so, two levels of constructions covering a different range of the schematicity continuum are examined: (1) two-character lexical-level constructions (community-specific 聖別 sheng4 bie2 'sanctified' vs. community-general 聖潔 sheng4 jie2 'holy') and (2) two-character constructions containing a verb and an object (community-specific 吃主 chi1 zhu3 'eat the Lord' vs. community-general 吃補 chi1 bu3 'eat nutritious food'). The results showed (1) greater MMN differences between community-specific/-general constructions for outsiders than for members at the lexical level, and vice versa at the VN phrase level; (2) greater MMNs for community-specific than for community-general constructions at the lexical level, and vice versa at the VN phrase level. While implying sensitivity of MMN to sociopragmatic factors such as conventionalization, these findings are interpreted in terms of critical influences of linguistic usage on linguistic knowledge in the mind, as well as the emergent nature of grammar.

119 P2 New behavioral paradigm that generates event related potentials associated with language and action

Johan Sebastian Orozco Henao[1], Lina Marcela Henao Grisales[1], Jonathan Gallego[1], & Yamile Bocanegra[2]

[1]*Bioingeneering, University of Antioquia, Colombia*
[2]*Neurocience, University of Antioquia, Colombia*
sebasorozcoh@gmail.com

Action and language are linked with words or verbs that refer to acts which are carried out with body parts. It has been established that such words have a somatotopic representation that is overlapping with motor areas that are activated when the movements are executed. On the other hand, Fischler works allow to demonstrate that the N400 component is linked with the semantic relationship among the main nouns in a sentence, more than with the accuracy of the same. Therefore, the research question to solve is: is it possible to elicit a N400 component with incongruences of semantic relationships in language and action? A new

behavioral paradigm was designed based on the background presented. It aimed to elicit an event related potential (ERP) associated with language and action. Images of objects and actions done with body parts were combined to design the paradigm. The effect of semantic priming was implemented to evaluate its motor content, whether it is motor congruent, non-motor congruent and incongruent. EEG signals were recorded on 12 healthy subjects while they were taking the test. It is established that for incongruent stimulus (object-object), the deflection to 400 ms is significantly different than in the other stimuli present in the paradigm. It was demonstrated that the implementation of this new paradigm elicits a N400 component. We suggest that it could be implemented in studies related to failures of the neural processing of language.

Adult listeners' processing of indexical versus linguistic differences as reflected by the mismatch negativity

120
P3

Kateřina Chládková[1], Rozmin Dadwani[2], Varghese Peter[2], & Paola Escudero[2]

[1]*Amsterdam Center for Language and Communication, University of Amsterdam, Netherlands*
[2]*MARCS Institute, University of Western Sydney, Surry Hills, Australia*
paola.escudero@uws.edu.au

A puzzling phenomenon in speech research is the ability of humans to comprehend speech sounds regardless of variation across speakers and dialects. Previous studies assume that during speech comprehension, differences between speakers and dialects are normalized using the same underlying mechanism (Pierrehumbert, 2002). However, dialect normalization appears to rely on lexical knowledge and exposure (White & Aslin, 2011). In contrast, speaker normalization seems to occur automatically and without lexical knowledge since not only human infants (Kuhl, 1983), but also birds can discriminate human speech sounds across different voices (Ohms, et al., 2010). The present study uses event-related potentials to test whether such different mechanisms exist in a pre-attentive discrimination paradigm. We tested Australian English monolinguals and bilinguals and native Dutch listeners. Using a multiple-deviant oddball paradigm we assessed their perceptual sensitivity to four types of variation in vowels: in speaker identity, sex, dialect, and vowel category. We predicted that vowel category and dialect deviants would yield larger MMN amplitude than speaker identity deviants, because the vowel category and dialect deviants involved the largest spectral difference from the standard stimulus and represented a combined acoustic and linguistic change. Interestingly, all listeners showed similar results regardless of their linguistic background: changes in dialect elicited large MMN amplitude. Rather surprisingly, however, speaker identity deviants elicited larger MMN than vowel category deviants, which is not in line with previous overt vowel classification findings. The present MMN results are explained by adults' automatic sensitivity to differences in voice quality, rather than to spectral properties of vowels.

121 P1 Stability of the MMN, P3a and LDN responses to auditory frequency change between two repeated measurements in typically developing 5- to 6-year-old children

Leena Ervast[1], Jarmo Hämäläinen[2], Kaisu Heinänen[1], Kaisa Lohvansuu[2], Swantje Zachau[1], Mari Veijola[3], Matti Lehtihalmes[4], & Paavo Leppänen[2]

[1]*Child Language Research Center, University of Oulu, Finland*
[2]*Department of Psychology, University of Jyväskylä, Finland*
[3]*Department of Otorhinolaryngology, Oulu University Hospital, Finland*
[4]*Logopedics, University of Oulu, Finland*
leena.ervast@oulu.fi

The evidence for the auditory processing skills is usually based on only one event-related potential (ERP) measurement. Only a few studies have reported the changes of the ERPs in the repeated measurements. We studied whether mismatch negativity (MMN), P3a, and late discriminative negativity (LDN) to frequency change remain stable between two measurements in twelve 5 to 6-year-old typically developing Finnish-speaking children. The stimulus pairs with two sine tones were presented in a passive oddball/MMN paradigm. The standard stimulus (80 %) was a tone pair with a 150 ms within-pair interval (WPI) and the deviant stimulus (20 %) was similar but having a frequency change in the latter tone. The time between the measurements was 6 weeks. In the first measurement, the frequency change generated a fronto-central negative response (N250/MMN) at about 370 ms and LDN-like response 640–680 ms after the deviancy. In the second measurement the N250/MMN response was quite stable compared to the first measurement although the enhancement of N250/MMN was seen at the central scalp area. Between the measurements the amplitude of the LDN-like response differed, especially at the central and mastoid scalp areas indexing the strong activation of the auditory cortex. Additionally, P3a (at about 460 ms after the deviancy) appeared in the second measurement reflecting the involuntary attention switching mechanisms. No correlation was found between N250/MMN and P3a nor LDN and P3a indexing the independent auditory mechanisms.

122 P2 On the role of different acoustic-phonetic cues in encoding voicing in Russian and German: a cross-linguistic MMN study with native and non-native stop consonants

Mariya Kharaman, Natalia Bekemeier, & Carsten Eulitz

Department of Linguistics, University of Konstanz, Germany
mariya.kharaman@uni-konstanz.de

The voicing contrast of stop consonants in Russian and German is based on different laryngeal features. German speakers differentiate between aspirated and unaspirated stops, whereas native speakers of Russian depend upon voice onset time (VOT, negative vs. positive). This may result in misperceptions. Taking an English example, the Russian pronunciation of the word “pair” would sound like “bear” to a German listener, and vice versa. The best explanation would be that listeners automatically rely on acoustic cues used in their mother tongue, categorizing non-native stops into native categories. Thus, for Russian listeners aspirated and unaspirated stops with positive VOT, which form a contrast in German, would fall within the

category of voiceless stops. For German listeners, stop consonants with negative and positive VOT (both unaspirated), forming a contrast in Russian, would be categorized as voiced stops. To test this prediction, we measured the mismatch negativity (MMN) using the roving standard design on three types of contrasts in CV-syllables for Russian and German participants. The MMN differed between the groups, not only in the traditional latency window, but also later up to 600 ms. The German group showed early and late MMNs for contrasts with aspirated stops as deviants. For the Russian group, only the late MMNs showed an influence of the native language cues. This indicates that perceptual assimilation of non-native sounds seems to be based on native language-specific acoustic cues. Moreover, the reliance on different acoustic cues by Russian and German listeners affects the temporal dynamics of MMN effects.

Audiovisual speech perception of homophones using mismatch negativity

123
P3

Arunraj Karuppannan, Vijaya Kumar Narne, M. K. Ganapathy, & Shivaprasad Beelgi

All India Institute of Speech and Hearing, Manasagangothri, Mysore, India
nahularun@gmail.com

Speech perception is a multimodal process. It combines both auditory and visual sense for integration of auditory information. Visual cues can supplement the missing auditory information. However, if the auditory sounds are identical with only a difference in visual characteristics of speech, it might either facilitate greater or lesser degrees of integration depending on the pre-attentive cognitive skills. Hence, the present study investigated the effect of visual contribution of homophones to its auditory perception using the mismatch negativity in non-native English speakers. The study included 15 individuals in the age range from 18 to 40 years. The stimuli included the recorded homophones of the words 'SEE' (/si:/) and 'SEA' (/si:/), which were continuously presented auditorily in an oddball paradigm, for eliciting auditory MMN (aMMN). On the other hand, the visual stimuli included the written words in the orthographic form for eliciting visual MMN (vMMN). The experiment was carried out in 3 conditions: auditory only mode (Ao), visual only mode (Vo) and auditory-visual mode (AV). The results indicated better elicitation of MMN in the AV condition than Vo and Ao conditions. However, aMMN was not elicited in auditory only mode, as there existed no difference in the characteristic of the word (/si:/). This indicates that the visual mode could add to the understanding ability in concordance with the auditory perception. Even with no difference in the perception of auditory stimulus, the integration of information could be taking place due to the pre-attentive cognitive skills that could be contributing to the perception of speech.

Finding the origin of directionality effects in MMNs to phonetic contrasts

124
P1

Mirjam J. I. de Jonge

Amsterdam Center for Language and Communication, University of Amsterdam, Netherlands
m.j.i.dejonge@uva.nl

Different MMN amplitudes depending on deviance direction are reported for speech sound contrasts and are argued to support abstract phonological representations (e.g. Eulitz & Lahiri, 2004). This study set out to establish whether the directionality effect in the MMN to the

vowel contrast [o]–[ø] could be replicated and whether it could be explained by spectral properties of the vowels rather than abstract phonological concepts. In this experiment, the vowels differed only in frequency of the second formant, 793 Hz for [o] versus 1417 Hz for [ø]. Two types of control stimuli were created: sinusoids matching the formant frequencies, and non-speech sounds matching the spectral envelope of the vowels but containing only harmonics within the spectral band of the critical formant. For each stimulus type (sinusoid, spectral band, vowel), two oddball blocks were created using either the high or the low F2 stimulus as a deviant (probability .09). EEG was recorded from 64 scalp locations while participants watched a silent subtitled film. MMN amplitudes at Fz were calculated in a 40 ms window centered around the grand average minimum of the difference waves in all 6 conditions. Preliminary inspection of the data of the first 10 participants suggests that high F2 vowels evoke larger MMNs than low F2 vowels, replicating the original pattern. A similar pattern appears for the spectral band stimuli, but not for the sinusoids. Testing the statistical significance of the MMN data will only be carried out once the planned sample of 24 participants is completed.

125 P2

Perceptual asymmetry effects on the MMR to Danish speech sounds

Andreas Højlund Nielsen[1], Line Gebauer[2], William B. McGregor[3], & Mikkel Wallentin[1]

[1]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
[2]*Interacting Minds Centre (IMC), Aarhus University, Denmark*
[3]*Department of Linguistics, Aarhus University, Denmark*
linahn@cas.au.dk

Perceptual asymmetries in the mismatch response (MMR) to speech sounds have received little attention in the MMR literature. Furthermore, the effects of the immediate phonetic context on the MMR to speech sounds have not been investigated. Using magnetoencephalography (MEG), we investigated native listeners' MMRs to the phonetic contrast between [t] and [d] in Danish. We used both sounds as both deviants and standards in two different phonetic contexts: one preserving the contrast's phonemic status ([CV]), and another neutralizing it ([VC]). This allowed us to examine perceptual asymmetries in the MMR to the [t]–[d] contrast, as well as effects of the immediate phonetic context on the MMR to the contrast. We found a perceptual asymmetry effect on the MMR to the [t]–[d] contrast. Hearing [t] among [d]s elicited significantly stronger MMRs than hearing [d] among [t]s, regardless of the immediate sound context. We found no effects of the immediate phonetic context on the MMR. The asymmetry effect was mirrored in a behavioral oddball-detection task with a different group of native Danish listeners who showed reduced sensitivity for hearing [d] among [t]s. We discuss these results in relation to psychoacoustic accounts involving low-level feature detectors and the theory of phonological underspecification.

The influence of acoustic phonetics on the processing of complex consonant onsets

126
P3

Eve Higby[1], Monica Wagner[2], Anne Gwinner[3], Tanja Rinker[3], & Valerie Shafer[1]

[1]*Speech-Language-Hearing Sciences, The Graduate Center, CUNY, NY*
[2]*St. John's University, Queens, NY*
[3]*Department of Linguistics/ Zukunftskolleg, University of Konstanz, Germany*
evehigby@gmail.com

The goal of this study is to explore the role of acoustic phonetic versus phonological cues in speech processing. Eight American English (AE) listeners heard word forms that differed in the onset sequence of phonemes. The stimuli were German words with complex onsets that are meaningless in English (Geschenke, Getränke). The deviant stimuli consisted of lengthening the first vowel or deleting it. Event-related potentials (ERPs) were recorded to these stimuli using an oddball paradigm designed to elicit the mismatch negativity. AE speakers were expected to show smaller MMNs to a vowel reduction compared to a vowel length increase because the former is not phonological for similar English word structures (guitar, gazelle), but the latter is phonological in English (gator, Geisha). Mismatch responses were found for the vowel increase as well as the vowel deletion. The vowel increase also showed a P3a, indicating orienting, while no P3a was seen for vowel deletions. For the vowel deletion conditions, the mismatch was larger for the Geschenke type than the Getränke type, even though behaviorally these are not perceptually distinct in English. This suggests that the acoustic-phonetic properties influence the robustness of processing as well as phonological properties. These findings will be discussed in relation to language experience in languages that allow stop-stop consonants (e.g., Russian) versus languages that have very few consonant clusters (e.g., Spanish).

