

**UK Synaesthesia Association Annual Conference**  
**March 26<sup>th</sup> – 27<sup>th</sup> 2011**  
**University of East London**

**Saturday 26th March 2011**

- 8.45am      **Registration (with teas/coffees)**
- 9.30am      **James Wannerton**  
*Welcome and Introduction*
- 9.45am      **Giles Hamilton-Fletcher, Noam Sagiv, Adrian Williams**  
*An fMRI Study into Projector and Associator Grapheme-Colour Synaesthetes*
- 10.10am     **H. Melero, A. Peña-Melián, M. Ríos-Lago, and J. Álvarez-Linera**  
*Emotion as the key: anatomic and functional aspects of achromatic synaesthesia*
- 10.35am     **A. Asghar, M.J. Spiller, G. Green, W. Woods, M. Simpson, T. McGlashan, V. Pironti, S. Petty, A. Nevado, M. Pulgarin, J. Simner and A. Jansari**  
*Early responsiveness of the brain's V4/V8 "colour centre" to hearing words in synaesthetes revealed by magnetoencephalography*
- 11am        **Break with teas/coffees**
- 11.30am     **Kitamura Sae**  
*Representing Synaesthesia: Synaesthetes as Minorities in Japanese and English-language Fiction*
- 11.55am     **Fiona Burrows**  
*'The Hurt of the Colour of Blood': Synaesthetic Metaphor in the Poetry of the First World War*
- 12.20pm     **Jessica Morris**  
*Synaesthesia & Musicology*
- 12.45pm     **Lunch and Poster Session**
- 2pm         **Julia Simner, Georgina Cooper, C. Ben Simmons, and Mark Price**  
*Time-space Synaesthetes and Event memory*
- 2.25pm      **Beat Meier & Nicolas Rothen**  
*Cognitive consequences of synaesthesia: Is there a common basis?*
- 2.50pm      **Bryan D. Alvarez and Lynn C. Robertson**  
*Additive Effects of Print and Synesthetic Color and the Role of Imagery*
- 3.15pm      **Break with teas/coffees**
- 3.45pm      **Anton Sidoroff-Dorso**  
*Synaesthesia in Russia: history of psychological and neurophysiological research*

- 4.10pm **Jörg Jewanski, Julia Simner, Sean A. Day, & Jamie Ward**  
*1849: Three new cases of synesthesia?*
- 4.35pm **Break**
- 4.45pm **KEYNOTE SPEAKER:**  
**Edward M. Hubbard**  
***The Cross-Activation Theory at Ten: Substantial Growth, Future Challenge***
- 7.30pm+ **Conference dinner**

## Sunday 27th March

- 9am **Registration (with teas/coffees)**
- 9.30am **Romke Rouw**  
*The most fascinating question in synesthesia research*
- 9.55am **Jamie Ward**  
*How many different types of grapheme-colour synaesthesia are there?*
- 10.20am **Lidell Simpson**  
*Synesthesia -- A Personal Perspective*
- 10.45am **Break with teas/coffees**
- 11.15am **Uta M. Jürgens, Nicolas Rothen, Beat Meier, Aleksandra Mroczko, Danko Nikolić**  
*Swimming-style synaesthesia*
- 11.40am **Michael J. Proulx and David Brown**  
*Synthetic Synaesthesia and Sensory Substitution*
- 12.05pm **Olympia Colizoli, Jaap Murre, and Romke Rouw**  
*Can you teach yourself synesthesia?*
- 12.30pm **Lunch**
- 1.30pm **Monika Sobczak, Noam Sagiv, and Adrian Williams**  
*Personification and the brain: An fMRI study*
- 1.55pm **Valentina Niccolai, Tessa M. van Leeuwen, Blakemore Colin and Petra Stoerig**  
*Colour and visuospatial perception in a blind subject: an fMRI case study on synaesthesia*
- 2.20pm **Devin Blair Terhune, Sarah Tai, Alan Cowey, Tudor Popescu, and Roi Cohen Kadosh**  
*Stimulating the Synaesthetic Brain: A Transcranial Magnetic Stimulation (TMS) and Transcranial Direct Current Stimulation (TDCS) Study*

- 2.45pm **Break with teas/coffees**
- 3.15pm **Carrie Firman**  
*Multimedia Synesthetic Art*
- 3.40pm **Barbara Ryan**  
*"Im Wonnemonat Mai – A Play for Voices." Exploring the multi dimensional nature and potential of the spoken word via synaesthetic perception*
- 4.05pm **Closing remarks**
- 4.15pm **Farewell**

## Poster Presentations

### **The Space Is Alive With The Sound Of Music: The Case Of Musical Tone-Space Synaesthete**

*Lilach Akiva-Kabiri, Limor Gertner, Gil Ben-Tzvi & Avishai Henik*

### **Synaesthetic experience in the university. Synthesis and application on innovative didactics (Survey Of possible synaesthetes in the field of university education 2006-2010)**

*M<sup>a</sup> Jose de Córdoba Serrano and Julia Lopez de la Torre Lucha*

### **Months in Space: Synesthesia Modulates Attention and Action**

*Liana Diesendruck\*<sup>1</sup>, Limor Gertner\*<sup>2</sup>, Lior Botzer<sup>3</sup>, Liat Goldfarb<sup>4</sup>, Amir Karniel<sup>5</sup>, and Avishai Henik<sup>2</sup>*

### **Synaesthetic metaphors and the Semantics/Pragmatics distinction**

*Filippo Domaneschi*

### **The role of cognitive control in grapheme-color synesthesia**

*Joram van Driel & Romke Rouw*

### **The Ambiguous Synaesthesia of Olivier Messiaen**

*Solange Glasser-Sbieh*

### **Synaesthesia in adults with high functioning autism and Asperger Syndrome**

*Johnson, D., Allison, C., Baron-Cohen, S.*

### **Probing for induction of synaesthetic behaviour in non-synaesthetes through explicit versus implicit learning of grapheme-colour associations**

*Flor Kusnir & Gregor Thut*

### **The Shape of Sounds**

*Timothy B Layden*

### **Perception of voice quality by synaesthetes, phoneticians and controls**

*Anja Moos<sup>1, 2</sup>, Rachel Smith<sup>1</sup>, David Simmons<sup>2</sup>*

**Swimming-style synaesthesia – an ideaesthesia?**

*Danko Nikolic<sup>1, 2</sup>, Uta M. Jürgens<sup>1, 3</sup>, Nicolas Rothen<sup>4</sup>, Beat Meier<sup>4</sup>, Aleksandra Mroczko<sup>1, 5</sup>*

**Swimming-style colour synaesthesia: Genuine or acquired through training?**

*Nicolas Rothen<sup>1</sup>, Danko Nikolic<sup>2,3</sup>, Uta Maria Jürgens<sup>2,4</sup>, Aleksandra Mroczko<sup>2,5</sup>, Josephine Cock<sup>1</sup>, & Beat Meier<sup>1</sup>*

**Is there such a thing as normal perception?**

*Noam Sagiv<sup>\*1</sup>, Alireza Ilbeigi<sup>1</sup>, Oded Ben-Tal<sup>2</sup>*

**An Independent Component Analysis of fMRI data of grapheme-colour synaesthesia**

*Karsten Specht<sup>1, 2</sup> and Bruno Laeng<sup>3</sup>*

**Exploring synaesthetes' mental imagery abilities across multiple sensory modalities**

*Mary Jane Spiller, Clare Jonas, Ashok Jansari*

**Numbers in the Synaesthete's Brain: Negative and Positive Aspects.**

*Jacqueline M. Thompson<sup>1</sup>, Hans-Christoph Nuerk<sup>2,3</sup>, Tudor Popescu<sup>1</sup>, Korbinian Moeller<sup>2,3</sup>, Roi Cohen Kadosh<sup>1</sup>*

**Training Synaesthesia**

*Andrea Wantz, Nicolas Rothen, Beat Meier*

**What you see is what you smell: The social neuroscience of olfaction.**

*Sean Williams\*, Adrian L. Williams, & Noam Sagiv*

**Working memory in grapheme-colour synaesthesia**

*Olga Wudarczyk, Devin Blair Terhune, & Roi Cohen Kadosh*

## **Saturday March 26<sup>th</sup> 2011**

### **An fMRI Study into Projector and Associator Grapheme-Colour Synaesthetes**

*Giles Hamilton-Fletcher\*, Noam Sagiv, Adrian Williams*

Centre for Cognition and Neuroimaging, Brunel University, West London, UK

We examined spatial representations of grapheme-colour synaesthesia, investigating the neural correlates of 'external' colour photisms (in projectors) and 'internal' colour photisms (in associators). Additionally we also investigated to what extent colour photisms overlapped with standard colour perception. In an fMRI experiment, synaesthetes either viewed graphemes that induced photisms, novel-graphemes that did not induce photisms or novel-graphemes in colour. These graphemes were alternated at either 4Hz or 12-24Hz. In two projectors, we found that photism perception correlated with additional early visual activation, and left parietal activation in one projector. For projectors, photism and colour sensitive regions were adjacent. The associator showed additional temporal lobe activity and left parietal lobe activity. Associator photisms and colour perception overlapped within parietal regions. Alternating inducers at 12Hz caused the associator to lose their photisms, and this correlated with a reduction in temporal lobe activation. We also report findings from two synaesthetes that are not easily classified on the projector-associator spectrum. Unexpectedly, two synaesthetes reported new colour experiences to novel-graphemes during the scanning. We found that these new grapheme-colour combinations recruited frontal regions. We conclude that projector synaesthetes utilise occipital regions and that associators use temporal regions as spatial representations for their photisms. We suspect that methodological problems may have masked previous attempts to identify the neural correlates of projector synaesthesia, and suggest several ways of countering this. We also propose that more accurate classifications of synaesthetes and evidence of different spatial representations from neuropsychology could help refine cognitive theories and better explain synaesthetes 'outside' of the traditional projector-associator dichotomy.

### **Emotion as the key: Anatomic and functional aspects of achromatic synesthesia**

*H. Melero,<sup>1</sup> A. Peña-Melián,<sup>2</sup> M. Ríos-Lago,<sup>3</sup> and J. Álvarez-Linera<sup>4</sup>*

<sup>1</sup>Department of Psychobiology. Faculty of Psychology. Universidad Complutense de Madrid. Spain. Department of Investigation, Development and Promotion. International Artecittá Foundation; <sup>2</sup>Department of Anatomy and Embriology of Human Nervous System I. Faculty of Medicine. Universidad Complutense de Madrid. Spain; <sup>3</sup>Department of Basic Psychology II. UNED Brain Damage Unit. Beata Mariana Hospital. Madrid. Spain. Fundación Cien-Fundación Reina Sofía. Madrid. Spain. <sup>4</sup>Image Diagnosis Department. Ruber International Hospital

Grapheme-colour is one of the most studied variants of synaesthesia. Most synesthetes report having one or more achromatic grapheme among their letters and numbers, however, to our knowledge, researchers have not focused attention on these black, white and grey experiences. For the first time, we have carried out an MRI study on achromatic synesthesias for graphemes. Eight *associator* grapheme-colour synesthetes and matched controls underwent fMRI scans on a 3.0 T Signa HDx MR scanner (GE Healthcare). Neuroimaging data were analysed using SPM5 (Wellcome Department of Imaging Neuroscience, London). Qualitative information about synesthetic experiences was taken into account to fully understand the observed brain activity. The achromatic synesthetic brain web includes bilateral insula, left anterior cingulate cortex, right superior temporal gyrus and left caudate tail. Our results suggest that emotion plays a key role, and could explain not only colour appearance, but also the conscious experience of synaesthesia from an integral multi-dimensional perspective.

### **Early responsiveness of the brain's V4/V8 "colour centre" to hearing words in synaesthetes revealed by magnetoencephalography.**

A. Asghar<sup>1,2</sup>, M.J. Spiller<sup>4</sup>, G. Green<sup>2</sup>, W. Woods<sup>2</sup>, M. Simpson<sup>2</sup>, T. McGlashan<sup>2</sup>, V. Pirontf<sup>2</sup>, S. Petty<sup>2</sup>, A. Nevado<sup>2</sup>, M. Pulgarin<sup>2</sup>, J. Simner<sup>3</sup> and A. Jansari<sup>4</sup>

<sup>1</sup>Hull York Medical School and Biological Sciences, University of Hull; <sup>2</sup>York Neuroimaging Centre, York University; <sup>3</sup>School of Philosophy, Psychology and Language Sciences, The University of Edinburgh; <sup>4</sup>School of Psychology, University of East London, UK

Magnetoencephalography records magnetic fields arising from the head and directly provides a measure of neuronal activity in the brain. These magnetic fields, when analysed using a spatial filtering technique called beamforming, allow identification of the sources within the brain that generate the fields. In our present beamformer analysis, overlapping time windows are utilized to reveal time-dependent changes in source localisation within the brain's V4/V8 "colour centre" and auditory areas in synaesthetes and controls in response to hearing words. Fourteen synaesthetes and controls received binaural presentation of spoken words. A moving 500msec time window with increments of 50msec (from 0-1000msec post-stimulus) was used in the beamforming to locate neuronal sources within the brain in the context of power amplitude changes in the alpha (8-13Hz) and beta band (13-30 Hz) rhythms. The most prominent results of the beamforming overlapping time window analyses were that in synaesthetes there was: 1) an early and sustained decrease in beta power in the brain's V4/V8 "colour centre" which was not seen in controls, and 2) time-dependent greater alpha band power decreases and less beta band power decreases within the auditory cortical brain areas compared to controls. These results suggest that in synaesthetes there are prominent early time-dependent changes in the beta band rhythm of colour responsive V4/V8 neurones in response to hearing words, and this may contribute to the mechanism of colour perception when hearing words. In addition, there are differences in the processing of spoken words in the brain auditory areas between synaesthetes and controls.

### **Representing Synaesthesia: Synaesthetes as Minorities in Japanese and English-language Fiction**

*KITAMURA Sae*

Department of English, King's College London, UK

The exact ratio of the world's synaesthetes to non-synaesthetes is unknown, but they are certainly in the minority – their different perceptions make them a 'minority of the senses,' with synaesthetes of each type forming minorities within the greater minority. This presentation will discuss the fictional representations of synaesthetes as members of a minority, using techniques that have been used in women's studies, queer studies, and disability studies. It will compare fictional works, in both English and Japanese, that feature synaesthetic characters, demonstrating similarities and differences; the main focus will be on the way such characters are regarded as weird outsiders or as possessors of mystic powers. Although philosophers and poets (including Shakespeare) had observed the effects manifested by synaesthesia long before scientists began full-fledged studies, it was not until the rise of Romanticism in the eighteenth century (and Symbolism in the nineteenth) that European writers deliberately featured synaesthesia. Since then, various synaesthetes have appeared in English-language fiction, many described as monstrous, though modern fiction attempts 'realistic' or 'mature' portrayals. In twenty-first century Japanese popular fiction, synaesthetes are in fashion, possibly because of their appearance in English-language works, though (except in hard science fiction) they are usually depicted sensationally. Because my own readings may be bound up in my personal experience as a synaesthete, I hope to exchange opinions with other synaesthetes, researchers, and non-synaesthetes about these 'unrealistic' portrayals, and to invite discussion on to what extent they can be aesthetically justified in fiction.

## **'The Hurt of the Colour of Blood': Synaesthetic Metaphor in the Poetry of the First World War**

*Fiona Burrows*

The University of Western Australia, Australia

This paper looks at synaesthetic metaphor in the works of First World War poets including Wilfred Owen, Siegfried Sassoon and Isaac Rosenberg, to establish its significance as a poetic device for conveying meaning through imagistic expression in response to the new and unfamiliar experiences of trench warfare. The translation of experience into poetic language is an endeavour to which metaphor is innate, and synaesthetic metaphor acts as a powerful poetic device for creating a linguistic representation of sensory experience. The poetic implications of synaesthesia are particularly relevant to the early twentieth century, when poets were attempting to convey meaning through perceptual experience rather than direct statement. For those directly involved in combat during the First World War, the relentless assault of new and horrific sounds, sights and smells was inescapable. When Owen writes of '*the hurt of the colour of blood*' (*Insensibility*, 1917) or the '*green thick odour of his breath*' (*The Next War*, 1917) he is attempting to adequately express the distressing sensory impact of his war experience by aligning the senses of sight and touch (pain, as a form of tactile bodily experience), or linking smell with colour. This paper examines the different forms of synaesthetic metaphor employed consistently by those poets who experienced life on the front-line. It suggests that the widespread use of similar synaesthetic metaphors by these poets indicates the possibility of a universal capacity for synaesthetic expression that is evident in the attempt to translate, through poetic language, personal or traumatic sensory experiences.