Omission responses in speech are differentially modulated by speaking rate and attention

127
P1

Mathias Scharinger[1] & Alessandro Tavano[2]

[1]*Institute of Psychology, University of Leipzig, Germany*
[2]*Neuroscience, Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany*
mathias.scharinger@uni-leipzig.de

Human brains closely monitor the surrounding acoustic scene: omissions of anticipated sounds result in an automatic change detection response, the "omission mismatch negativity" (oMMN). Previous research has provided evidence for temporal constraints on the oMMN, with a maximum stimulus-onset-asynchrony (SOA) of 150 ms between actual (preceding) and anticipated (omitted) sound (cf. temporal window of integration, TWI). However, given the rather flexible temporal structure of speech afforded to less discrete sound boundaries and differences in speaking rate, this TWI may actually differ between non-speech and speech stimuli. In this EEG-study (n = 21, 64 electrodes), we compared the oMMN in response to word-final consonant omissions (La– from German Lachs 'salmon') across two levels of SOAs, 150 and 300 ms (corresponding to normal and slow speaking rate). Additionally, we contrasted a passive with an active condition. Results showed discernible oMMNs peaking between 120 and 170 post deviance onset. Mixed-effect models on mean amplitudes in this window

stemming from central midline electrodes revealed an interaction of stimulus type (standard, deviant) and SOA, with greater oMMN amplitudes for the short than for the long SOA. This interaction further depended on presentation mode (active, passive), and was only visible for the passive presentation. Thus, both speaking rate and attention affect the oMMN, albeit in a differential way: pre-attentively, an extension of the TWI seems to indeed cause a reduction in the oMMN response, similar to non-speech findings. Under attention, however, no fixed TWI appears to exist, suggesting that attentive listening is beneficial for dealing with slow speakers.

Symposia

Symposium 1: When the brain errs

Wednesday, September 9, 2015, 9:30–10:30, Hörsaalgebäude, Hörsaal 3
Chair: Iria SanMiguel & Markus Ullsperger

How do prior expectations change sensory processing?

Floris de Lange

Centre for Cognitive Neuroimaging, Donders Institute, Nijmegen, Netherlands
floris.delange@donders.ru.nl

Although there is ample behavioral evidence for the predictive nature of perception, the incorporation of prior expectations in the neural computations underlying perception is still poorly understood. In my lecture, I will review recent work on how prior expectations about the sensory world change the neural computations that give rise to perception. I will highlight recent neuroimaging data (MEG and fMRI) and methods (multivariate classification techniques) that show how stimulus expectations modify the sensory response. I will also contrast the effects of prior expectation with the modulatory effects of selective attention and adaptation.

Error signals and their weighting to guide adaptive behavior

Markus Ullsperger

Neuropsychology, Otto-von-Guericke University, Magdeburg, Germany
markus.ullsperger@ovgu.de

The presentation will give an overview of signals coded in the posterior medial frontal cortex (pMFC) which are related to monitoring performance and other action-relevant information. Evidence from EEG and fMRI for the representation of reward prediction errors, valence-free expectancy violations, and errors observed in others will be presented. It will be discussed how these pieces of information are weighted in the light of preceding outcome history thereby determining their impact on future adaptations. It will be argued that the performance monitoring network centered on the pMFC collects and weights action-relevant information from multiple different sources in a context-dependent manner and that accumulation of this information is used in the service of action optimization by guiding recruitment of cognitive control and and updating value representations which in turn influence decisions in similar future situations.

Midfrontal theta and response conflict: past and future

Mike Cohen

Department of Psychology, University of Amsterdam, Netherlands
mikexcohen@gmail.com

We and others have been studying the role of midfrontal theta-band (~6 Hz) activity in cognitive control. This field is about 10 years old, although it started gaining traction in 2009. I'll briefly review this nascent literature, outline what I think are the main discoveries and challenges, and describe what I think are the important future developments.

Symposium 2: Development of auditory and speech processing in infants and children

Wednesday, September 9, 2015, 11:00–12:00, Hörsaalgebäude, Hörsaal 3
Chair: Valerie Shafer

The role of emerging templates in infants' speech perception

Valéria Csépe, Linda Garami, Anett Ragó, & Ferenc Honbolygó

Brain Imaging Centre, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
csepe.valeria@ttk.mta.hu

Studies on contrasting rhythmic properties revealed that stress variability detection was a significant factor as formulated in the native language acquisition hypothesis. Other studies showed that cues like lexical stress signaled word boundaries before any lexical knowledge and might play a crucial role in deriving words from spoken utterances. Languages of regular word stress like Hungarian do not use lexical stress so that the only rule used should not interact with the lexicalization in progress. We conducted two experiments (passive oddball, pdev = 25 %) with 6 and 10 month-old infants. We used legal and illegal stress variants of a phonotactically correct Hungarian pseudo-word ('bebe') in the first experiment (number of participants: 48). Their meaningful counterparts, the frequent Hungarian word 'baba' (meaning baby or doll) were used in the second experiment (number of participants: 35). Event-related brain potentials elicited by legal (stress on the first syllable) and illegal (stress on the second syllable) stress both as standards and deviants were recorded in two separate conditions. Words elicited well detectable MMRs in both conditions indicating a successful detection of deviation irrespectively of stress legality. While a genuine MMR was elicited by the illegal pseudo-word contrasted to legal standard, responses to the illegal standard and deviant did not differ. Our data speaks for a different developmental trajectory of word stress detection and lexicalization showing that the emerging stress template may serve as perceptual anchor and lexicalization may contributes to more flexible word stress processing. Supported by the research grant OTKA 101087.

Infant mismatch responses to complex auditory stimuli

Eino Partanen

Center of Functionally Integrative Neuroscience, Aarhus University, Denmark
eino.partanen@helsinki.fi

While the MMN has been extensively used to assess infant auditory discrimination since the first infant MMN study in 1990 (Alho et al.), there has been considerable variation in both the MMN polarity and latency among the published studies. Although the longitudinal studies on MMN (e.g. Shafer et al., 2011; Choudhury et al., 2010) suggest that positive MMNs precede negative MMNs in the developmental timeline, a majority of the studies in newborns have reported negative MMNs. Furthermore, several studies have indicated that the infant MMN polarity seems to be associated with both maturational and attentional factors (e.g. Leppänen et al., 2004; Friederici et al., 2002), but also with stimulus parameters, such as the magnitude of change and presentation rate. In this presentation, the current literature on infant MMN responses to complex stimuli will be reviewed, with an emphasis on factors underlying the observed differences in MMN polarity and latency across the various studies. Furthermore, the presentation will discuss the possibility of dual model of change detection, with positive and negative infant MMN responses being indicative of different types of change detection mechanism in the developing brain.

Neural indices of speech perception in bilingual children

Valerie Shafer[1], Tanja Rinker[2], Markus Kiefer[3], Nancy Vidal[1], Arild Hestvik[4], Hia Datta[5], & Yan Yu[6]

[1]*Speech-Language-Hearing Sciences, The Graduate Center, CUNY, NY*
[2]*Department of Linguistics/ Zukunftskolleg, University of Konstanz, Germany*
[3]*University of Ulm, Germany*
[4]*Linguistics and Cognitive Science, Universit of Delaware, Newark, DE*
[5]*Molloy College, Rockville Centre, NY*
[6]*William Patterson University, Wayne, NJ*
val.shafer@gmail.com

In language development, a child's earliest task is to select the relevant acoustic-phonetic cues from the speech signal that will allow successful segmentation and recovery of meaning. First Language (L1) speech perception is initially effortful, but with increasing experience, the child becomes efficient and automatic. Bilingual speech perception introduces additional challenges. A child must learn the relevant acoustic-phonetic properties for two different languages, and these cues may be in conflict. The mismatch negativity (MMN) serves as a highly useful measure for exploring the development of speech perception in bilingual situations. This talk will focus on results from two sets of studies, one focusing on Spanish-English children in the United States (US) and the second focusing on Turkish-German children in Germany. The MMN was recorded from young children to an English vowel contrast and a German vowel contrast that was not phonemic in Spanish or Turkish. The results showed less robust neural speech discrimination (MMN) for preschool bilingual children than monolingual controls. By seven years of age, bilingual and monolingual children showed similar MMN amplitudes, but the MMN latency was still later than found for adults. The results will be discussed in relation to amount of language input, the relationship of the L1 and L2 phonolo-

gy and maturation of speech processing in relation to other neural measures (P1 and T-complex).

Atypically large brain response to deviant speech sounds in dyslexic children – compensatory effects on reading related skills?

Kaisa Lohvansuu[1], Jarmo Hämäläinen[1], Annika Tanskanen[1], Leena Ervast[2], Heikki Lyytinen[1], & Paavo Leppänen[1]

[1]*Department of Psychology, University of Jyväskylä, Finland*
[2]*Child Language Research Center,University of Oulu, Finland*
kaisa.lohvansuu@jyu.fi

Dyslexia is a neurobiological disorder impairing reading acquisition of around 10 % of school-aged children despite adequate cognitive level, reading instruction, and other extraneous factors. Dyslexia is characterized by a phonological deficit, but the way the impaired phonological processing mediates resulting dyslexia or reading disabilities is unclear. We used ERPs to study speech sound processing in 30 dyslexic children with familial risk for dyslexia, 51 typically reading children with familial risk for dyslexia, and 58 typically reading control children. In dyslexics with familial risk enhanced brain responses to shortening of a phonemic length in pseudo-words (/at:a/ vs. /ata/) were found as compared to other groups. The enhancement was related with better behavioral phonemic length discrimination performance, and with better reading and writing accuracy. Source analyses showed the brain responses of a sub-group of dyslexic children with largest responses to originate from a more posterior area of the right temporal cortex as compared to the responses of the others. We concluded that the best readers within the dyslexic group have probably developed alternative strategies employing compensatory mechanisms to substitute their possible earlier deficit in phonological processing. Consequently, they could perform better in phoneme length discrimination, as well as in reading and writing accuracy tasks. Nevertheless, we found no association to reading fluency, which as usually has been found, seems to need more effort and time to compensate.

Symposium 3: Clinical applications: hearing and speech disorders

Wednesday, September 9, 2015, 12:00–13:00, Hörsaalgebäude, Hörsaal 3
Chair: Teija Kujala

Atypical responses generated in MMN-paradigms as brain signatures of reading difficulties

Paavo Leppänen[1], Jarmo Hämäläinen, & Kaisa Lohvansuu

[1]*Department of Psychology, University of Jyväskylä, Finland*
paavo.ht.leppanen@jyu.fi

Deficits in phonological processing play a role in dyslexia, a disorder in learning to read. Relatively little is known, however, of early neurocognitive risk factors and their interaction with phonological deficits and later reading difficulties at school-age. Here I review and discuss brain signatures of dyslexia and its risk factors using brain event-related potentials (ERPs) generated in MMN-paradigms at infancy and childhood and their associations with later development. Jyväskylä Longitudinal Study of Dyslexia (JLD) at the University of Jyväskylä (Finland) shows that dyslexic children, diagnosed at school-age and who have familial risk background have atypical auditory/speech processing for various sound features, including non-speech and speech sounds, already at infancy. Atypical brain activation also persists in development until school-age, albeit with different response patterns. Infant brain responses also correlate to childhood language and pre-school age reading related skills, and reading and writing skills at school age up to the 8th grade. Similar findings from the large scale longitudinal Dutch Dyslexia Programme (DDP) show that infant brain responses to speech sound changes are related to familial risk for dyslexia and also predict later reading skills at school-age. Overall, such findings suggests developmental differences in the organization of the neural networks sub-serving auditory/ speech perception, with cascading effects on later reading related skills. However, the evidence also suggests that atypical basic processing skills alone are not likely a sufficient reason for dyslexia, but rather one endophenotype /risk factor. Challenges remain, therefore, for the individual identification of high risk children.