## **Synaesthesia & Musicology**

*Jessica Ruth Morris*

Cardiff University, UK

The idea of Musicology for a synaesthete may not seem to be of any importance. However, the important link between a composer or musician's cognitive and sensory reactions upon hearing music and their own musical output can be hugely revealing, both for a musicologist's understanding of music and a synaesthete's understanding of the condition. At present, the academic field of Musicology does not acknowledge the exploration of synaesthesia as anything other than a novelty. However, this paper challenges this notion and suggests that, although synaesthesia may never be at the forefront of musical research it has a place within musicology that has been overlooked. Using the Sound → Colour form of synaesthesia as an example, this paper submits that by exploring the sources of many well known synaesthete composers and musicians both past and present (from Nikolaus Rimsky-Korsakov to Billy Joel) we may be able to extract invaluable information ranging from working methods to personal preferences that otherwise may not have been obvious. Such an approach has the potential to further inform and enhance current literature, and in light of this enable us to broach further questions regarding this fascinating symbiotic relationship. In the very least, such an investigation will enable a greater understanding of the effect of synaesthesia within musicology, of which the subject is in great need.

### **Time-space Synaesthetes and Event memory**

*Julia Simner<sup>a</sup>, Georgina Cooper<sup>b</sup>, C. Ben Simmons<sup>c</sup>, and Mark Price<sup>d</sup>*

<sup>a</sup>Department of Psychology, University of Edinburgh, UK; <sup>b</sup>School of Medicine, King's College London, UK; <sup>c</sup>School of Engineering, University of Edinburgh, UK; <sup>d</sup>Psychology Faculty, University of Bergen, Norway.

Synaesthetes show exceptional abilities in some domains but where do these abilities come from? This talk will examine time-space synaesthetes, who experience time sequences as explicit spatial structures (e.g., they may see months in an ellipse around the body). Time-space synaesthetes are also recognised by their exceptional ability to recall past events (Simner et al., 2009) and by their high visual imagery (Price, 2009). We investigated whether their superior event-recall results from their time-lines per se, or from the superior mental imagery that accompanies those time-lines. We tested 67 non-synaesthetes on their visual imagery, and on their memory for past events. We found that people with better mental imagery also had a better recall of autobiographical events (unrelated to general intelligence). We then selected the non-synaesthetes who showed very high imagery, and compared these to a group of time-space synaesthetes. We found that synaesthetes remembered yet more personal memories in a shorter period of time. It is likely therefore that the superior event-memory of synaesthetes is due in part to their high imagery but also to retrieval strategies involving their explicit synaesthetic time-space forms. We conclude that although high visual imagery may give superior event recall in the general population, imagery alone may not be sufficient to account for the exceptional memories of time-space synaesthetes.

### **Cognitive consequences of synaesthesia: Is there a common basis?**

*Beat Meier & Nicolas Rothen*

University of Bern, Switzerland

There is accumulating evidence that synaesthesia can lead to a variety of cognitive consequences such as an advantage in memory, enhanced imagery, and more creativity, besides those related to phenomenological experience. In the first part of this presentation, we give a brief review of the impact of synaesthesia on memory, imagery, and creativity. Next, we provide some new results which emphasize cognitive styles (visualizer vs. verbalizer) and particular aspects of memory, such as prospective memory and recognition memory. Finally, we put forward the hypothesis that cognitive consequences may be rooted in the phenomenological experiences. That is, synaesthesia provides for a richer world of experience than is normal and this itself is the common basis for the cognitive consequences associated with synaesthesia.

### **Additive Effects of Print and Synesthetic Color and the Role of Imagery**

*Bryan D. Alvarez and Lynn C. Robertson*

University of California Berkeley, Berkeley, CA, USA

Synaesthesia is well understood to be an automatic perceptual phenomenon paralleling print color in some ways but also differing in others. We examined this juxtaposition in a group of 13 grapheme-color synesthetes using a color priming paradigm. Primes either induced no color, print color only, synesthetic color only, or both forms of color simultaneously (e.g., letter "A" printed in red that also triggers synesthetic red). All primes were followed by probes that were printed in the same or different color as prime colors (synesthetic or print). Replicating previous work, synesthetes were faster to name a probe color that was congruent with the prime color versus incongruent (priming). Importantly, we found that synesthetes showed significantly larger priming effects when the prime was a grapheme inducing the same print *and* synesthetic color than when the prime was either color type

alone, suggesting an additive interaction of congruent synesthetic and print color when present simultaneously. Additionally, synesthetes exhibited a strong positive correlation between priming effects (synesthetic and combination color only) and the vividness of self reported imagery as assessed with the Vividness of Visual Imagery Questionnaire (Marks, 1973). Yoked non-synesthete controls showed significant color priming only for primes printed in color and showed no significant correlations with VVIQ. These results suggest that synesthetic and print colors operate through separate but overlapping networks of color perception and that synesthetic color may operate through a unique mechanism supporting visual mental imagery in some respects.

### **Synaesthesia in Russia: history of psychological and neurophysiological research**

*Anton V. Sidoroff-Dorso*

Dept. of Foreign Languages, Moscow Social Pedagogical Institute of Moscow Pedagogical State University, Russia

In 1742, the Russian Imperial Academy of Sciences summoned a public assembly on the topic of coordination of the senses, first on the record. The issue later became a frequent object of physiological research such as equivalent functional and anatomical properties between vision and haptics (Sechenov, 1884) or the specifics of nervous activity and its selective character in *mitempfindungen* (Kovalevsky, 1884; Bekhterev, 1896). In 1888, Prof. Merzhayevsky published his research of a case of *adventitious synaesthesia*. Subsequent theories of synaesthesia were based on a psychological interrelation of emotional analogy and bodily ideation (Sokolov, 1896), psychoanalysis (Yermakov, 1914), ionic diffusional cross-influence and physiochemical processes (Lazarev, Anisimov, 1930). Following Sechenov's and Pavlov's early methodological emphasis on investigating the physiological determinants of the human mind, several major experimental studies of synaesthesia were carried out such as: (1) physiological research into coordination of the senses that identified distinct types/degrees of cognitive/physiological integration in synaesthesia (Kravkov, 1948); (2) determination of its functional status in the sensory system and cognitive performance (Anokhin, Ananyev, Natadze); and (3) longitudinal exploration of a synaesthete's personality and cognitive processes and its neuropsychological interpretation (Luria). At present, recent data from research into implications of subject-dependent psychophysics for sensory tasks (Gusev) and EEG correlations coupled with functions of deep brain nuclei in categorical cognition (Mukhin, 2004) can also provide an informative framework for current synaesthesia research.

### **1849: Three new cases of synesthesia?**

*Jörg Jewanski<sup>1</sup>, Julia Simner<sup>2</sup>, Sean A. Day<sup>3</sup>, & Jamie Ward<sup>4</sup>*

<sup>1</sup>Department Musikhochschule, Universität Münster, Germany; <sup>2</sup>Department of Psychology, University of Edinburgh, U.K.; <sup>3</sup>Department of English and Journalism, Trident Technical College, Charleston, USA; <sup>4</sup>School of Psychology and Sackler Centre for Consciousness Science, University of Sussex, Brighton, U.K.

The first case of synesthesia was reported in 1812 by Georg Sachs (Jewanski, Day, & Ward, 2009). There are no known new cases described between 1812 and 1848, but from 1849, there were at least 12 reported cases of synesthesia during the next three decades, and many reviews of these cases. If we believe authors from this second half of the 19th century (Perroud 1863, Chabaliere 1864, Krohn 1892, Millet 1892, Clavière 1898), there were three new cases of synesthesia ›after Sachs‹ discovered in 1849 alone. This talk will provide an overview of these early three cases, taken from our forthcoming article "The Development of a Scientific Understanding of Synesthesia from Early Case Studies (1849–1873)" (Journal of the History of the Neurosciences, in press; Jewanski, Simner, Day & Ward). We bring these

cases to a wider audience because the literature describing synesthesia during the 19th century is largely unknown to contemporary researchers.

## **KEYNOTE TALK**

### **The Cross-Activation Theory at Ten: Substantial Growth, Future Challenges**

*Edward M. Hubbard*

Vanderbilt University, Nashville, TN, USA

In 2001, Ramachandran and Hubbard introduced the cross-activation model of grapheme-colour synaesthesia. On the occasion of its tenth birthday, I will review the evidence from experiments that have been conducted to test the model, in order to assess the growth and abilities of the model. I will review data from behavioural, functional neuroimaging (fMRI), anatomical (DTI and VBM) and electroencephalography (EEG) and magnetoencephalography (MEG) studies of grapheme-color synesthesia. Although much of this evidence has supported the basic cross-activation hypothesis, our growing knowledge of the neural basis of synaesthesia, grapheme-processing and colour-processing has necessitated two specific updates and modifications to the basic model: (1) Our original model assumed that binding and parietal cortex functions were normal in synesthesia; we now recognize that parietal cortex plays a key role in synesthetic binding, as part of a two-stage model. (2) Based on MEG data we have recently collected demonstrating that synaesthetic responses begin within 140 ms of stimulus presentation and an updated understanding of the neural mechanisms of reading as hierarchical feature extraction, I will present a revised and updated version of the cross-activation model, the cascaded cross-tuning model. I will then briefly discuss data demonstrating that the cross-activation model may be extended to account for other forms of synaesthesia, and end with a discussion of open questions about how learning, development and cortical plasticity interact with genetic factors to lead to the full range of synaesthetic experiences. An explicitly neurodevelopmental approach will be required to better understand how experience shapes the brain circuits that mediate synaesthetic experiences, and may constitute the major challenge for the next ten years of the cross-activation theory.