Vowel length and stress pattern discrimination in young children with cochlear implants

Anja Hahne

Saxonian Cochlear Implant Center, TU Dresden, Germany
anja.hahne@mailbox.tu-dresden.de

Cochlear implantation restores hearing in congenitally deaf children with the prospect of oral language acquisition. Only scarce knowledge exists, however, of what these children actually perceive, when receiving their first auditory input and specifically what speech relevant features they are able to extract from the new modality. We presented congenitally deaf infants and young children implanted before the age of four with an oddball paradigm of either (a) long and short vowel variants of the syllable /ba/ or (b) bisyllabic items with stress

either on the first or on the second syllable (/báaba/ vs. /babáa/). We measured the EEG in regular intervals to study their discriminative ability starting with the first activation of the implant up to six months later. We were thus able to time-track the emerging ability to differentiate two of the most basic linguistic features that help in word segmentation, namely vowel length and stress pattern. Results show that already two months after the first auditory input, but not directly after implant activation, these early implanted children differentiate between long and short syllables. Surprisingly, after only four months of hearing experience the ERPs have reached the same properties as those of the normal hearing control group. A similar development is seen for the stress pattern contrast. We thus show that simple but linguistically highly relevant features reach age-appropriate electrophysiological levels within the first months after the initial acoustic stimulation, providing good ground for further language acquisition.

Magnetoencephalographic correlates of auditory processing from tones to words: contributions to clinical language impairment

Timothy Roberts

Children's Hospital of Philadelphia, University of Pennsylvania, PA
ROBERTSTIM@email.chop.edu

Auditory processing deficits, and the consequent degradation of auditory sensory input may underlie ineffective higher order processing with subsequent impairment of language function. This is particularly significant in pediatric populations as language acquisition occurs at young age, and anomalies may not be appreciated during time-periods critical for effective interventions. Results will be presented from studies of language impairment in autism spectrum disorder across developmental age range. Using MEG, discussion will focus on the magnetic analog of the MMN, termed mismatch field (MMF). Prior literature in this area has been discordant, partly due to methodological differences, but primarily associated with the vast heterogeneity of the ASD population, and insufficient sample size to power statistical inferences. MMF results will be discussed in terms of simpler auditory evoked responses, as well as related priming paradigms (for which change detection is also reflected in electrophysiological signals). Moreover, sample sizes exceed 100 and thus begin to address the heterogeneity-related inconsistencies in the literature. Sensitivity of the MMF delays, independent of etiology, is demonstrated by inclusion of a comparison cohort with specific language impairment (SLI). Correlations with clinical language function assessed e.g. with eth CELF-4/CELF-5 measures are also presented. Extension of these methods to much younger populations (6–48 months) through dedicated MEG hardware, and less compliant populations (including minimally-verbal low functioning children) through combined behavioral/technical approaches will be discussed.

Symposium 4: MMN, music, and life span

Wednesday, September 9, 2015, 14:30–15:30, Hörsaalgebäude, Hörsaal 3
Chair: Mari Tervaniemi

The specialists' brain: the advantage of using passive oddball paradigms as a window into auditory processing and neurocognition

Stefan Elmer

Neuropsychology, Department of Psychology, University of Zurich, Switzerland
s.elmer@psychologie.uzh.ch

Professional musicians can serve as a suitable model for understanding how experiential and maturational/degenerative processes interact across lifespan by influencing perceptual and cognitive functions. However, since musical training is known to conjunctively affect bottom-up and top-down processes and both mechanisms are tightly coupled, often it results difficult to disentangle mutual reciprocal influences. In the first part of my talk I will specifically address advantages and disadvantages of using passive oddball paradigms for evaluating transfer effects from musical training to the processing of spectral and temporal speech information, a faculty that often deteriorates with age. In the second part, I will present recent data pointing to putative interrelationships between MMN responses and functional connectivity among bilateral auditory-related brain regions as well as brainstem activity.

Do formal and informal musical activities accelerate the development of neural sound discrimination?

Vesa Putkinen

Deparment of Music, University of Jyväskylä, Finland
vesa.putkinen@jyu.fi

Cross-sectional mismatch negativity (MMN) studies have revealed enhanced neural sound discrimination in musicians. However, it is unclear whether these augmentations reflect experience-induced plasticity or pre-training neural enhancement in individuals who seek out and persist in musical training. Our recent longitudinal studies indicate that school-aged children who receive formal musical training show greater increase in MMN and P3a amplitudes with age than children without musical training. Importantly, there was no evidence for pre-training group differences in response amplitudes. In a related cross-sectional study, we found ERP and behavioral evidence that suggests improved executive functions and top-down control over auditory novelty processing in musically trained children and adolescents. In a second set of studies, we explored the relation between informal musical activities and neural sound discrimination in preschool-aged children. Children who attended a musical playschool from the age of 2 to 6 years displayed more rapid development of MMN-like responses than those with shorter attendance at a musical playschool. Compared to previous cross sectional studies, our longitudinal data provides better evidence for a causal role of musical experience in shaping the development of neural sound discrimination reflected by the MMN and P3a. They do not however refute the possibility that, in addition to musical

experience, genetic factors might also contribute to differences in MMN-P3a complex between musicians and non-musicians.

Effects of age and music expertise on Western music chord processing

Paula Virtala[1], Minna Huotilainen[1,2], & Mari Tervaniemi[1]

[1]*Institute of Behavioral Sciences, University of Helsinki, Finland*
[2]*Finnish Institute of Occupational Health, Helsinki, Finland*
paula.virtala@helsinki.fi

We summarize the results of a project where processing of Western music chords was examined with an abstract mismatch negativity (MMN) paradigm. The studies included three age groups: newborn infants, school-aged children and adults. Children with and without music training and musician and non-musician adults were compared. Adults participated in an additional behavioural chord detection task. In the MMN paradigm, minor chords, second inversions of major chords, and highly dissonant chords were presented infrequently in the context of root form major chords in passive listening conditions. All chords were presented randomly from various frequency levels so that no novel frequencies appeared in the deviant chord types. The results demonstrate readiness for discriminating between Western music chord types already in newborns as evidenced by MMN-like responses to minor and highly dissonant chords. The results also show the facilitating effect of music expertise on chord processing in children and adults. In childhood, only the children with music training had MMNs in response to minor chords. In adults, there was some evidence of major/minor discrimination also without extensive music training. MMNs in response to second inversions of major chords were evident in adult musicians only. The results show that while already newborn infants have many auditory processing skills, enculturation and formal training shape the brains responses to music sounds. Consistent neural representations of complex sounds may require extensive formal training. The studies demonstrate that MMN can be studied with complex, natural paradigms and used in studies of small infants.

Symposium 5: Attention, perception, and memory in scene analysis

Wednesday, September 9, 2015, 15:30–16:30, Hörsaalgebäude, Hörsaal 3
Chair: Elyse Sussman & Christoph Herrmann

Multi-tasking: influence of irrelevant sounds on target detection

Elyse Sussman

Neuroscience, Albert Einstein College of Medicine, Bronx, NY
elyse.sussman@einstein.yu.edu

Is it possible to multi-task effectively? Dividing attention between active, relevant tasks generally comes at a 'cost' – a measurable decrease in performance. But what happens to task performance when there are irrelevant, competing sound events, such as in a noisy environ-

ment? The current study tested how task-relevant processing demands interact with task-irrelevant sound processes to affect task performance. We hypothesized that task-irrelevant sounds must be structured to monitor ongoing events in the background 'scene', and that the processing demands for task-irrelevant sounds would affect task-relevant performance. Using event-related brain potentials (ERPs) and behavioral responses to task-relevant and task-irrelevant feature-pattern deviants, we found that task performance was reduced when there were competing feature-patterns. Errors primarily occurred in response to the to-be-ignored pattern deviants, indicating that tone feature-patterns were structured in memory as separate informational streams when irrelevant to task performance. Task-irrelevant elicitation of ERP components was consistent with the error analysis. These results provide evidence for multiple task performance, involving processing of task-relevant and task-irrelevant informational streams, a type of 'multi-tasking' that decreased behavioral performance. Together, these findings demonstrate that working memory processes interact with selective attention. Our results demonstrate that irrelevant informational streams are processed at a cost to performance, which may be considered a type of 'multi-tasking' that is an ongoing, automatic processing of task-irrelevant sensory events.

Brain oscillations are causal for cognitive processes

Christoph Herrmann

Experimental Psychology, University of Oldenburg, Germany
christoph.herrmann@uni-oldenburg.de

Event-related brain responses can be viewed in two ways: 1) In the time domain they are regarded as event-related potentials (ERPs). 2) In the frequency or time-frequency domain they are regarded as event-related oscillations (EROs). It is a matter of debate whether one of the two views is superior to the other. However, it is without doubt that brain oscillations are important for multiple cognitive processes. Especially, modulating brain oscillations and observing resulting changes of cognitive functions allows the demonstration of a causal relationship. Therefore, the ERO approach offers some advantages over the ERP approach that will be highlighted here. Special emphasis will be given to studies that have applied time-frequency analysis to mismatch negativity paradigms. The deviant stimulus of such a paradigm evokes an ERO in the theta frequency band (4–8 Hz) that is stronger than for the standard stimulus. Conversely, the standard stimulus evokes a stronger response in the gamma-band (30–80 Hz) than does the deviant. This is interpreted in the context of the so-called match-and-utilization model.

Contextual influences on object recognition – evidence from SSVEPs

Ulla Martens[1] & Thomas Gruber[2]

[1]*Institute of Cognitive Science, University of Osnabrück, Germany*
[2]*Department of Psychology, University of Osnabrück, Germany*
umartens@uos.de

Contextual knowledge is stored in memory and the strength of associative links between an object and a given context should facilitate recognizing this object in this context. In other words, the context triggers expectations of the occurrence of certain objects. Objects which

possess a low probability of appearing in a certain context are fixated earlier, more often and longer and thus, attract more attention. We investigated this influence of context on object recognition by means of an SSVEP experiment, using the method's major advantage to separate brain responses elicited by simultaneously presented stimuli. In particular, we tagged concurrently presented backgrounds and objects with different presentation frequencies. As a result, background and object elicited different SSVEPs, which were separately quantified in the frequency domain. Analyzing the effects of semantic consistency, SSVEPs related to background processing showed higher amplitudes in the consistent as opposed to the inconsistent condition, whereas object-related SSVEPs showed the reversed pattern of effects. Thus, if all image parts were semantically related, attention was rather directed to the background. Semantic inconsistency instead led to higher attention towards the object. Right inferior and middle frontal neuronal sources of the inconsistency effect indicated a top-down attentional shift from the background to the object. This can be interpreted as the result of a mismatch between background-based expectations and semantic object representations. A clear lateralization of the consistency effect in the anterior temporal lobes indicates functional hemispheric asymmetries in processing background- and object-related semantic information.

Symposium 6: MMN as a translational biomarker of psychosis

Thursday, September 10, 2015, 9:30–10:30, Hörsaalgebäude, Hörsaal 3
Chair: Juanita Todd & Gregory Light

MMN as a highly sensitive measure of subtle changes in NMDAR-mediated glutamate transmission in mice

Steven Siegel

Department of Psychiatry, University of Pennsylvania, Philadelphia, PA
siegels@upenn.edu

Reductions in glutamate function are an important contributory factor in schizophrenia. However, there is a paucity of animal models characterized by developmental reductions in glutamate function. Pharmacological models using NMDA antagonists have been widely used but these typically produce only transient changes in behavior and brain function. Likewise, mice with homozygous constitutive reductions in glutamate receptor expression show stable brain and behavioral changes, but many of these phenotypes are more severe than the human disease. This presentation describes a variety of schizophrenia-related EEG measures in mice with a heterozygous alteration of the NMDA receptor NR1 subunit gene (NR1). NR1+/- mice showed a 30 % reduction in NR1 expression and were reared after weaning in either group or isolated conditions. Outcomes include the response to paired white noise stimuli, escalating inter-stimulus intervals (ISI) and deviance-related mismatch negativity (MMN). In contrast to (NR1-/-) mice and mice treated with NMDA antagonists, (NR1+/-) mice showed no change on obligatory event-related potentials (ERPs) including the murine P50 and N100

equivalents, or measures of baseline or evoked gamma power. Alternatively, (NR1+/-) mice showed a marked reduction in MMN . Data suggest that EEG response to deviant, rather than static, stimuli may be more sensitive for detecting subtle changes in glutamate function. Deficits in these heterozygous NR1 knockdown mice are consistent with data demonstrating MMN deficits among family members of schizophrenia patients and among prodromal patients. Therefore, the current study suggests that (NR1+/-) mice may be among the most sensitive models for increased vulnerability to schizophrenia.

Structural and functional brain correlates of at-risk mental state

Ulrich Schall

PRC Translational Neuroscience & Mental Health Research, The University of Newcastle, Callaghan, Australia
Ulrich.Schall@newcastle.edu.au

At-risk mental state (ARMS) is characterized by a significant drop of global function levels (GAF) when occurring together with emerging attenuated or brief limited intermittent psychotic symptoms (BLIPS) or having an immediate family history of schizophrenia, thus predicting a high risk of developing a severe mental illness. Brain imaging research to date has provided some evidence of emerging and progressive grey and white matter abnormalities in the early phase of psychosis. We investigated mismatch negativity (MMN) as well as grey and white matter changes in individuals meeting ARMS criteria in our Mind in Transition (MinT) project. Contrary to some other reports, we did not find differences of MMN amplitudes of 85 ARMS versus 61 healthy individuals or a change of MMN amplitudes in ARMS individuals when followed up after one year with only 7.1 % developing some form of psychotic illness. Lower GAF ratings scores correlated with reduced grey matter thickness in frontal, prefrontal, and occipital cortical areas whereas symptom rating scores correlated with reduced grey matter thickness in left and right superior frontal gyri, right anterior cingulate, and right medial occipito-temporal cortex (i.e. lingual gyrus). On other morphological measures, ARMS individuals with low versus high symptom expression (medial split) did not differ in total brain volume, grey or white matter volume, or pial or white matter surface areas. These findings suggest that low-grade psychotic symptoms and functional impairment are associated with reduced cortical grey matter thickness, a putative measure of brain pathology.