## **Sunday 27<sup>th</sup> March**

### **The most fascinating question in synesthesia research**

*Romke Rouw*

University of Amsterdam, the Netherlands

The most fascinating aspect of synesthesia for me (as a non-synesthete) is not merely the presence of additional sensations. Even more intriguing is the synesthete's strong ability to deal with the simultaneous presence of these synesthetic sensations with 'real' (non-synesthetic) events. Why do synesthetes \*not\* get confused by this mix of sensory experiences? One possibility is that synesthetes have generally increased 'cognitive control processes'. These processes control other mental processes. For example: planning, task switching, inhibiting inappropriate actions, or selecting relevant information. We used well-known 'cognitive control' tasks, such as the 'Stroop' task. In the Stroop task, a color word (e.g. 'green') is presented in a color that is congruent or incongruent with that word. We also presented the "synesthetic Stroop task", where a letter is presented in a color that is congruent or incongruent to the synesthetic color of that letter. We did not find improved performance of synesthetes as compared with non-synesthetes on general cognitive control functions. Thus, synesthetes did not show better performance than non-synesthetes on the

Stroop task. Furthermore, we found no correlation between general cognitive control and 'synesthetic control' tasks. For example, those subjects that are best in inhibiting the non-relevant information during a classical Stroop task, are not the same as those that are best in inhibiting the non-relevant color during the Synesthetic Stroop task. One explanation for our results is that people with synesthesia have special 'synesthetic control' functions, that are not dependent on their general cognitive control functions.

### **How many different types of grapheme-colour synaesthesia are there?**

*Jamie Ward*

University of Sussex, UK

The most common answer to that question is two: projectors (who experience the colours 'on the page') and associators (who know the colour or see it in their mind's eye). Confirmatory evidence appears to come from functional imaging studies showing different neural substrates for synaesthetes divided along this dimension using questionnaire data. However, other interpretations are possible. For instance, if questions relating to other potential variants are not included on the questionnaire in the first place then we'd never know about them. Also, previous questionnaires have not been explored (using factor analysis) to determine whether the best solution is 2 factors, 3 factors or more. In this talk, I'll present evidence from a new questionnaire measure of grapheme-colour synaesthesia and link it to objective tests of synaesthesia. The results yield several new insights. For example, synaesthetes who claim to 'know' the synaesthetic colour report less automatic associations but do not necessarily vary in intensity or consistency. The quality of 'knowing' may relate more to whether the association is passively/actively retrieved rather than its perceptual nature. Moreover 'knowing' appears to be separate from 'seeing in the mind's eye' and 'seeing literally inside the body' (the latter being a very common experience, but neglected in all previous research).

### **Synesthesia -- A Personal Perspective**

*Lidell Simpson*

Independent, USA

I am a synesthete with Vision to Sound synesthesia having congenital sensorineural nerve deafness. Along with vision to sound, also have touch to sound synesthesia which are more prominent also have to a lesser degree, smell and taste to sound, and body motion to sound synesthesia. In effect, just about all of my sensory perception has a sound counterpart. Even emotions gets translated to sound. And not so infrequently, certain techno music caused me to see blue blobs projected and certain sounds of music also get translated into sense of touch as a bi-directional synesthesia. Just over a decade ago, I joined the American Synesthesia Association with the determination to better understand this seemingly mysterious phenomena which early on left no doubt that its study will open a new fascinating window into the inner working of the mind and the nature of human consciousness. I have taken on a particular interest in colored-grapheme synesthesia wondering why the is the color A is red as the saying goes. Many studies have been done and presented over the years at the conferences. With all its idiosyncrasies, many different theories were presented to explain this by several researchers. What is the common thread that could account for the colors and its frequency? What are the factors that selects a particular color? Those questions are just some that kept my interest in this subject. Along with audio clips reflecting my vision to sound synesthesia, I shall offer my perspective as to the origin and the significant of synesthesia. What does it mean to more importantly to the non-synesthete population and what tells us about how we perceive and orient the world around us. Are we getting mired in too much detail that we are missing the big picture?

### Swimming-style synaesthesia

*Uta M. Jürgens<sup>1,2\*</sup>, Nicolas Rothen<sup>3\*</sup>, Beat Meier<sup>3</sup>, Aleksandra Mroczko<sup>1,4</sup>, Danko Nikolić<sup>1,5</sup>*  
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In swimming-style colour synaesthesia, each swimming style evokes another synaesthetic colour. Importantly, the synaesthetes' experience is evoked also in the absence of direct sensory stimulation, i.e. the proprioceptive input during swimming. To evoke synaesthetic colours, it is sufficient to trigger the concept of a given swimming style e.g., by showing a photograph of a swimming person. We verified the genuineness of the phenomenon with behavioural and a psychophysiological tasks, i.e., colour-consistency test, two different Stroop-type tests and a synaesthetic conditioning task. In the behavioural tests, synaesthetes differed from a naive control, but not from a trained control. On the psychophysiological level, however, we found a conditioned synaesthetic response only for the synaesthete, but not for the trained control. Our results demonstrate that i) only behavioural facets of synaesthesia, but not the experience, can be evoked through training. Swimming-style colour synaesthesia, thus, is a genuine form of synaesthesia; and that ii) furthermore, semantic representations play a pivotal role in the emergence of synaesthetic experience in swimming-style color synaesthesia. This suggests that synaesthetic inducers in general do not operate at a sensory level but instead, at the semantic level at which concepts are evoked.

### Synthetic Synaesthesia and Sensory Substitution

*Michael J Proulx & David Brown*

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Sensory substitution devices for blind persons provide the missing visual input by converting images into sound. Some blind expert users experience visual qualia while listening to the output of a device (The vOICe) after extensive use. Although some aspects of the conversion rely on natural crossmodal mappings, the extensive training required suggests that synthetic mappings are required to use the device and to experience visual qualia. Here I will discuss the perceptual and attentional attributes of learning the conversion from images to sounds. Sensorimotor experience may be required to facilitate learning, develop expertise, and to develop synthetic synaesthesia, where the auditory output of the device could evoke visual qualia in users.

### Can you teach yourself synesthesia?

*Olympia Colizoli, Jaap Murre, Romke Rouw*

University of Amsterdam, the Netherlands

One of the most common types of synesthesia is grapheme-color. Why do some people develop this form of synesthesia and others do not? There seems to be a strong genetic component to synesthesia, yet the specifics of a language are acquired as we develop. We wondered if it is possible to learn grapheme-color synesthesia by reading in color. Therefore, we investigated whether reading in color produces synesthetic behavioral effects as well as subjective experiences. We gave subjects books to read, in which four high-frequency letters were matched with high-frequency colors. Each person was asked about their preference for specific letter-color combinations. The individual letter-color pairings were unique for each subject. A synesthetic-Stroop task was given before and after reading to measure implicit learning of grapheme-color associations. The synesthetic-Stroop effect is present after reading the colored novels. Frequency effects are also significant, meaning that

the amount of exposure determines the level of association. A crowding test was given after the reading, comparing the letters which had been colored in the book to letters which had not been in color. Subjects who read the book in color did significantly better on trained graphemes within the crowding task compared to a group of controls. No subjects reported seeing colors when viewing letters. Subjects reported experiencing color when thinking about certain letters and this rating correlates with the size of the effect on the synesthetic-Stroop task, meaning that the tendency to visualize the colored letters is related to behavioral performance.

### **Personification and the brain: An fMRI study**

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Modern synaesthesia research goes beyond looking at purely sensory information processing and includes correspondences involving social and affective properties as well. One such example is the study of Ordinal Linguistic Personification (OLP), a phenomenon that sometimes accompanies coloured-grapheme synaesthesia. OLP synaesthetes attribute mental states and other human characteristics to graphemes, weekdays and months. The attribution of mental states such feelings, intentions, and beliefs, is essential for understanding other people's behaviour, although we sometimes extend this to non-human agents and inanimate objects. Thus, testing synaesthetes who personify objects and ordinal linguistic sequences provides us with a novel test case for our theories concerning the neural bases of social cognition. This also highlights the problem of individual differences in how people think about inanimate things. We will present the results of a new functional neuroimaging study of personification and examine whether the brain areas engaged in implementing synaesthetic personifications are "recruited" from the social cognitive network.