MMN, cortisol, inflammation, and gray matter loss in individuals at clinical high risk for psychosis

Daniel Mathalon

Department of Psychiatry, University of California San Francisco, CA
daniel.mathalon@ucsf.edu

Cortisol and neuroinflammation are known to interfere with NMDAr-dependent mechanisms of synaptic plasticity, such as long-term potentiation, but their effects on shorter-term plasticity as reflected by mismatch negativity (MMN) are not known. Deficient neuroplasticity may contribute to weakened synapses that are then over-pruned during the pathogenic cascade underlying the transition to psychosis in individuals at clinical high risk (CHR) for psychosis. This pathogenic model is examined in data from the multi-site NAPLS study. Participants were

individuals at CHR for psychosis (n = 598), including a subgroup who transitioned to psychosis (CHR-T; n = 72) and a subgroup who did not transition during a 24-month follow-up period (CHR-NT; n = 199), and healthy controls (HC; n = 242). Measures included: 1) MRI-based cortical gray matter and ventricular volumes at baseline and 12-months (or post-transition to psychosis), 2) Baseline duration- and pitch-deviant MMN, 3) Baseline inflammatory cytokine (TNF-α, IL-2, IL-6, interferon-γ) and cortisol levels. CHR-T, relative to CHR-NT and HC, showed faster rates of right prefrontal cortical thinning and third ventricle expansion ($p < .01$, FDR cluster-corrected), smaller MMN amplitudes ($p < .05$), and elevated cortisol ($p < .05$). Reduced MMN was associated with higher inflammatory cytokine ($r = .48$, $p < .01$) and cortisol ($r = .34$, $p < .01$) levels, and faster prefrontal cortical thinning ($r = -.36$, $p < .05$) and third ventricle expansion ($r = .41$, $p < .05$), in CHR-T, but not CHR-NT. Thus, MMN deficits increase risk for psychosis and are associated with increased cortisol and inflammatory cytokines and faster cortical thinning in CHR individuals who transition to psychosis.

The "Other Side" of translational biomarker development: taking MMN out of academic labs and into real-world settings to improve our understanding and treatment of psychosis

Gregory Light

Department of Psychiatry, University of California San Diego, La Jolla, CA
glight@ucsd.edu

Advances in neuroscience have transformed our understanding of impaired and spared brain functions in psychotic illnesses. Despite substantial progress, few if any laboratory tests have graduated to clinics to inform diagnoses, guide treatments, and monitor treatment response. Providers must rely on careful behavioral observation and interview techniques to make inferences about patients' inner experiences and then secondary deductions about impacted neural systems. Development of more effective treatments has also been hindered by a lack of translational quantitative biomarkers that can span the brain-behavior-treatment knowledge gap. This presentation will show that mismatch negativity (MMN) offers promise for improving our understanding and treatment of psychotic illnesses. MMN is sensitive to and/or predicts response to some pharmacologic and non-pharmacologic interventions and accounts for substantial portions of variance in clinical, cognitive, and psychosocial functioning in schizophrenia. Most recently, MMN has been validated for use in large-scale multi-site clinical studies of schizophrenia supporting the view that this measure can be "scaled up" for use in non-academic community treatment centers. These attributes suggest that MMN can contribute to future personalized biomarker-guided treatment strategies for psychosis.

Symposium 7: Fast dynamic encoding of the sound landscape

Thursday, September 10, 2015, 11:00–12:00, Hörsaalgebäude, Hörsaal 3
Chair: Carles Escera & Sabine Grimm

Evoked gamma band and microsaccadic responses indicate fast deviance detection and sound categorization

Andreas Widmann[1], Nicole Wetzel[1], Ralf Engbert[2], & Erich Schröger[1]

[1]*Institute of Psychology, University of Leipzig, Germany*
[2]*Department of Psychology, University of Potsdam, Germany*
widmann@uni-leipzig.de

A key function of predictive processing is the fast deviance detection and stimulus categorization in complex and dynamic environments in order to quickly adapt behavior. With an audio-visual symbol-to-sound matching and with an auditory oddball paradigm we aimed to benchmark how fast auditory deviance detection and sound categorization can be performed using EEG and eye-movements. In the symbol-to-sound matching paradigm participants are presented with visual patterns predicting corresponding sound patterns and asked to detect incongruent symbol-sound pairs. We found an enhanced evoked gamma-band response to congruent compared to incongruent symbol-sound pairs peaking 42 ms after sound onset presumably reflecting the successful matching of expectation and sensory input. Furthermore, we observed a sharp increase in rightward saccades at 118 ms presumably indicating the overt allocation of visual attention to the subsequent visual symbol. A congruent-incongruent categorization was, thus, established already 80–100 ms after sound onset. These findings were corroborated by microsaccade rates measured in the active and passive oddball paradigm. In the three-tone oddball paradigm a significant difference between microsaccade rates in target vs. standard and target vs. distractor trials was observed 120 ms after sound onset. In the passive oddball paradigm saccade inhibition in response to novel but not to standard sounds was observed as early as 65–80 ms. Our results demonstrate that predictive processing allows the fast detection of a violation of the expected input 40–60 ms and sound categorization as early as 80–100 ms after sound onset. This is considerably faster than assumed previously on the basis of electrophysiological data.

How the brain discovers regularities in sound sequences

Maria Chait[1] & Nicolas Barascud

[1]*UCL Ear Institute, University College London, United Kingdom*
m.chait@ucl.ac.uk

Sensitivity to patterns is fundamental to sensory processing, in particular in the auditory system, since most auditory signals only have meaning as successions over time. Accumulating evidence from the MMN literature suggests that the brain is tuned to the statistics of sensory stimulation. However, the process through which these statistical regularities are discovered – how the brain finds regularities within the ongoing input – has eluded investiga-

tion. In my presentation I will review recent brain imaging and psychophysics findings in my lab that suggest that the auditory brain is a well-tuned 'pattern seeker', continuously scanning the unfolding auditory input for regularities, even when listeners' attention is focused elsewhere. Our data demonstrate that listeners are remarkably sensitive to the emergence of complex patterns within rapidly evolving sound sequences, performing on par with an ideal observer model. Brain responses reveal online processes of evidence accumulation – dynamic changes in tonic activity precisely correlate with the expected precision or predictability of ongoing auditory input – both in terms of deterministic (first-order) structure and the entropy of random sequences. Source analysis demonstrates an interaction between primary auditory cortex, hippocampus and inferior frontal gyrus in the process of 'discovering' the regularity within the ongoing sound sequence. The results are consistent with precision based predictive coding accounts of perceptual inference and provide compelling neurophysiological evidence of the brain's capacity to encode high order temporal structure in sensory signals.

Functional dissociation between regularity encoding and deviance detection along the auditory hierarchy

Maryam Aghamolaei[1,2,3], Katarzyna Zarnowiec[1,2], Sabine Grimm[4], & Carles Escera[2]

[1]*Department of Psychiatry and Clinical Psychobiology, University of Barcelona, Spain*
[2]*Institute for Brain, Cognition and Behavior (IR3C), University of Barcelona, Spain*
[3]*Department of Audiology, Faculty of Rehabilitation Sciences, Tehran University of Medical Sciences (TUMS), Iran*
[4]*Institute of Psychology, University of Leipzig, Germany*
m.aghamollaie@gmail.com

It is well known that the human auditory brain can extract acoustic regularities and detect any deviation from those regularities in the dynamically changing acoustic environment. The mechanism under which the brain can detect deviating stimuli has been a matter of research since the discovery of the mismatch negativity (MMN) component of the event-related potential (ERP), peaking at about 100–250 ms from an acoustic change onset. However, recent studies have identified correlates of auditory deviance detection already at about 20 ms after the deviant stimulus onset, both in animal models and at the level of the Middle-Latency Responses (MLR) of auditory evoked potentials (AEPs). These findings have demonstrated that deviance detection is a basic property of the auditory system that extends from lower to higher levels of the auditory hierarchy. Yet, the functional relationship between regularity encoding and deviance detection at different levels of the auditory hierarchy has not been addressed so far. In this talk, we will present a recent study where the magnitude of deviance processing at different levels of the auditory deviance detection system was examined. MLR and MMN responses were recorded to auditory stimuli presented randomly from 5 loudspeakers at azimuthal angles of 0°, 12°, 24°, 36° and 48° during oddball and reversed-oddball conditions. Our results showed that MMN amplitude increased as a function of the separation between the standard and deviant locations, whereas MLR deviance-related enhancements did not. These data support the differential role of these two levels of the auditory hierarchy in deviance processing.

Symposium 8: Deviance-detection across modalities

Thursday, September 10, 2015, 12:00–13:00, Hörsaalgebäude, Hörsaal 3
Chair: Stefan Berti & Gábor Stefanics

The neural network underlying automatic visual change detection

Gábor Stefanics, Jakob Heinzle, & Klaas Enno Stephan

[1]*Translational Neuromodeling Unit, University of Zurich & ETH Zurich, Switzerland*
gstefanics@gmail.com

Perceiving an object as a whole requires combining its different features encoded by different neural populations/brain areas into a unified representation. We used a multi-feature visual 'roving standard' paradigm to elicit mismatch responses by rare changes either in 1) color (red, green), or 2) emotional expression (happy, fearful) of human faces, or 3) both. Importantly, this allowed us to study brain responses to physically identical stimuli violating regularity in color and emotion separately. FMRI data was acquired on a Philips 3 Tesla scanner from 34 participants. A general linear model (GLM) with parametric modulation (prediction and prediction error (PE)) was estimated for each participant. We used a novel model of Bayesian learning, the hierarchical Gaussian filter to generate fMRI regressors parametrically modulated by PEs and predictions. Finally, as second level statistic we used F-tests to find regions whose response was significantly modulated by either prediction or prediction error. We found visual and other areas where activity showed a relationship with model-based prediction and prediction error parameters. Our results suggest that automatic visual perceptual predictions are generated in several areas including feature-specific cortical sites. Prediction-related activity is generated also in several cortical areas, and some of them are upstream relative to the prediction error generating areas, consistently with the hierarchical predictive coding hypothesis. Our results indicate that PEs and predictions related to different features of complex objects are generated probably in complex hierarchical networks including several structures.

Musical training enhances automatic deviance detection within and across sensory modalities

Evangelos Paraskevopoulos[1], Anja Kuchenbuch[2], Sibylle Herholz[3], Panagiotis Bamidis[4], & Christo Pantev[5]

[1]*Klados Manousos & SIA E.E., Thessaloniki, Greece*
[2]*Leibniz Research Center for Working Environment and Human Factors, Dortmund, Germany*
[3]*German Center for Neurodegenerative Diseases, Bonn, Germany*
[4]*Laboratory of Medical Physics, Aristotle University of Thessaloniki, Greece*
[5]*Institute for Biomagnetism and Biosignalanalysis, Münster, Germany*
parasvag@gmail.com

The meaningful interpretation of the complexity of our environment is based on the human ability to integrate the input of several sensory systems. Musical training provides a valuable model for the study of cortical plasticity of multisensory integration. The present work presents a short review of three recent studies that used magnetoencephalography to investi-

gate cortical plasticity effects on multisensory integration induced by short and long term musical training. These studies identified the neural correlates of audio-visual and audio-tactile incongruency responses, which are not generated due to incongruency of the unisensory physical characteristics of the stimulation, but due to the violation of an abstract multisensory rule that binds the unisensory stimuli. The relation of these abstract multisensory incongruency responses with unisensory mismatches was investigated using an appropriate modification of the multi-featured oddball paradigm. Results of all 3 studies indicate that during the typical mismatch negativity (MMN) latency (i.e. 120–250 ms), an automatic deviance detection takes place in cortical regions related to multisensory processing that consists of different cortical activation patterns than the corresponding unisensory MMNs. Additionally, the results of all three studies indicate that musical training is related to neuroplastic changes in a network of cortical regions linked with multisensory integration and coordination of different cognitive processes in frontal, temporal and occipital areas.

Somatosensory mismatch response in young and elderly adults

Piia Astikainen[1], Saara Järveläinen[1], Sanni Koivula[1], Ina Tarkka[2], & Juho Strömmer[1]

[1]*Department of Psychology, University of Jyväskylä, Finland*
[2]*Department of Health Sciences, University of Jyväskylä, Finland*
piia.astikainen@jyu.fi

In aging, change detection and predictive coding of the environmental events is gradually declined. Accordingly, the mismatch negativity in the auditory and visual modalities is reported to be declined in healthy aging. Here I describe two studies in which somatosensory mismatch responses (sMMR) are examined in healthy young and elderly participants. We recorded event-related potentials to electrical pulses with changes in the location of the stimuli in hand, while participants were attending to a visual task. In the first study, two differential responses with positive polarity were found in young: an early sMMR centro-parietally at 180–220 ms and a late sMMR fronto-centrally at 250–290 ms mean latency. In aged, the early sMMR was absent and the late sMMR was attenuated and reduced in scalp distribution compared to young. In the second study, the early and late sMMR were depicted at 153–193 ms and at 258–358 ms mean latency range, respectively. Again, the early sMMR was attenuated in aged compared to young, but no differences between the age groups in the late sMMR were found. In aged, the early sMMR showed a positive correlation with a composite score of processing speed, derived from principal components analysis of neuropsychological test scores. The late sMMR, instead, correlated positively with cardiorespiratory fitness (walking speed and VO2max-estimate) in older adults, but no relationships to neuropsychological test scores were found. The results suggest that sMMR is a valuable measure of aging-related changes in cognitive and physical capacity.

Processing of nociceptive deviant input in the brain: is there a real pre-attentive nociceptive-related mismatch response?

Elia Valentini

Psychology, Sapienza University of Rome, Italy
eliavalentini@gmail.com

The mismatch negativity (MMN) has been advocated as a tool for assessing abnormal brain function in a large number of clinical conditions, except that for chronic pain conditions. To date, as a matter of fact, there is no evidence of MMN elicited by nociceptive stimuli. Given the current quest for objective neural markers of pain sensitivity, it is surprising that a pre-attentive electrophysiological index of brain activity associated with potentially noxious sensory events has not been investigated yet. In this talk I will illustrate experimental results showing event-related potentials (ERPs) linked to the process of deviance detection and standard formation of nociceptive stimuli as compared to other sensory stimuli. In a first study we show that the nociceptive MMN is topographically similar to the somatosensory MMN while differing in latency and possibly in functional organization of their generators. In a second study we attempted to improve the separation of ERPs elicited by different sensory stimuli in the context of a cross-modal design. By combining the topographical segmentation analysis with cluster-based statistical testing we were able to identify the neural activity associated with deviance detection and standard formation in the auditory, non-nociceptive somatosensory, and nociceptive modalities. Findings from both studies converge in showing that the manipulation of attention in a MMN paradigm is crucial to discriminate the effect of automatic change detection mechanisms from the modulatory effect of attention, particularly for nociceptive processing. I will discuss methodological and theoretical aspect that currently prevent the robust identification of a purported nociceptive MMN.

Symposium 9: Past, present and future of the MMN

Thursday, September 10, 2015, 16:30–18:00, Hörsaalgebäude, Hörsaal 3
Chair: István Winkler

Past, present, and future of the MMN

Risto Näätänen[1,2,3], Carles Escera[4], Erich Schröger[5], Juanita Todd[6], & István Winkler[7]

[1]*Institute of Behavioural Sciences, University of Helsinki, Finland*
[2]*Institute of Psychology, University of Tartu, Estonia*
[3]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
[4]*Institute for Brain, Cognition and Behavior (IR3C), University of Barcelona, Spain*
[5]*Institute of Psychology, University of Leipzig, Germany*
[6]*Psychology, The University of Newcastle, Callaghan, Australia*
[7]*Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary*
winkler.istvan@ttk.mta.hu

Näätänen, Gaillard and Mäntysalo have introduced the mismatch negativity (MMN) over 35 years ago. It is perhaps time to take a bird's eye view of the progress and achievements of MMN-related research through time, assess where we are at this point, and discuss which future directions appear to be most promising. The symposium will commence with Risto Näätänen's overview of the context within which MMN has been discovered and how early findings led to an ever widening set of questions that could be studied by MMN. Next, a panel of four experienced MMN researchers, Carles Escera, Erich Schröger, Juanita Todd, and István Winkler give their assessment of the current state of MMN research in some of the most important topics addressed with this methods: the neural bases of auditory sensory deviance detection, functional and computational models of MMN, applying MMN to the study of speech and music perception, developmental and clinical issues. The rest of the session will be dedicated to short statements about the future of MMN research. Conference participants are encouraged to submit a 2–3 sentence synopsis of their statement to István Winkler at winkler.istvan@ttk.mta.hu preferably before the meeting, but no later than the evening before the session. We will have time for ca. 10–15 statements of 3–4 minutes duration.

Symposium 10: Human language mechanisms as revealed by the MMN

Friday, September 11, 2015, 9:30–10:30, Hörsaalgebäude, Hörsaal 3
Chair: Friedemann Pulvermüller & Thomas Jacobsen

The MMN as an index of spoken language processing: what's new? (Introduction)

Friedemann Pulvermüller

Brain Language Lab, Freie Universität Berlin, Germany
friedemann.pulvermuller@fu-berlin.de

Human language is characterized by the storage of huge vocabularies of ten thousands of symbols and by a sheer endless ability to combine these stored symbols into stings. The ability to store elements and combine them flexibly also characterizes other higher cognitive domains, including music, arithmetics, gestalt/pattern recognition etc. The MMN seems to indicate stored form retrieval and combinatorial processing in different ways: if a stimulus matches a stored memory trace, it is typically larger than that to an unfamiliar stimulus, which does not match a stored trace. In contrast, a stimulus that matches the regular combination of stored elements elicits a smaller MMN than an unfamiliar and irregular sequence violating combinatorial principles. This introduction will point to recent advances in studying the storage vs. combination of complex linguistic forms, thereby addressing key linguistic questions using MMN methods. The potential role of the MMN as an index of language-related perceptual mechanisms, semantic priming, and second language proficiency will also be highlighted.

Acquisition of novel word-forms by adult language learners

Alina Leminen[1], Suzanne Hut[2], Laura Hedlund[2], Lilli Kimppa[2], Miika Leminen[2], & Yury Shtyrov[1]

[1]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
[2]*Institute of Behavioural Sciences, University of Helsinki, Finland*
alina.leminen@gmail.com

New words and even new grammatical units are acquired throughout one's life. It has been shown that native (L1) speakers are able to parse novel complex words (derivations, e.g., chickenish) online even when they have never heard them previously. How do second language (L2) learners process novel word-forms in their L2? To address this issue, we recorded EEG in a passive multifeature MMN paradigm and presented L1 speakers, beginning and advanced learners of Finnish with 1) real derived words, 2) novel previously unencountered derivations (real stem+real suffix), and 3) pseudowords (real stem+pseudosuffix). For L1 speakers, real derivations elicited a larger MMN than novel derivations, demonstrating early automatic access of full-form memory traces for real derivations. Moreover, pseudowords showed larger responses than both novel and real derivations, demonstrating a syntactic ERP pattern. Advanced L2 learners also showed a syntactic ERP pattern but only for pseudowords vs. real derivations, whereas there were no differences between real and novel derivations.

Finally, ERPs in beginning learners did not differ between any of the stimuli. We conclude that L1 speakers have stronger memory traces for real derived words but they parse and integrate novel derivations more flexibly than L2 learners. Advanced L2 learners show sensitivity to lexicality and to the morphosyntactic structure of complex words, while beginning learners do not, as suggested by the syntactic ERP pattern. Instead, beginners do not distinguish between different morphology types and therefore possibly use the parsing route to decompose all complex items into their constituents.

Can the MMN measure proficiency in a second language?

Jeff Hanna[1], Yury Shtyrov[2], John Williams, & Friedemann Pulvermüller[1]

[1]*Brain Language Lab, Freie Universität Berlin, Germany*
[2]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
jeff.hanna@gmail.com

Humans show variable degrees of success in acquiring a second language (L2). In many cases, morphological and syntactic knowledge remain deficient, although some learners succeed in reaching native-like levels, even if they acquire their L2 relatively late. We use psycholinguistic, online language proficiency tests and the syntactic mismatch negativity, a neurophysiological index of automatic syntactic processing that occurs less than 200 ms after stimulus onset, to compare neural grammar mechanisms of native speakers (NS) of English with non-native speakers (NNS). Variable grammar proficiency was measured by standard psycholinguistic tests. When NS heard ungrammatical word sequences lacking agreement between subject and verb (e.g. *we kicks), this brain response was increased compared with syntactically legal sentences (e.g. he kicks). More proficient NNS also showed this difference, but less proficient NNS did not. The cortical sources of the MMNm responses were localised in bilateral superior temporal perisylvian areas. Crucially, activation peaks in bilateral superior temporal areas revealed correlations between the magnitude of MMNm sources and grammatical proficiency. We conclude that grammar knowledge is manifest in the early neurophysiological response to grammar violations and that the corresponding brain indices of morphosyntactic mechanisms can become indistinguishable from those in NS, even among late-acquiring NNS.

Automatic neural discrimination of lexical information in unattended visually presented words

Yury Shtyrov

Center of Functionally Integrative Neuroscience, Aarhus University, Denmark
yury.shtyrov@cfin.au.dk

Previous MMN studies using auditory presentation of spoken words have established that the brain is capable of automatic lexical processing even in the absence of attention on the linguistic input. This automaticity is attributed to the robustness of strongly-connected word-specific neural memory circuits that activate irrespective of the task or attention level. Such an account predicts the automatic activation of memory traces upon any presentation of words, irrespective of the presentation mode. However, neurolinguistic experiments in the visual modality have not been able to explore this phenomenon, as they usually present stimuli

(even if masked) in the focus of attention. Our recent experiments investigated the putative automatic processing of unattended lexical stimuli in the visual modality, in different languages. Matched words and pseudowords were presented to volunteers outside the focus of attention while they were engaged in a non-linguistic visual dual task of detecting colour combinations in the centre of their visual field. Event-related EEG and MEG responses revealed a complex timecourse of brain activation dynamics underpinning lexical processing. Differential processing of words and pseudowords started early, from ~100 ms, and continued over extended time of a few hundred milliseconds. This was found in MMN designs for both standard and deviant orthographic stimuli, as well as in non-oddball presentation. Furthermore, similar to earlier auditory findings, automatic visual responses can track rapid formation of new memory traces for novel words. This body of results suggests automatic neural processing of linguistic information as a supra-modal mechanism shared by visual and auditory modalities.

Symposium 11: Deviance detection along the auditory pathway

Friday, September 11, 2015, 11:00–12:00, Hörsaalgebäude, Hörsaal 3
Chair: Manuel S. Malmierca & Yonatan Fishman

Stimulus-specific adaptation, repetition suppression, and the MMN: bridging the gap with small-animal MEG

Jennifer F. Linden

UCL Ear Institute, University College London, United Kingdom
j.linden@ucl.ac.uk

In animal models, single-neuron response properties such as stimulus-specific adaptation and repetition suppression have been described as possible precursors to the mismatch negativity. In humans, brain responses to stimulus change are often studied using magnetoencephalography (MEG). We attempted to bridge the gap between the animal and human studies by characterising responses to changes in the frequency of repeated tone series in the anaesthetised guinea pig using the novel technology of non-invasive small-animal MEG. We found that: (1) auditory evoked fields (AEFs) qualitatively similar to those observed in human MEG studies can be detected noninvasively in rodents using small-animal MEG; (2) guinea pig AEF amplitudes reduce rapidly with tone repetition, and this AEF reduction is largely complete by the second tone in a repeated series; and (3) differences between responses to the first (deviant) and later (standard) tones after a frequency transition resemble those previously observed in awake humans using a similar stimulus paradigm. These data raise the possibility that MMN-like latency shifts can arise through differential effects of tone repetition on the latency of early versus late deflections in the tone-evoked brain response. Moreover, the similarities between our results obtained in anaesthetised guinea pigs and previous results obtained in awake humans using a similar stimulus paradigm suggest that MMN-like latency shifts can be generated by low-level adaptive processes independent of conscious awareness.

Adaptation, predictive coding, and perceptual objects in the human auditory system

Iiro Jääskeläinen

Department of Neuroscience and Biomedical Engineering, Aalto University School of Science, Espoo, Finland
iiro.jaaskelainen@aalto.fi

Stimulus-specific adaptation (SSA) of MEG/EEG responses can be used to probe change-detection in the human auditory cortex (AC). By measuring the degree that adaptor stimuli reduce the amplitude (and/or increase the latency) of responses to subsequent probe stimuli as a function of difference on a specific stimulus attribute such as sound frequency, phoneme category, or spatial location, it can be estimated whether the underlying neural populations have specificity to that attribute. Functionally, change-detection also implies predictive coding of the attribute by the neural population. In our previous MEG/EEG SSA, and supporting transcranial magnetic stimulation, studies we have demonstrated that areas anterior and posterior to primary AC process "what" and "where" information in parallel, with responses of the anterior "what" pathway lagging those of the posterior "where" pathway by a few tens of milliseconds. Recently, we have studied where, when, and how information from auditory and visual "what" and "where" pathways is integrated to perceptual objects. In this combined MEG/EEG/MRI study, we again utilized SSA. Subjects viewed two moving audiovisual objects. Identical adaptor-probe sound pairs were linked with visual cues to the same vs. different perceptual object. Based on SSA due to changes in the object that produced the probe sound with respect to the adaptor sound, our results suggest that posterior AC areas initiate and anterior AC areas consolidate associations between sensory events and perceptual objects.