### **Colour and visuospatial perception in a blind subject: an fMRI case study on synaesthesia**

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In spatial sequence synaesthesia (SSS) one or more categories of ordinal stimuli are perceived as arranged in peripersonal space. Using ER-fMRI, we examined the neural bases of SSS and colour (C) synaesthesia in a late-blind developmental synaesthete, JF, to learn 1. whether visual cortex would still be recruited, and 2. to what extent the correlates of SSS correspond to those of spatial imagery. JF reported days of the week and months of the year as coloured and spatially ordered in peripersonal space; parts of the days and festivities of the year were spatially ordered but uncoloured. Two experimental conditions, SSS and SSS+C, were compared. Words denoting time-units that triggered no concurrents were used in a control condition. The stimuli were matched for semantic and syntactic characteristics and the task required the detection of order reversals. Results show that both the SSS and the SSS+C condition activated the occipito-parietal, infero-frontal and insular cortex, but only the SSS+C condition engaged the colour area hOC4v. Whereas the latter result shows the continued recruitment of visual colour cortex in a late-blind synaesthete, the spatial geometry of SSS appears to be related to occipitoparietal areas also engaged by spatial imagery in blind (Vanlierde et al., 2003) and sighted non-synaesthetes (Mellet et al., 1996). Inferior frontal activation may be related to spatial memory and detection, while the insula may contribute to audiovisual integration related to the processing of inducers and concurrents as well as to engagement in a task-dependent vestibular process.

## **Stimulating the Synaesthetic Brain: A Transcranial Magnetic Stimulation (TMS) and Transcranial Direct Current Stimulation (TDCS) Study**

*Devin Blair Terhune<sup>1</sup>, Sarah Ta<sup>2</sup>, Alan Cowey<sup>1</sup>, Tudor Popescu<sup>1</sup>, and Roi Cohen Kadosh<sup>1,3</sup>*

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Two explanations for synaesthesia have been advanced. Synaesthesia may be due to greater-than-normal neuronal connectivity between brain areas (the hyperconnectivity hypothesis). Alternatively, the synaesthetic experience may be mediated by the same neuronal connections that exist in normal brains, and the unusual experience may be induced by disinhibition of signals within or between brain areas (the disinhibition-unmasking hypothesis). Here we examine a new hypothesis that proposes that synaesthesia might be due to cortical hyperactivity. In Experiment 1 we applied Transcranial Magnetic Stimulation (TMS) to the visual and motor cortices of grapheme-colour synaesthetes and non-synaesthetes. We found that grapheme-colour synaesthetes have a lower phosphene threshold by an order of three magnitudes as compared to non-synaesthetes, indicative of higher primary visual cortex excitability. In contrast, the motor threshold was similar in both groups. In Experiment 2 we coupled a grapheme-colour priming task together with transcranial direct current stimulation (TDCS), a method that affects the neuronal threshold, to examine the functional role of the visual cortex in the synaesthetic experience. We found that TDCS, but not sham stimulation, increased the magnitude of the priming effect. These results were specific to the synaesthetic experience, as performance in a non-synaesthetic task (numerical Stroop task) was not affected by TDCS. Our results suggest that grapheme-colour synaesthesia is characterised by hyperactivity or reactivity of the visual cortex. This idea can explain some of the benefits and costs that are associated with synaesthesia, as well as its effect on synaesthetic brain organisation.

## **Multimedia Synesthetic Art**

*Carrie C Firman*

University of Buffalo, NY, USA

My creative process and goals involve the authentic description of the very real, beautiful nature of synesthesia. I strive to build interdisciplinary ties to my work so that it may accurately represent and support research, as well as inviting synesthetes to interact and share their own experiences. My new work includes an electronic installation which senses the viewer's location and responds by projecting a sound and visual animation from my synesthetic experience. "Synexperience" speaks of the involuntary, consistent nature of our phenomenon and the simple, abstractaesthetic of our triggered photisms. (<http://carriecfirman.com/newwork/synexperience.html>) "That Which Cannot Be Said With Words" is an abstract photography series that demonstrates the vibrant diversity of synesthetic photisms. The pictures that evoke the strongest reaction from myself and other synesthetes greatly resemble Klüver's form constants, hinting at the possibilities of commonalities. Selections from this work are being used to collect data online. (<http://carriecfirman.com/synesthesia/nowords.html>) (<http://carriecfirman.com/synesthesia/survey/>) My "Synesthetic Keyboard" is developing as an outlet for the grapheme-color synesthete. Part abstract electronic art, part scientific testing instrument, this computer program displays colored blocks instead of letters and numbers. Options for alphanumeric display and custom color settings will be available so that each synesthete may have a tool that displays text as they see it, in their very own colors.

(<http://carriecfirman.com/synesthesia/applet/>)

**“Im Wonne~~n~~monat Mai – A Play for Voices.” or Exploring the multi dimensional nature and potential of the spoken word via synaesthetic perception***Barbara Ryan*

Independent

At last year's conference I presented my findings from working with The Synaesthesia Translator – a computer programme designed to automatically assign individual graphemes in large chunks of text to their 'correct' synaesthetic colours. This work dealt mostly with 'literal translations'. In 'real time' however, whilst synaesthetic perception remains true to specific allocations, it *does* vary according to individual language, accent, tonality and the influence of prominent graphemes and phonemes within individual words or phrases. This year I will be concentrating on the portrayal of synaesthetically perceived data as it is experienced in real time through a short film that illustrates the perceptions and sensations triggered by the spoken word. "Im Wonne~~n~~monat Mai" is a play for voices – a monologue in which one performer plays all four parts. Unless deliberately parodying another character, each commentator expresses themselves solely in their native tongue, speaking in Polish, German, English and French respectively and each bringing their individual cultural slant and 'prejudices' to the proceedings as they satirise a yearly art event." Accordingly, each character has a distinct synaesthetic 'persona', which is reflected on film by the use of digital editing techniques. The dialogues create a literal manifestation of the 'spoken decor' stage technique by displaying the associated 'scenery' of colour, pattern and sensation. The dialogue itself is presented as a sub-titled 'ticker-tape' synaesthesia – its nuances and natural variance influenced by the alternating delivery of the script. This particular film screening will also be accompanied by persona to olfactory 'scratch and sniff' cards. All material written, performed and produced by Barbara Ryan – Institut St-Loup Projects 2010. Film running time approx 9 minutes.

**POSTER ABSTRACTS****The Space Is Alive With The Sound Of Music: The Case Of Musical Tone-Space Synaesthete***Lilach Akiva-Kabiri, Limor Gertner, Gil Ben-Tzvi & Avishai Henik*

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In a musical tone-space synaesthesia auditory tones are experienced in spatially-defined array. Previously it was shown, that symbolic inducers (i.e., numbers, months) may trigger shifts of attention according to the inducer's relative position on the synaesthetic spatial form. In the current study we tested A, a musical tone-space synaesthete and group of matched controls, on a spatial cueing task adopted from Fisher et al., (2003). Participants were presented with an auditory tone (cue) – C4, D4, A4 or B4 (Do, Re, La and Si from the central octave) - followed by an asterisk (target) in an upper-right square or lower-left square. Cue-target compatibility was manipulated according to the synaesthetes' diagonal spatial tone-form. Participants were asked to ignore the tone and press a key as soon as the target appeared. For A, but not for controls, a compatibility effect was observed. Accordingly, a shorter reaction time was observed when the cue-target was compatible (e.g., the sound of DO followed by a lower-left asterisk) than when it was incompatible (e.g., the sound of DO followed by an upper-right asterisk). This effect was evident only for long cue-target SOAs (500 and 750). Our results reveal that synaesthete A could not ignore the tone, since it involuntarily oriented her attention according to her spatial notes-form. This is the first study to show the genuineness of musical tone-space synaesthesia.

**Synaesthetic experience in the university. Synthesis and application on innovative didactics (Survey Of possible synaesthetes in the field of university education 2006-2010)***M<sup>a</sup> Jose de Córdoba Serrano and Julia Lopez de la Torre Lucha*Artecittà International Foundation (*Research, Development and Promotion Department*) & Granada University

Artecittà International Foundation (FIAC), in collaboration with the University of Granada, has been conducting a study interdisciplinary on synaesthesia in different university environments. Besides, FIAC has organized three international conferences and international courses in collaboration with various Spanish and European universities. As a result of the effort made in the university environment about the relevance of synaesthesia, we have achieved including the study of synaesthesia study in Masters Degrees at the University of Seville and Granada. Then, at the beginning of the 21<sup>st</sup> century comprehensive synthesis and results were put into practice. As a result, an innovative didactic project for students of Fine Arts in Granada University has started, called *New artistic didactics: Synaesthesia as a core for developing a holistic creative thinking*. The analysis and application of new discoveries on our natural synaesthetic ability and the necessary research for the application on artistic and educational environments clearly prove that although synaesthesia was discovered more than 300 years ago, this ability or condition is present in our cognitive, perceptual development. It also encourages multiplicity of intelligences and creativities, what also implies multiplicity of synthesis of arts.