Stimulus-specific adaptation: can it be a neural correlate of habituation?

Yoram Gutfreund

Neurobiology, The Technion, Haifa, Israel
yoramg@tx.technion.ac.il

The optic tectum (OT) is a multisensory midbrain structure (also called the superior colliculus in mammals) which is believed to be linked with the control of spatial attention to salient stimuli. It is therefore of interest to characterize stimulus-specific adaptation (SSA) in the OT. In this presentation I will present our recent studies on SSA in the barn owl's OT. Most Neurons in the OT of barn owls are robustly sensitive to auditory stimuli simplifying the study of auditory SSA in this species. Using Oddball and constant-order paradigms we exposed robust SSA in the OT. However, SSA in the OT differed in several aspects from SSA types that were reported in the inferior colliculus, thalamus and A1. First, SSA was recorded to multiple auditory features. In addition to SSA to frequency we identified in the same neurons SSA to binaural cues, to amplitude modulations and to the intensity of the sound. Second, significant SSA was still recorded even if the inter-stimulus-intervals were increased up to 60 s. This relatively long memory trace is correlated with the time scale of behavioral habituation. We suggest that the SSA in the OT represents a higher level of deviance processing compare to most other SSA types. These results point to the superior colliculus as a possible new target for focusing research on SSA and deviance detection in mammals.

Cortical mapping of mismatch negativity in rat

Tomoyo Shiramatsu & Hirokazu Takahashi

Research Center for Advanced Science and Technology, The University of Tokyo, Japan
isoguchi@brain.imi.i.u-tokyo.ac.jp

In animal studies, the existence of the homolog MMN to human has been debated because, in some recent studies, MMN-like responses were best explained by stimulus-specific adaptation (SSA). In this study, we aimed to investigate whether the putative MMN (MMNp) in rats is a mere effect of SSA or has comparable properties to human MMN. A surface microelectrode array recorded auditory evoked potential (AEP) epipially from rat auditory cortex under anesthesia, while the stimuli were presented in an oddball manner. In both of the standard and deviant AEP, middle-latency positive potential (P1) was recorded. By contrast, only in the deviant AEP, MMNp was recorded as a negative deflection. We found that this MMNp and P1 were functionally different in the following four ways. First, while P1 exhibited strong SSA, MMNp didn't appear in "many standard" control, suggesting that MMNp isn't a mere effect of SSA. Second, the spatial distribution of P1 and MMNp was different: P1 mainly elicited from the core region of the auditory cortex, however, MMNp spread toward the belt region in addition to the core region. Third, blockage of the NMDA receptors extinguished MMNp, but didn't affect P1. Fourth, trial-to-trial variation of P1 amplitude showed a unimodal distribution, while MMNp amplitude showed a bimodal distribution, suggesting that, while SSA is always observed at every deviant, MMNp is generated only in some trials. Thus, the MMNp in rat is likely functionally different from P1 with SSA, and in turn, may be comparable to human MMN.

Symposium 12: Aging

Friday, September 11, 2015, 12:00–13:00, Hörsaalgebäude, Hörsaal 3
Chair: Claude Alain

The role of temporal structure in the investigation of sensory memory and auditory scene analysis: a healthy-aging perspective

Johanna Rimmele

Department of Neurophysiology and Pathophysiology, University Medical Center Hamburg-Eppendorf, Germany
johanna.rimmele@gmail.com

Everyday communication requires the ability to cope with background noise or multi-talker listening situations. These situations have been reported to be particularly demanding for older adults. The ability to segregate relevant sound from background sound is crucial in these listening situations, and might be impaired in older adults. Recent research suggests that temporal structure processing in auditory sensory memory is involved in the ability to use regular patterns inherent in a sound mixture to stabilize stream segregation. In this talk, first, I will present electrophysiological research that investigates the hypothesis that tone pattern processing in auditory sensory memory, as indicated by MMN component, is impaired

in older adults. Second, I will present research on older adults ability to use regular tone patterns for stream segregation. Furthermore, the relevance of these findings for speech processing in multi-talker scenes, as well as possible neurophysiological indicators will be discussed.

Auditory processing in ageing: evidence for the inhibitory deficit hypothesis

George Stothart & Nina Kazanina

School of Experimental Psychology, University of Bristol, United Kingdom
George.Stothart@bristol.ac.uk

We investigated the effects of ageing on auditory processing in 20 younger adults (aged 18–23 years, mean age 20 (±2), 5 males) and 26 older adults (aged 62–88 years, mean age 76 (±7)) who listened to syllables presented at 60 dB above the participant's hearing threshold in an auditory-only or audiovisual oddball paradigm. Older adults showed increased early sensory responses (i.e. increased P50 and N100 amplitudes compared to younger adults) followed by an absence of a standard N2 response; the MMN was not affected by age. A similar pattern was observed in the control puretone condition (200 repetitions of a 1 kHz tone) when the sound volume was kept the same across participants. We propose that the increased early P50 and N100, followed by the absence of a standard N2 provides evidence for the inhibitory deficit hypothesis of ageing (IDH) theory whereby declines in auditory processing are a result of age-related inefficiency of the fronto-cortical areas in inhibiting irrelevant information. Reduced ability of the frontal lobes to inhibit and regulate the primary sensory areas results in increased responses from these areas (P50 and N100). N2 is typically observed in response to stimuli that involve inhibitory processing (e.g. ignoring the standard stimulus in an oddball task or not responding to the no-go stimulus in a go/no-go task), hence its absence in older individuals matches the predictions by the IDH. We discuss theoretical significance of a preserved MMN in ageing.

Recovering from the sensory effects of auditory distraction: no difference between young and old adults

János Horváth, Márta Volosin, & Zsófia Anna Gaál

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
horvath.janos@ttk.mta.hu

Numerous studies suggest that old adults might be more susceptible to distraction than young adults. The present study utilized the auditory N1 event-related potential (ERP) to assess potential age-related differences in the recovery time from distraction-related sensory processing changes. The N1 waveform is enhanced when the eliciting sound events are in the focus of the on-going perceptual task. It has also been shown that distraction – an involuntary attention change triggered by task-irrelevant, infrequent, unpredictable sounds – may "remove" this attentional enhancement for a brief (at least 150 ms, not longer than 650 ms) period of time after a distractor is presented. In the present study we utilized an auditory continuous-stimulation paradigm to assess the temporal characteristics of this distraction

effect in young (19–26 years) and old adults (62–74 years). Participants listened to a continuous tone during the experiment and signaled the presence of occasional gaps by pressing a button. Infrequently, unpredictably, the pitch of the continuous tone changed in quick exponential glides. ERPs to gaps following such glides in 150 and 250 ms exhibited reduced N1-amplitudes in comparison to those elicited by gaps separated from glides by 650 ms or longer. Although N1 amplitudes were markedly lower for old adults, the proportional glide-gap separation-related N1-change did not differ between the two age groups. This suggests that the speed of recovery from the sensory effects of distraction is not affected by age.

Effects of age, noise and hearing loss on concurrent sound segregation

Claude Alain[1] & Anja Roye[2]

[1]*Rotman Research Institute, Baycrest Centre, Toronto, Canada*
[2]*Department of Biophysics, Radboud University Nijmegen, Netherlands*
calain@research.baycrest.org

Our ability to perceptually organize sounds that occur simultaneously is paramount to solving the cocktail party problem. In a series of experiments, we examined the effects of age, noise and hearing loss on listeners' ability to separate concurrent sounds using frequency periodicity. We measured auditory evoked fields (AEFs) using magnetoencephalography while participants were presented with complex tones that had either all harmonics in tune or had the third harmonic mistuned by 4 or 16 % of its original value. The harmonic complex tones (75 dB sound pressure level, SPL) were presented without, with low (45 dBA SPL), or with moderate (65 dBA SPL) Gaussian noise. For each participant, we modeled the AEFs with a pair of dipoles in the superior temporal plane. We then examined the effects of hearing loss and noise on the amplitude and latency of the resulting source waveforms. The results revealed an age-related increase in P1m amplitude and similar noise-induced changes in auditory responses of older adults with and without hearing loss. Our results also showed that the P1m amplitude was larger in the hearing impaired than in the normal-hearing adults. In addition, the object-related negativity (ORN) elicited by the mistuned harmonic was modulated by age and hearing loss. The changes in P1m and ORN amplitude in the hearing impaired older adults suggests that hearing loss increased neural excitability in auditory cortices, which could be related to deficits in inhibitory control.

Symposium 13: Computational models of MMN

Friday, September 11, 2015, 14:30–15:30, Hörsaalgebäude, Hörsaal 3
Chair: Marta I. Garrido

Modelling MMN in 22q11 deletion syndrome

Melissa Larsen[1,2], Morten Mørup[1], Elvira Fischer[2], Hartwig Siebner[2], William Baaré[2], Thomas Werge[3], & Marta I. Garrido[4]

[1]*Cognitive Systems, DTU Compute, Technical University of Denmark*
[2]*Danish Research Center for Magnetic Resonance, Centre for Functional and Diagnostic Imaging and Research, Copenhagen University Hospital, Hvidovre, Denmark*
[3]*Mental Health Centre Sct. Hans, Capital Region, Denmark*
[4]*Queensland Brain Institute & The University of Queensland, Brisbane, Australia*
kit.melissa.larsen@gmail.com

Detection of changes in the environment is a fundamental task that the healthy brain masters successfully on a daily basis, even non-intentionally. The mismatch negativity (MMN), a brain marker of this change detection mechanism, is reduced in people with schizophrenia compared to healthy controls. In the search of potential neural biomarkers for schizophrenia we investigated the neural basis of change detection in a group with 22q11 deletion syndrome (22q11DS), who have a 30 fold increased risk for developing schizophrenia. We recorded high-density EEG from the 22q11DS sample and a matched control-group while they listened to a sequence of sounds arranged in a roving MMN paradigm. While we found no indication of a significant decreased MMN response in the 22q11DS-group using standard ERP analysis, whole-scalp spatiotemporal analysis revealed a notable group difference in fronto-temporal regions in responses to tones per se, just prior to the typical MMN window. Dynamic causal modelling (DCM) revealed group differences in the network structure, indicating that models with feedback connections were favoured in the control-group, whereas models without feedback connections better explained the 22q11DS data. Bayesian model averaging (BMA) across the whole model space yielded a similar result whereby decreased top-down connections from superior temporal gyrus to primary auditory cortex were found bilateral in the 22q11 carriers as compared to controls. The observed differences in effective connectivity may present a possible biomarker for the development of schizophrenia, however this would have to be confirmed by a follow up study.

A neuronal model of predictive coding for MMN

Catherine Wacongne

Netherland Institute for Neuroscience (NIN), Amsterdam, Netherlands
catherine.wacongne@gmail.com

The mismatch negativity (MMN) is thought to index the activation of specialized neural networks for active prediction and deviance detection in auditory cortex. However, a detailed neuronal model of the neurobiological mechanisms underlying the MMN is still lacking, and its computational foundations remain debated. I propose here a detailed neuronal model of auditory cortex, based on predictive coding, that accounts for the critical features of MMN. I

also discuss how this model can be integrated with the stimulus specific adaptation data and explore which experimental paradigms can be used to better characterize the modifications of MMN amplitude seen in schizophrenia and other disorders.

MMN: a marker of statistical learning in the brain

Marta I. Garrido[1], C. L. James Teng[2], & Jason B. Mattingley[1]

[1]*Queensland Brain Institute, The University of Queensland, Brisbane, Australia*
[2]*Duke-National University of Singapore*
m.garrido@uq.edu.au

The ability to learn about regularities in the environment is fundamental for adaptive behaviour. Neural responses to unpredictable sensory events carry a unique prediction error signature, as the mismatch negativity (MMN) in classic "oddball" paradigms. In the real world, however, learning about regularities often occurs in the context of competing cognitive demands. Here we asked whether learning of statistical regularities is modulated by concurrent cognitive load. Across two experiments, we compared electroencephalographic (EEG) metrics associated with responses to pure tones with frequencies sampled from narrow or wide Gaussian distributions. In experiment 1, we replicated our previous finding that tones in the tails of the distributions ("oddballs") evoked a larger response than those in the center ("standards"). Moreover, this prediction error response (MMN) was larger for physically identical outliers in the narrow than in the wide distribution. These results suggest that observers can track the uncertainty associated with distributions of apparently random sensory events. In experiment 2, participants performed a n-back task on a central letter stream while listening to the same sequences presented in experiment 1. Here we compared "standards" and "oddballs" under different distributional variance (narrow and wide) and cognitive loads (low and high). We again observed reliable MMN to outliers that were greater when the distribution was narrower, suggesting that observers were able to track statistical uncertainty under cognitive load. Our findings suggest that statistical learning is not a capacity limited process, and that it might proceed automatically even when cognitive resources are taxed by concurrent demands.