### Months in Space: Synesthesia Modulates Attention and Action

Liana Diesendruck<sup>\*1</sup>, Limor Gertner<sup>\*2</sup>, Lior Botzer<sup>3</sup>, Liat Goldfarb<sup>4</sup>, Amir Karniel<sup>3</sup>, and Avishai Henik<sup>2</sup>

\*These authors contributed equally to this research; <sup>1</sup> Department of Computer Sciences and Zlotowski Center for Neuroscience, Ben-Gurion University of the Negev, Beer Sheva, Israel; <sup>2</sup> Department of Psychology and Zlotowski Center for Neuroscience, Ben-Gurion University of the Negev, Beer Sheva, Israel; <sup>3</sup> Department of Biomedical Engineering and Zlotowski Center for Neuroscience, Ben-Gurion University of the Negev, Beer Sheva, Israel; <sup>4</sup> Department of Psychology, Center for the Study of Brain, Mind and Behavior, Princeton University, Princeton, New Jersey.

Month-space synesthetes experience months as sequences arranged in spatially-defined configurations. While most works on synesthesia have studied its perceptual implications, this study focuses on the synesthetic influence on a synesthete's action behavior. SM, a month-space synesthete, and 5 matched controls performed a spatial Stroop-like task in a haptics and virtual reality combined environment, which was especially designed to simulate SM's three-dimensional synesthetic experience. In the experiment, a circle and a word were presented simultaneously. The word consisted of either a month name or a direction name, and was located at the center of the screen, while the circle was displayed in one of four peripheral positions—top, bottom, right or left. When SM was asked to ignore the word and reach for the circle, no effects were found. In contrast, when she was asked to ignore the circle and reach for a location indicated by the word, a congruency effect was found for both months and direction words. Crucially, these effects were evident in all measurements of reaching performance (i.e., path, velocity and trajectory of movement). Our findings revealed that for month-space synesthetes, months trigger spatial shifts of attention in a similar manner as directions do. Moreover, these shifts of attention affected not only latent cognitive processes (i.e., reaction time) but also overt behavior (i.e., entire hand movements).

### Synaesthetic metaphors and the Semantics/Pragmatics distinction

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Traditionally, two different models about the semantic-pragmatic distinction have influenced the theory of understanding metaphors. On the one hand, in the *literalist* view (Cappelen & Lepore, 2005), the comprehension of metaphorical utterances proceeds in two stages. First, the hearer computes the proposition literally expressed by the utterance; then, on the basis of this proposition, he or she infers what the speaker metaphorically implies (Grice, 1989). On the other hand, *contextualism* relies on the view that syntax and semantics do not produce a determined representation of meaning and the content expressed by an utterance is the result of a contextual modulation (Récanati, 2004). For that reason, the metaphorical comprehension is direct, in the sense that it comes first in the order of interpretation and the metaphorical meaning coincides with what is explicitly said (Bezuidenhout, 2001). My aim in this paper is to argue that synaesthetic metaphors (for example 'caressing voice', 'dark sound' and 'sweet smell') find in *moderate contextualism* a proper model to explain the process of understanding metaphors. Specifically, I defend two claims: first, against the literalist model, synaesthetic metaphors give further evidence to the contextualist thesis that the literal interpretation of utterances is not necessarily computed as a first step by default. That is because, in the case of synaesthetic metaphors, the metaphorical interpretation is the only candidate available to ordinary speakers. Second, against any radical contextualist approach to linguistic meanings, I argue that the syntax and the semantics of synaesthetic sentences show the necessity of maintaining the linguistic distinction between literal and metaphorical meanings.

**The role of cognitive control in grapheme-color synesthesia***Joram van Driel & Romke Rouw*

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The phenomenon of grapheme-color synesthesia (experiencing, e.g., a red color upon perceiving the letter 'L') is currently investigated intensively, especially regarding the level of processing at which the anomalous sensations arise. However, for synesthetes photisms are more than just additional color perceptions. Everyday life requires them to distinguish real from synesthetic colors, and to actively suppress them when necessary. Thus, we argue that there is at least a certain level of cognitive control involved in synesthetic experience. To investigate this, we used two 'classical' tasks to study synesthesia, a Stroop (cognitive) and a crowding (perceptual) task, and we combined these with different cognitive control paradigms. In Experiment 1, a stop-signal manipulation was added to a synesthetic Stroop task. We found Stroop-effects, but these did not change when cognitive load was increased by monitoring stop signals. Moreover, SSRTs were similar for stopping on congruent versus incongruent grapheme-trials. In Experiment 2, we combined visual crowding with task-switching. Synesthetes were able to use their synaesthetic photisms to reduce crowding, and were better than non-synesthetes when additional rule switches were required. These results are discussed in light of individual differences (e.g. projectors versus associators) and imply a possible special status of synesthetic experience in higher cognition.

**The Ambiguous Synaesthesia of Olivier Messiaen**

Solange Glasser-Sbieh

*Independent*

Born in 1908, French composer Olivier Messiaen showed prodigious musical capacities at a very young age, and became aware during his early adolescence of his ability to "see" music. While he understood that his ability to see coloured notes and chords was not common, he none the less persisted in meticulously writing and describing in detail the colours that he experienced in his compositions, including them as authentic aspects of his music. However, the question of the authenticity of this presumed idiopathic Synaesthesia remained. Did his research into sound-colour correspondences stem from a case of idiopathic synaesthesia, or was he simply a child of his time: an époque rich in experiments searching for a confluence of the arts, which nourished his creative genius and extraordinary capacity for synthesis? There is a third possibility: that of an induced, but decisively acquired Synaesthesia, provoked by extreme environmental conditions during the second world war, which in his case may have triggered synaesthetic hallucinations. Studying the case of Messiaen has given us the chance to explore the effects of his presumed Synaesthesia on his compositional style and objectives, as well as posing the question as to the role that this presumed Synaesthesia may have played in the development of his creative genius, and of his extraordinary ability to synthesize and juxtapose disparate elements within his works. In using Messiaen as an example, it is possible to consider that this metaphoric capacity is perhaps one of the keys to the understanding of creativity in general.

## Synaesthesia in adults with high functioning autism and Asperger Syndrome

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Case studies (Baron-Cohen et al., 2007) and clinical reports have suggested a potential link between autism spectrum conditions (ASC) and synaesthesia. A genetic study provided further support of this association, linking auditory-visual synaesthesia to an area on chromosome two, which has previously been associated with autism (Asher et al., 2009).

**Study 1:** To estimate the prevalence of synaesthesia in a high functioning autism/Asperger Syndrome (HFA/AS) sample, we asked volunteers whether they experienced synaesthesia.

**Sample:** 142 adults (18+) diagnosed with HFA/AS and 49 typical adults were recruited from the Autism Research Centre and Cambridge Psychology volunteer databases at [www.autismresearchcentre.com](http://www.autismresearchcentre.com) and [www.cambridgepsychology.com](http://www.cambridgepsychology.com). **Method:** Participants received a survey by email. They were asked to indicate whether they had any of 21 listed characteristics and conditions, including synaesthesia, epilepsy, and left-handedness.

**Results and Discussion:** Eighteen (12.7%) of the HFA/AS participants reported at least one form of synaesthesia compared to two (4%) control participants. Synaesthetes did not report which form(s) of synaesthesia they experienced. This three-fold difference between the groups was nevertheless non-significant ( $X^2(1) = 2.87, p = .09$ ) which may reflect the control group being under-powered. **Study 2** Aims to: (1) re-examine the rate of synaesthesia in the HFA/AS population using a larger control group and (2) validate auditory-visual (AV) and grapheme-colour (GC) synaesthesia in HFA/AS adults using two versions of the revised test of genuineness (TOG-R; Asher et al., 2006).