Disentangling sensory expectation and attentional modulation in the predictive coding framework

Ryszard Auksztulewicz

Wellcome Trust Centre for Neuroimaging, University College London, United Kingdom
R.Auksztulewicz@ucl.ac.uk

Despite similar behavioral effects, attention and expectation influence evoked responses differently: attention typically enhances event-related responses, while expectation reduces them. This dissociation has been reconciled under predictive coding, where prediction errors are weighted by precision associated with attentional modulation. In this talk I will present results of three studies where we used dynamic causal modelling (DCM) to test the predictive coding account of attentional gain modulation mechanisms. In the first study using MEG, temporal attention and sensory expectation were orthogonally manipulated in an auditory mismatch paradigm, revealing interactive effects on evoked response amplitude. This interac-

tion effect was modeled in a canonical microcircuit using DCM, comparing models with modulation of extrinsic and intrinsic connectivity at different levels of the auditory hierarchy. In the second study, we re-analysed the same dataset, this time focusing on oscillatory responses in the gamma range. We found an increase in stimulus-induced gamma power following temporal attention, and modelled this effect using DCM for induced responses. In the third study, we analyzed ECoG data recorded from patients performing a task in which content-based and time-based expectancy were orthogonally manipulated. DCM served to disambiguate between models of stimulus expectancy in terms of top-down processing and gain modulation.

Pre-conference Workshops

Pre-conference workshop 1: Visual mismatch negativity

Tuesday, September 8, 2015, 10:00–17:00, Städtisches Kaufhaus, room Z005
Chair: István Czigler & Gábor Stefanics

Visual mismatch negativity in clinical use

Jan Kremláček[1] & Kairi Kreegipuu[2]

[1]*Department of Pathological Physiology, Faculty of Medicine in Hradec Kralove, Charles University in Prague, Czech Republic*
[2]*Institute of Psychology, University of Tartu, Estonia*
jan.kremlacek@lfhk.cuni.cz

Continuing systematic exploration of the mismatch negativity in visual domain (vMMN) (93 PubMed entries, March 2015) rose an interest in the use of the vMMN for clinical research. Thirty three studies searched for the vMMN alterations among populations of different age (8 studies), or in developmental disorders like autism, dyslexia, mental retardation (6), neurodegenerative disorders (Alzheimer's disease, spinocerebellar ataxia, and mild cognitive impairment) (5), mood disorders (4), substance abuse (4), and schizophrenia or schizoaffective disorders (3), panic disorder (1), deafness (1), and hypertension (1). The vMMN successfully discriminated among clinical conditions in thirty studies, it was not altered only in three studies. A meta-analysis showed that a median of the effect size was 0.94 (e.g., large effect). Part of studies (16) also explored a relationship of the vMMN to various clinical markers. The relationship was significant in 10 cases. During the first part of the workshop we will review how the contemporary studies support a prosperity of the vMMN concept in clinical research. Beside diverse clinical conditions also experimental designs varied across studies in the deviance encoding (location, duration, color, motion, shape, face, or emotion), a way of statistical processing, a scalp localization, or a vMMN time interval, which increases possibility of a false positive finding. In the second part of the workshop we will concentrate on necessity of replication studies from independent labs, and standardization of the vMMN examination/evaluation to support inter-laboratory comparisons.

Visual mismatch negativity, prediction, and its functional roles

Motohiro Kimura[1] & Gábor Stefanics[2]

[1]*National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan*
[2]*Translational Neuromodeling Unit, University of Zurich & ETH Zurich, Switzerland*
m.kimura@aist.go.jp

Visual mismatch negativity (MMN) is an event-related brain potential (ERP) component that is automatically elicited when sequential rules inherent in a visual stimulus sequence are violated. So far, visual MMN has been observed in response to repetition-rule-violating stimuli (i.e., deviant stimuli) that are occasionally inserted in a sequence of repetition-rule-conforming stimuli (standard stimuli in an oddball sequence), as well as change-rule-violating stimuli (irregular stimuli) that are occasionally inserted in a more complex sequence of change-rule-conforming stimuli (regular stimuli). Based on these previous findings, recent theories have proposed that visual MMN is associated with stimulus-context-based prediction; that is, (1) sequential rules embedded in the temporal context or temporal structure of a visual stimulus are extracted, (2) a predictive model encoding the extracted sequential rules is established, (3) predictions about the forthcoming visual event are formed based on the predictive model, and (4) representations of the current and the predicted visual events are compared. When incongruence between them has been detected, visual MMN is elicited (Kimura, Schröger, & Czigler, 2011, NeuroReport; Kimura, 2012, International Journal of Psychophysiology). Furthermore, according to the hierarchical predictive coding framework, it has been proposed that visual MMN reflects a perceptual prediction error signal in the brain, which plays a functional role in updating the predictive model (Stefanics, Kremláček, & Czigler, 2014, Frontiers in Human Neuroscience). We will discuss the essence of these theoretical proposals and the possible future directions for more precise understanding of the functional role of visual MMN.

Methods in vMMN research (controlling attention, and adaptation)

István Czigler

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
czigler.istvan@ttk.mta.hu

According to the Web of Science database in the last 10 years more than 100 papers were published in the topic of 'visual mismatch negativity' (vMMN). In comparison to the auditory MMN, methods of these studies were rather diverse. Due to the richness of visual features and patterns, many different types of stimuli were used, and different methods were developed for diverting attention from the vMMN-related stimuli. Furthermore, unlike the fairly regular appearance of the obligatory auditory event-related potential (ERP) components, the structure of the obligatory visual ERPs is a function of a rich set of stimulus parameters (stimulated part of the retina, spatial contrast, composition of spatial frequencies, contour appearance, etc.). The variability of ERP components makes it difficult to separate the deviant-related ('genuine' vMMN) effects from standard-related (stimulus-specific adaptation) changes in the expected latency range and scalp locations of the vMMN. The separation is important, even if adaptation/refractoriness cannot be considered as an irrelevant consequence of low-level

physiological processes, i.e, both effects are parts of the processes involved into the mismatch paradigms.

Visual MMN to emotional faces and other higher-level stimuli

Piia Astikainen[1] & Marie Gomot[2]

[1]*Department of Psychology, University of Jyväskylä, Finland*
[2]*Université François-Rabelais de Tours, France*
piia.astikainen@jyu.fi

Visual MMN (vMMN) has been found to several low-level visual features such as orientation or color. In addition, it has been associated to change detection in complex visual features including facial expressions, gender of face, and human hands. We will present a brief review of the findings on vMMN to changes in higher-level stimuli such as faces. The results will be discussed in the framework of automatic detection of regularity violation.

Does the visual MMN develop independently of the auditory MMN? The case of deafness

Anne Caclin[1] & Davide Bottari[2]

[1]*Brain Dynamics and Cognition, Lyon Neuroscience Research Center INSERM U1028, Bron, France*
[2]*Institute for Psychology, University of Hamburg, Germany*
anne.caclin@inserm.fr

In deafness auditory cortices seem to be cross-modally recruited for the processing of other sensory modalities. Evidence from blindness suggests that these reorganized areas could maintain their functional specialization. The present study aimed at testing such functional selectivity hypothesis using the visual mismatch negativity (vMMN) as a tool. We presented a visual oddball paradigm to a group of early deaf (n = 12) and a group of controls (n = 12). Our hypothesis was that the vMMN topography in deaf individuals would suggest the recruitment of auditory areas. Stimuli consisted in the deformation of a circle into an ellipse either in the horizontal or in the vertical direction. In each block the standard stimulus was the deformation of the circle in one direction (73 % of the trials) while the deviant stimulus was the deformation in the other direction (14 % of trials). Visual features of the standards and deviants were counterbalanced between blocks. Participants were instructed to fixate a central cross and detect whenever it disappeared. Strikingly, the results showed that the vMMN displayed a difference in topography between groups (more anteriorly distributed in deaf than controls within the 150–300 ms time range), confirming the possibility of recruitment of auditory cortices in the deaf. SCDs, dipole fitting, and source estimates strongly suggested additional temporal plane generators in the deaf. These results show that the vMMN can develop also in the absence of audition and are compatible with a cross-modal recruitment of temporal cortices for motion change detection in case of auditory deprivation.

A form of visual mismatch negativity to color-deviant distractors disrupting visual search performance

Tom Campbell[1,2,3], Elke Lange[4], Alexander Sorokin[5,6], & Olga Sysoeva[7]

[1]*Neuroscience Center, University of Helsinki, Finland*
[2]*Center for Mind and Brain, University of California, Davis, CA*
[3]*Helsinki Collegium for Advanced Studies, University of Helsinki, Finland*
[4]*Institute of Behavioral Sciences, University of Helsinki, Finland*
[5]*Mental Health Research Center, Russian Academy of Medical Sciences, Moscow, Russia*
[6]*Center of Neurobiological Diagnostics, Moscow State University of Psychology and Education, Russia*
[6]*Scientific and Practical Center of Child Psychiatry and Neurology, Moscow, Russia*
[7]*MEG Center, Moscow State University of Psychology and Education, Russia*
[8]*Autism Research Laboratory, Moscow State University of Psychology and Education, Russia*
tom_campbell75@hotmail.com

When we close our eyes, we can actively envision what we have just seen, yet upon re-opening our eyes and searching the same visual scene, we paradoxically find features of the visual scene that we neither remember imagining nor even remember seeing in the first place. Visual search for a shape singleton was combined with a color oddball paradigm so as to investigate memory for to-be-ignored color. Color singleton distractor objects, when deviant in color elicited a color vMMN with a latency of 120–160 ms and a posterior distribution over the left hemisphere. That color deviance also slowed identification of a uniquely shaped visual target singleton, demonstrating that the deviance of to-be-ignored color singleton caused distraction. Correlations revealed the amplitude of this color vMMN electrophysiologically indexed this behavioral distraction effect. The interval between visual scenes was longer than 600 ms, indicating that the brain's memory for the color of the preceding visual scenes persisted for at least 600 ms. Therefore, in the case of the neural code for color, without the requirement of actively attending or deliberately retaining the color of the color singleton distractor, durable memory representations are formed obligatorily. In the light of this vMMN evidence, questioned is the received wisdom that i) visual search has no memory and ii) vision has no memory. Critically reconsidered rather are thus the corresponding concepts that i) visual search has a memory and ii) vision has a memory.

The vMMN is sensitive to within category and between category effect when using a morphing method

Krisztina Kecskés-Kovács, Flóra Bodnár, István Sulykos, Domonkos File, & István Czigler

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
kecskes.kovacs.krisztina@ttk.mta.hu

The aim of the study was to examine the event-related potential correlates of automatic face categorization processes. We supposed that the memory system underlying vMMN is capable of encoding categorial changes even if the eliciting stimuli are irrelevant to the ongoing task (the task was visual tracking). To this end, in a passive oddball paradigm we explored the sensitivity of vMMN to within category or between categories deviancies. The stimuli were

morphed female and male faces. We created six female-male gender-morph pairs with morph software. In each of the pairs four morph-^level stimuli were chosen. In the within category comparisons, 100 % and 67 % female/male faces were presented in reverse control conditions, whereas in the between category comparisons, the stimuli were 67-67 % female and male morphs. To avoid the specific physical effect of single faces, six pairs of morphs were created. The electrophysiological data showed that the deviant faces elicited a posterior negativity relative to the frequent standard ones. These effects are regarded as vMMNs generated by automatic detection of sequential regularities. Furthermore, the vMMN component in the between category sequences was larger than the vMMN in the within category sequences, even if the between and within category distances were similar. The results indicate that female and male information are encoded by different neural populations. According to the results, gender perception at an early stage of face processing does not require attentional processes, i.e., face gender categorical coding is automatic.

Predicting visual stimuli by auditory sequence regularities

Dagmar Müller, Katja Saupe, & Erich Schröger

Institute of Psychology, University of Leipzig, Germany
dagmar_mueller@uni-leipzig.de

Naturalistic objects are often characterized by both visual and auditory features. However, in everyday situations it frequently happens that our senses receive signals from only one of the two modalities, e.g. we hear the engine of a moving motorbike although it is hidden by a parked bus. In the present experiment, we investigated whether regularities established within a sequence of auditory stimuli generate predictions about the spatial position of a moving visual target stimulus. In our design the pitch of seven successive tones was linked to the vertical position of a visual stimulus moving stepwise rightwards across the screen. Crucially, some of the moving steps were hidden by an occluder. In different intermixed trials occurring equiprobably we varied the predictability of the spatial position of the visual target by playing the auditory sequence in either a regular vs. an irregular order. In the predictable compared to the non-predictable condition participants produced significantly shorter reaction times in discriminating a non-spatial feature of the visual stimulus presented at the final spatial position. Moreover, the P1 to N1 amplitude of the visual ERP was significantly reduced in the predictable compared with the non-predictable condition. We interpret the behavioural advantage and the reduction of neural activity in the visual system as an indicator of predictions generated on the basis of auditory sequence regularities. Thus, our results stress the importance of crossmodal predictions for everyday situations.