**Sample:** 149 adults diagnosed with HFA/AS and 130 typical adults were recruited from our databases. **Method:**

**Phase I:** All participants completed an online synaesthesia screening questionnaire. Based on their responses, participants were placed into one of four groups: (1) synaesthesia+HFA/AS, (2) synaesthesia+no ASC, (3) no synaesthesia+HFA/AS controls, (4) no synaesthesia+no ASC controls. **Phase II (in progress):** Based on self-report, synaesthetes will complete the AV and/or GC TOG-R(s). Depending on the distribution of AV/GC synaesthetes, matched non-synaesthete controls will complete the AV and/or GC TOG-R(s). **Results:** Preliminary results show a significantly higher rate of self-reported synaesthesia in adults with HFA/AS compared to typical adults. **Discussion:** Discovery of a higher rate of synaesthesia in an ASC population has important aetiological implications. If people with ASC are more likely to experience synaesthesia, the two conditions might share an underlying biological basis in terms of both neuronal connectivity and genetics. Furthermore, synaesthesia may be related to sensory features of ASC. This warrants further research.

## Probing for induction of synaesthetic behaviour in non-synaesthetes through explicit versus implicit learning of grapheme-colour associations

Flor Kusnir & Gregor Thut

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The two main models of grapheme-colour synaesthesia diverge on a central question: whether crossmodally triggered sensations reflect (1) a variant of normal brain organization/connectivity (at the extreme of the normal spectrum) or (2) instead qualitatively deviant connectivity. To test for a "synaesthetic continuum," implied by model 1, we developed a learning paradigm that aimed to train, either implicitly or explicitly, grapheme-colour associations in 30 non-synaesthetic adult observers via a visual search task. During learning, search arrays of coloured graphemes were presented, where graphemes were the target features and colours were irrelevant; and certain target-graphemes were more often associated with a distinct colour (statistical probability learning). A modified-STROOP test, a key marker of synaesthesia, followed. We found a dissociation between explicit and implicit learners. Explicit learners showed a correlation between the strength of the newly-formed

associations, as indexed by the learning curves, and the STROOP-effect, such that better search performance for more frequent (versus infrequent) grapheme-colour associations led to stronger STROOP-effects. Implicit learners did not show this relationship. This suggests that explicit learners bound graphemes with congruently-matched colours along a continuum.

## **The Shape of Sounds**

*Timothy B Layden*

THE SHAPE OF SOUNDS is a series of sound and visual art works that explores kinaesthetic and visual aspects of my experience of sound. There are particular kinds of sounds that give me strong synesthetic reactions. I recorded these kinds of sounds and used them to create sound compositions. While editing these compositions I created drawings that outline the trajectory and morphing of the sensations of objects moving in the space around me. These were used as source material to develop mixed media paintings of the shapes undergoing transformation. In each visual work my focus shifted to different aspects of the experience: looking at the shapes themselves, their movement and how they influence one another. Each visual piece is but a snapshot of the overall experience. I have developed a website to feature the project [www.theshapeofsounds.com](http://www.theshapeofsounds.com)

In continuation to The Shape of Sounds project I am currently beginning a new project combining techniques used to develop the Shape of Sounds together with figurative drawing to explore connections between what is the seemingly concrete experience of synesthesia and that of memory evoked by sensory stimuli.

## **Perception of voice quality by synaesthetes, phoneticians and controls**

*Anja Moos<sup>1, 2</sup>, Rachel Smith<sup>1</sup>, David Simmons<sup>2</sup>*

<sup>1</sup>Glasgow University Laboratory of Phonetics, School of Critical Studies <sup>2</sup>School of Psychology University of Glasgow

Although synaesthetic perceptions triggered by people's voices (the sound of the voice rather than the content or sound of the words) have been reported by synaesthetes, there is little scientific research on this variant of synaesthesia. We therefore conducted a survey on voice colour/texture synaesthesia. Voice synaesthetes, phoneticians and control participants were asked to describe recorded voices in their own words, to choose one of sixteen colours and sixteen textures which best fit the voice, and to choose the strength of some attributes which describe the voice (e.g. rough vs. smooth, light vs. dark, grey vs. colourful). Two sentences spoken by two trained phoneticians as reference exemplars of ten articulatory-defined voice qualities (VQ) each (e.g. nasal, whisper, falsetto) served as stimuli. There was a short voice discrimination task at the end of the survey. Preliminary results from 7 voice synaesthetes, 8 phoneticians and 28 controls indicate that all three groups agreed on a harsh voice as being significantly harder, rougher and dryer than any other VQ and falsetto being higher than any other VQ (results from attribute strength selection). It was also found that both the fundamental frequency and harmonicity of the stimuli correlated significantly and positively with the luminance of the colours that participants associated with them. A general pattern was found insofar as similar colours were associated with the same VQ across groups. Qualitative analysis of the verbal descriptions will be presented as well. Overall, synaesthetes performed worse on the voice discrimination task than other participant groups, but were outstanding at discriminating speakers when the voice quality was whisper.

### **Swimming-style synaesthesia – an ideaesthesia?**

*Danko Nikolic<sup>1,2</sup>, Uta M. Jürgens<sup>1,3</sup>, Nicolas Rothen<sup>4</sup>, Beat Meier<sup>4</sup>, Aleksandra Mroczko<sup>1,5</sup>*

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The traditional and predominant understanding of synaesthesia is that a sensory input in one modality (inducer) elicits sensory experiences in another modality (concurrent). Recent evidence suggests an important role of semantic representations of inducers. We report here the cases of two synaesthetes, experienced swimmers, for whom each swimming style evokes another synaesthetic colour. Importantly, synaesthesia is evoked also in the absence of direct sensory stimulation, i.e. the proprioceptive input during swimming. To evoke synaesthetic colors, it is sufficient to evoke the concept of a given swimming style e.g., by showing a photograph of a swimming person. A colour-consistency test and a Stroop-type test indicated that the synaesthesia is genuine. These findings suggest that synaesthetic inducers in general do not operate at a sensory level but instead, at the semantic level at which concepts are evoked. Hence, the inducers are not defined by the modality-dependent sensations but by the “ideas” activated by these sensations.

### **Swimming-style colour synaesthesia: Genuine or acquired through training?**

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In swimming-style colour synaesthesia different colour experiences are elicited by different swimming-styles. This new form of synaesthesia seems to be far more complex in terms of the synaesthetic inducer compared to other forms of synaesthesia documented so far because a swimming-style involves proprioceptive input and kinaesthetic sensations, in addition to conceptual representation. However, as there are only four different swimming-styles (i.e., butterfly, breaststroke, backstroke, and crawl), it is possible that this form of synaesthesia has developed through learning swimming-style colour associations rather than being a genuine, form of synaesthesia. To test this question we compared performance of a swimming-style colour synaesthete and a matched non-synaesthete control, who received extensive training on swimming-style colour associations, with a behavioural and a psychophysiological task. The behavioural was a priming tasks (i.e., synaesthetic Stroop). The psychophysiological was a conditioning task (i.e., synaesthetic conditioning). In both tasks, the synaesthete and the matched control were presented with different colours and pictograms of swimming-styles. On the behavioural level, we found a synaesthetic Stroop effect for both the synaesthete and the trained control. On the psychophysiological level, however, we found a conditioned synaesthetic response only for the synaesthete, but not for the trained control. Our results demonstrate that swimming-style colour synaesthesia is a genuine form of synaesthesia. On a behavioural level, but not on a psychophysiological level, swimming-style colour synaesthesia can be mimicked in a trained control. Thus, our results show that only behavioural facets of synaesthesia, but not the experience, can be evoked through training.

**Is there such a thing as normal perception?***Noam Sagiv*<sup>\*1</sup>, *Alireza Ilbeigi*<sup>1</sup>, *Oded Ben-Tal*<sup>2</sup><sup>1</sup>Centre for Cognition and Neuroimaging, Brunel University, West London; <sup>2</sup>Music Department, Kingston University, London.

Most people take perception for granted and rarely stop to consider that others may actually see things differently. Although it is difficult to compare experiences, synaesthesia seems to provide strong evidence for substantial individual differences in perception. Because synaesthetic experience is not shared by all (admittedly, it can depict objects or features that are not really there), synaesthetic experience could actually be considered hallucinatory. Indeed anyone who does not have synaesthesia might conclude that synaesthetic images, like hallucinations, occur "in the absence of an appropriate stimulus" (one of the terms used to define hallucinations; Slade & Bentall, 1988). But who decides what stimuli are appropriate inducers of a given perceptual experience? Should this be down to the majority opinion or could we actually incorporate individual differences into this picture? After all, what is normal or appropriate depends on the neural architecture of each individual. A visual stimulus may be appropriate for evoking a visual experience in most individuals, but not in the blind. Conversely, if one's brain has extra connections between the visual and auditory cortex, then synaesthesia should be expected to be the normal mode of perception in such a case. Thus, as we learn more about the functional neuroanatomy of brains, we can predict more precisely what perceptual experiences should be expected. Perception is thought to facilitate our interaction with the environment. Unlike hallucinations that could be viewed as noise in the signal, synaesthetic experiences appear to serve a useful function: Owing to the stable mapping between inducer and concurrent synaesthetic experience, synaesthetic imagery does convey meaning. We suggest that neuroscience is providing us with direct evidence to support a pluralist view of perception. This evidence should be incorporated into theories concerned with the relationship between perception and reality. We develop these ideas further in the upcoming paper in *Intellectica* (Sagiv, Ilbeigi, & Ben-Tal, in press).