"What is it?" and "Where is it going?" Two questions in the language of the brain: the additivity issue of the visual mismatch negativity

István Sulykos, Krisztina Kecskés-Kovács, & István Czigler

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
sulykos.istvan@ttk.mta.hu

We investigated the relationships of visual mismatch negativity (vMMN) generators during the processing of double deviancies in case of various elementary features. Theories of independent, modular mechanisms suppose that the vMMN signal is aggregated from multiple deviations. This is because the deviant-related response is generated by independent brain electrical activities to the single deviations. In contrast, interactive processes would result in super- or sub-additive responses. In a series of five experiments, we compared the effects of two separate deviant features with the joint effect of these two features. The stimulus dimensions were orientation (O), movement direction (MD) and spatial frequency (SP). The stimuli (patterns of Gabor-patches) were delivered in passive oddball paradigms. O-SF double deviants elicited sub-additive vMMN, irrespective of whether the stimulation were static (experiment 1) or dynamic (experiment 2). Contrarily, MD-O double deviants elicited additive vMMN (experiment 3). However, in the latter experiment, the onsets of O and MD deviancies were asynchronous (the O deviancy preceded the MD deviancy) while in experiment 1 and 2, the deviancies occurred simultaneously. Therefore, the following two experiments were designed in such a way that the MD deviancy was either concurrent with (experiment 4) or followed by (experiment 5) the SF deviancy. In both cases, the vMMN to double deviants were additive again. As the robust results of the studies show, deviant-related processing of movement direction is independent of the deviant-related processing of orientation and spatial frequency, while the latter two are mutually dependent.

The diagnostic and prognostic value of visual evoked potentials and vMMN in Alzheimer's disease and mild cognitive impairment

George Stothart[1], Nina Kazanina[1], Andrea Tales[2], & Risto Näätänen[3,4,5]

[1]*School of Experimental Psychology, University of Bristol, United Kingdom*
[2]*Psychology, Swansea University, United Kingdom*
[3]*Institute of Behavioural Sciences, University of Helsinki, Finland*
[4]*Institute of Psychology, University of Tartu, Estonia*
[5]*Center of Functionally Integrative Neuroscience, Aarhus University, Denmark*
George.Stothart@bristol.ac.uk

Cortical visual association areas are highly vulnerable to Alzheimer's disease (AD) microscopic pathology and visual evoked potentials (VEPs) provide the tools to examine the functional integrity of these areas. Visual mismatch negativity (vMMN), previously shown to be maintained in healthy ageing (Stothart et al. 2012), may potentially be a useful tool to examine such processes in clinical populations. Cross Sectional study: We used VEPs to investigate the visual processing of healthy older adults (n = 26), patients with amnestic mild cognitive impairment (aMCI) (n = 26) and AD patients (n = 20) in a visual oddball paradigm. AD patients showed a significant reduction of P1 and N1 VEP amplitudes and a reduction in vMMN associ-

ated with the degree of cognitive impairment. AMCI patients showed a reduction in N1 amplitude and an absence of vMMN at a group level. Further investigation showed a high degree of group heterogeneity in the evoked potentials of the aMCI group compared to both healthy ageing and AD. Changes in VEPs in AD may reflect the microstructural AD pathology typically found in the extrastriate cortex and vMMN may be a useful objective marker of cognitive decline in AD. Longitudinal follow-up of aMCI patients: In three years 12 aMCI patients had converted to Alzheimer's disease, of which 8 were able to attend a re-test EEG session. Data on the diagnostic and prognostic value of VEPs and vMMN in dementia will be discussed.

Multi-way data decomposition and analysis for vMMN

Fengyu Cong[1] & Piia Astikainen[2]

[1]*Department of Biomedical Engineering, Dalian University of Technology, China*
[2]*Department of Psychology, University of Jyväskylä, Finland*
cong@dlut.edu.cn

In order to study time-frequency representation (TFR) of ERP data, usually, ERP data is first represented by a single vector from each recording channel. The wavelet transform is then applied to it to obtain its TFR. Next, the region of interest (ROI) is defined (a time window and a frequency band). Subsequently, the magnitude of responses within the ROI is calculated and submitted for statistical analysis. Defining a ROI with a rectangular shape is convenient, but may not be the most optimal or objective method. Indeed, TFR of ERP data can contain multiple channels, multiple stimuli and multiple subjects and can naturally compose a multi-way array (called as tensor), including the modes of time, frequency, space, stimulus and subject. The interactions among those modes can be simultaneously exploited and ROI can be adaptively extracted if the multi-way array is factorized (called as tensor decomposition). Here, we applied tensor decomposition on the TFR of visual ERP data recorded in a passive oddball paradigm using neutral faces as standard stimuli and fearful and happy faces as deviant stimuli. In terms of the conventional ERP analysis for visual mismatch negativity (vMMN), no significant difference was found in any interactions among the three factors of group (control vs depressed), hemisphere (P7 vs. P8), and deviant type (fearful vs. happy). Using tensor decomposition, the interaction between group and hemisphere was significant ($p = .015$), reflecting a right-lateralized vMMN in the participants with depressive symptoms, and a bilateral vMMN in the control participants.

Comparing emotional and neutral visual mismatch negativity

Andres Neuhaus & Bob Vogel

Department of Psychiatry, Charité Universitätsmedizin, Berlin, Germany
andres.neuhaus@charite.de

In the predictive coding framework, mismatch negativity (MMN) is regarded as a correlate of the prediction error that occurs when top-down predictions conflict with bottom-up sensory inputs. Expression-related mismatch negativity (EMMN) is a relatively novel construct thought to reflect a prediction error specific to emotional processing. This claim, however, has to be validated by directly comparing visual MMN with visual EMMN in the same population. In this

talk, I will present results of a recent study that characterizes visual MMN and visual EMMN with respect to spatiotemporal profiles and neuronal sources.

Automatic detection of configural processing of faces under non-attentional condition: a visual MMN

Wei Wang, Danmin Miao, & Lun Zhao[1]

[1]*Psychological Research Center, Beijing Yiran Sunny, China*
zhaolunlun@aliyun.com

It has been shown that adults' expertise in recognizing faces is attributed to configural processing (i.e., processing not just the shapes of individual features but also the relations among them), whereas the object identification is mainly based on featural processing. In the first experiment, we investigated automatic configural processing of faces versus non-face objects under non-attentional condition by recording visual MMN. We found that compared with vMMNs in response to non-face (scrambled faces and face contour) stimuli, the vMMN elicited by the orientation change of faces was significantly enhanced with shorter latency. In a second experiment we investigated whether the second-order configural computation of own-race versus other-race faces automatically occurs under non-attentional condition. The results showed that own-race faces elicited larger vMMN than did other-race faces. These data provided electrophysiological evidence for automatic detection of configural changes of faces under unattended conditions.

Dynamic causal modelling for MMN

Tina Wentz

Translational Neuromodeling Unit, ETH & University of Zurich, Switzerland
tina.wentz@gmail.com

Information processing in the human brain is thought happen in networks comprising multiple areas/neural populations. The dynamics of interaction between areas is hidden in the raw EEG data. Dynamic causal modelling (DCM) helps to infer on the effective connectivity between brain regions from EEG signals using biologically informed models. This talk will give a quick overview on the fundamentals and possible application of DCM to study prediction error signals such as mismatch negativity.

Pre-conference workshop 2: Methodological aspects of MMN research

Tuesday, September 8, 2015, 10:00–17:00, Städtisches Kaufhaus, room 133
Chair: Alexandra Bendixen & Andreas Widmann

MMN paradigms

János Horváth

Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences, Budapest, Hungary
horvath.janos@ttk.mta.hu

Mismatch negativity (MMN) has been the focus of numerous studies, and it has also been utilized as a tool to answer questions in a wide variety of topics including auditory memory, stream segregation, speech perception, perceptual development, and so forth. This tutorial gives a detailed overview of the various paradigms used to elicit and investigate MMN, with special attention on the motivations and rationale behind the designs.

MMN from a cognitive point of view

Alexandra Bendixen

Department of Physics, Chemnitz University of Technology, Germany
alexandra.bendixen@uni-oldenburg.de

The mismatch negativity (MMN) can serve as a powerful tool for studying questions of perception or cognition. For instance, MMN can be used to assess whether participants are able to discriminate between two different stimuli, whether they are able to pick up certain regularities from their sensory environment, whether they have formed a given perceptual object representation, and so on. However, the inferences made in such research approaches are often very indirect, such that the researcher must bear in mind a range of alternative interpretations – not only when MMN is present, but even more so when MMN is absent in a given situation or population. The talk will address typical use cases of the MMN and discuss which interpretations are viable as well as how to avoid common misinterpretations.

The mechanisms and meaning of the mismatch negativity

Yonatan Fishman[1]

Neurology and Neuroscience, Albert Einstein College of Medicine, Bronx, NY
yonatan.fishman@einstein.yu.edu

The underlying neural mechanisms and meaning of the mismatch negativity (MMN) continue to be debated. Two dominant explanations for the MMN have been proposed. According to the "neural adaptation" hypothesis, repeated presentation of 'standard' sounds results in adapted (i.e., attenuated) responses of feature-selective neurons in auditory cortex. Rare 'deviant' sounds activate neurons that are less adapted than those stimulated by the frequent standard sounds, and thus elicit a larger 'obligatory' event-related response (e.g., N1), which

yields the MMN upon subtracting the response to standards from the response to deviants. In contrast, according to the "sensory memory" hypothesis (and the related "predictive coding" interpretation), the MMN is a 'novel' (non-obligatory) response component that reflects the deviant's violation of a neural 'memory trace' or prediction generated by the regularity of the preceding standards. In this talk I consider evidence supporting the adaptation and sensory memory/predictive coding models of the MMN. I also present neurophysiological data obtained from monkey auditory cortex, which have potential implications for the debate between proponents of the two competing models and for the interpretation of non-invasively recorded event-related responses more generally. I conclude with an assessment of where the debate currently stands and with remarks on how further progress can be made with regard to clarifying the mechanisms and meaning of the MMN.

MMN Interpretation – the adaptation model

Patrick May

Leibniz Institute for Neurobiology, Magdeburg, Germany
pjcmay@yahoo.co.uk

This presentation serves as a brief introduction to the so-called adaptation model of MMN. This model explains the MMN in terms of physiologically known mechanisms of auditory cortex, namely serial structure, stimulus selectivity, and adaptation realized through short term synaptic plasticity (STP). In its simplest form it suggests that the frequently presented standard stimulus results in stimulus-specific adaptation of auditory cortex. This leads to attenuated responses to the standard and to response recovery when the deviant is presented. The model suggests that the memory system and comparison process underlying MMN generation – as advocated by the orthodox theory of MMN – are physiologically realized by STP and stimulus selectivity, respectively. The adaptation model parts company with orthodox theory by suggesting that the MMN, rather than resulting from a separate change-detection process, is in fact part of a modulated N1 response. The methodological consequence of this is that the subtraction curve technically defining the MMN might actually represent an artefact produced by off-line data analysis.

Recording mismatch negativity and related potentials in neurological patients

Leon Deouell

Department of Psychology & The Edmond and Lily Safra Center for Brain Sciences, The Hebrew University of Jerusalem, Israel
deouell@gmail.com

The ability to detect and orient to violations of regularity in the sensory environment requires multiple capacities including (non-comprehensive list) sensitivity and adequate resolution within the dimension of variance, sensory memory, predictive coding, attention orienting, and inhibition mechanisms. Thus, recording deviance-related potentials like the MMN, P3a, RON provides a probe into the integrity of these mechanisms in patients who suffer from neurological ailments. Indeed, the MMN and P3a were used to test patients with various neurological conditions, including stroke, coma, and degenerative diseases. In my talk I will

discuss how studies can be designed to address well-formed hypotheses about specific conditions, what are the special challenges in recording patients, and what type of conclusions can or cannot be drawn from such studies.

Pre-MMN indicators of deviance detection

Sabine Grimm

Institute of Psychology, University of Leipzig, Germany
sabine.grimm@uni-leipzig.de

The mismatch negativity is the most important, yet not the earliest scalp-recorded index of deviance detection. Several event-related potential (ERP) studies reported that in the oddball paradigm, compared to repeated standard sounds, simple-feature deviants are accompanied by enhanced middle-latency responses (MLR) occurring in the first 50 ms after sound onset. Whereas part of this effect seems primarily due to a reduction of the MLR to standard sounds, some findings indicate that a genuine deviance-related effect is contributing to the enhancement as well. This is in line with the findings from animal studies showing stimulus-specific adaptation (SSA), i.e. a reduced neural response to repeated sounds, which is restored or elevated when presenting a deviant sound. In this talk, I provide methodological suggestions and guidance for measuring and analyzing the MLR, which constitutes a rather small signal embedded in high levels of background noise. Further, I will overview the usefulness of MLR measurements when investigating perception and cognition, as well as their limitations. Particularly, I will discuss studies measuring MLR during auditory deviance detection and focus on their implications on our understanding of the functional organization of regularity encoding and the detection of violations in the auditory system.

Author index

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W

Y

Z

UNIVERSITÄT LEIPZIG

MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

ISBN: 978-3-00-050311-5