**An Independent Component Analysis of fMRI data of grapheme-colour synaesthesia***Karsten Specht*<sup>1,2</sup> and *Bruno Laeng*<sup>3</sup><sup>1</sup>Department of Biological & Medical Psychology, University of Bergen, Norway; <sup>2</sup>Department of Clinical Engineering, Haukeland University Hospital, Bergen, Norway; <sup>3</sup>Department of Psychology, University of Oslo, Norway

In this fMRI study, two synaesthetes and a matched group of control subjects performed a coloured-word (classic) Stroop task and a single-letter (synaesthetic) Stroop task, where the participants had to name aloud the ink-colour of the colour-word and of the single-letter, respectively. It is known that the classic Stroop task creates a cognitive-conflict situation in both groups of subjects, while the single-letter task does this only in synaesthetes. In order to identify the underlying neuronal mechanisms and the involved neuronal networks in more detail, an independent component analysis (ICA) was performed. Three components of interest were identified and the individually reconstructed component maps were subject to a 2x2 ANOVA with the factor task (colour-word/single letter) and group (synaesthetes/control group). The ICA identified an „attention" network, a „perceptual" network as well as a „conflict monitoring" network. Furthermore, increased activity was observed, for synaesthetes only, in right V4 during the single-letter Stroop task. In addition, these three networks were differentially activated in the two groups, as reflected by significant „task" x „group" interactions. Importantly, V4 and ACC activity occurred in different components, indicating that these areas belong to different networks. Thus, the ICA analysis is able to differentiate between networks in a remarkably clear-cut way.

**Exploring synaesthetes' mental imagery abilities across multiple sensory modalities***Mary Jane Spiller, Clare Jonas, Ashok Jansari*

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Previous research on the mental imagery abilities of synaesthetes has concentrated on visual and spatial imagery in synaesthetes with spatial forms (Price, 2009; 2010; Simner et al, 2008) and letter-colour synaesthesia (Spiller & Jansari, 2008). Though Barnett and Newell (2008) asked synaesthetes of all types to fill out a questionnaire on visual imagery, most of their synaesthetes reported some form of linguistic-colour synaesthesia. We extend the investigation of mental imagery to a wider variety of synaesthesia types and a wider variety of sensory modalities using a questionnaire study and (in future) several tests of mental imagery ability. Our preliminary results indicate that, as a group, synaesthetes self-report greater vividness of visual, auditory, tactile, and taste imagery (but not olfactory, somatic or kinaesthetic imagery) than do non-synaesthetes. They also report making greater use of mental imagery than non-synaesthetes, in everyday activities. These results have important implications for our understanding of synaesthesia, and potential fundamental differences in perceptual processing of synaesthetes and non-synaesthetes.

**Numbers in the Synaesthete's Brain: Negative and Positive Aspects.**Jacqueline M. Thompson<sup>1</sup>, Hans-Christoph Nuerk<sup>2,3</sup>, Tudor Popescu<sup>1</sup>, Korbinian Moeller<sup>2,3</sup>, Roi Cohen Kadosh<sup>1</sup><sup>1</sup>Department of Experimental Psychology, Oxford University, Oxford, UK; <sup>2</sup>Department of Psychology, Eberhard Karls University, Tuebingen, Germany; <sup>3</sup>Knowledge Media Research Center, IWM-KMRC

Past research has suggested that synaesthesia may simply be a more explicit manifestation of widespread human tendencies for implicit cross-modal and cross-categorical cognition. For instance, number-space synaesthetes experience numbers as being situated in an idiosyncratically shaped and oriented layout, called a number form, in their "mind's eye." It has been suggested that the explicit mental representation of numbers in number-space synaesthesia can shed light on the implicit mental representation of numbers in non-synaesthetes. The current research investigated possible differences in numerical processing between pure sequence-space synaesthetes (number-space synaesthetes without any other type of synaesthesia apart from time-space synaesthesia) and non-synaesthete controls (matched for age, handedness and gender). Experiment 1 evaluated differences in a number magnitude comparison task. Compared to controls, synaesthetes exhibited a significantly more pronounced distance effect: that is, faster responses to number pairs with larger numerical differences, an effect interpreted to indicate a more precise representation of numerical magnitude. In Experiment 2, participants were asked to mark the position of a given number on a physical "number line" defined by a lower numerical limit on the left and an upper limit on the right. While accuracy of mapping did not differ between the groups, synaesthetes were significantly slower to map numbers which corresponded to their explicit mental representation (i.e. positive numbers, as compared to negative numbers); controls, however, exhibited no such difference in response times. Together, these experiments demonstrate that while the explicit representation of numbers in synaesthetes can be advantageous, under some conditions it can be disadvantageous.

### **Training Synaesthesia**

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Grapheme-colour synaesthesia denotes the psychological phenomenon in which digits and/or letters involuntarily evoke a sensation of colour. Automaticity of these sensations is conventionally demonstrated with the synaesthetic Stroop test in which coloured letters are presented and participants have to name the colour of each letter. Some letters are in a colour congruent to the synaesthetic experience (e.g., a red “A” when the synaesthetic colour for “A” is red) and some are incongruent (e.g., a green “A” when the synaesthetic colour for “A” is red). Many studies have demonstrated that synaesthetes are slower in the incongruent compared to the congruent condition. These results may indicate that the synaesthetic Stroop test can be used as a diagnostic marker to identify true synaesthetes. However, recently it was demonstrated that also non-synaesthetes with trained letter-colour associations are able to show a “synaesthetic” Stroop effect in a colour naming paradigm. The present study was designed to replicate and extend these findings. Forty non-synaesthete participants were trained on 10 consecutive days with either the previously used non-adaptive or a new adaptive digit-colour training. Pre- to post-training changes were tested with a conventional Stroop task (colour naming) and a modified Stroop task (digit naming). The results showed a conventional Stroop effect for both types of training. However, in the modified Stroop task interference was solely found for adaptively trained subjects. We conclude that the propagation of interference caused by grapheme-colour associations in trained non-synaesthetes depends on the type of training.

### **What you see is what you smell: The social neuroscience of olfaction.**

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Previous research concerning cross-modal interactions in odour perception has highlighted the tendency of olfactory stimuli to spontaneously cue autobiographical memories and vividly bring back to life past perceptual experiences. These strong learned associations are the basis for providing odour descriptions as well as forming positive and negative valence distinctions – thought to be the primary function of olfaction. More recently, olfaction has been implicated - both as the inducing and concurrent perception - in many varieties of synaesthesia. Additionally, studies of cross-modal interactions in non-synaesthetes suggest a common mechanism that partially re-invokes neural processing of associated stimuli, in a manner reminiscent of synaesthetic cross-activation. Motor representations associated with the object in question are shown to be similarly activated. Here we introduce the notion of an ‘odour-tag’ (an olfactory ‘object token’) – a perceptual component that enables rapid access to previously configured sensorimotor representations. Furthermore, we synthesize the evidence from synaesthesia, memory research, and embodied cognition. Lastly, we discuss preliminary enquiries into ‘mirror-smell’ – an olfactory analogue of mirror-touch synaesthesia.

**Working memory in grapheme-colour synaesthesia***Olga Wudarczyk, Devin Blair Terhune, & Roi Cohen Kadosh*

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Previous research has inconsistently found that synaesthesia is associated with superior memory. Superior memory among synaesthetes may be driven by highly consistent synaesthetic associations, which may provide an additional channel to aid retrieval. Although a number of studies have examined episodic memory among synaesthetes, the beneficial effects of synaesthesia on working memory have been neglected. The impact of stimulus congruency on memory among synaesthetes has also received little attention. This study investigates the influence of grapheme-colour synaesthesia on working memory, using an n-back paradigm with achromatic neutral symbols and digits that are either congruently or incongruently coloured relative to participants' synaesthetic associations. The results from 3 synaesthetes and a control group suggest that synaesthetes display superior working memory across conditions. Participants also showed higher accuracy for congruent than incongruent trials. Upon completion, the findings of this study will help clarify the benefits of synaesthesia on working memory and how it is constrained or facilitated by synaesthetic colour associations.