

# Proceedings

12th International  
Conference

EFFECTIVITY

PERCEPTION  
&  
ACTION

AFFORDANCE

Griffith University  
Australia

*Edited by  
Paul Treffner*

*Proceedings*

**12<sup>th</sup> International Conference on  
Perception Action**

**July 13<sup>th</sup>-18<sup>th</sup>, 2003  
Gold Coast, Australia**

**Organised by**

**Paul Treffner**  
*Griffith University*

**Sponsored by**

*The International Society*  *for Ecological Psychology*

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## Contents

Forward	1
Programme	3
Schedule	4
Keynote addresses: <i>Perceptual ecology</i>	9
Invited symposium: <i>Cognitive constraints on coordination dynamics</i>	15
Open session: <i>Visualisation</i>	21
Open session: <i>Coordinated action</i>	24
Open session: <i>Specification and recognition</i>	28
Invited symposium: <i>Interpersonal perception-action systems</i>	32
Invited symposium: <i>Multimodal dynamical gestures</i>	38
Open session: <i>Development and affordances</i>	44
Open session: <i>Anticipatory information</i>	48
Invited symposium: <i>Invariants in the visual world and their relation to invariants in the visual system</i>	52
Open session: <i>Interceptive action</i>	56
Open session: <i>Complexity of ecological experience</i>	62
Posters list	
Session 1	67
Session 2	70



## Foreword

We are pleased that for the first time in the history of the International Society for Ecological Psychology (ISEP)<sup>1</sup>, the International Conference on Perception and Action (ICPA)<sup>2</sup> is being held in the Southern Hemisphere, hosted by the Complex Active Visualisation (CAV) lab at Griffith University's School of Information Technology. With a conference location of Surfers Paradise on the Gold Coast in Queensland, Australia, ICPA is sure to be a rewarding event for all.

This is the twelfth instance of ICPA since its inauguration in 1981 as an initiative of the ISEP. ICPA has become the main biannual forum for researchers and scientists interested in how information constrains an organism's behaviour—a concept that was first championed by the psychologist James J. Gibson, was developed and elaborated by both James and his wife and colleague Eleanor, and has since developed into the ecological approach to perception and action. This year, we commemorate the recent passing of Eleanor Gibson in December 2002. We expect that ICPA12 will constitute a fitting tribute to the Gibsons' deep and profound effect upon modern behavioural science.

ICPA12 unites researchers from multidisciplinary backgrounds to interact and consider issues of mutual interest that can all broadly be related to the general theoretical theme of information-based behaviour. Topics such as perception, action, visual and auditory information, perceptual learning, dynamical systems models of behaviour, human and animal cognition, neurodynamics, haptic perception, event perception, speech perception and production, social coordination, virtual vs. direct realism, vision and visualisation, embodied intelligence and robotics, the nature of intention, attention, and affordances—are all representative of the issues addressed at ICPA12.

Of special interest this time was the option to attend the ICPA satellite conference, *Sensorimotor Coordination: Behavioural Modes and Neural Mechanisms*, which was held in the week prior to the conference at a beautiful resort on Fraser Island off the Queensland coast.

For ICPA12, approximately 50 oral submissions and 60 poster papers were accepted. As a truly international conference, ICPA12 brings together over 100 professional scientists and students with approximately 80% of delegates visiting Australia from overseas. Countries represented include Japan, USA, Netherlands, China, France, New Zealand, UK, Canada, Brazil, and Belgium, as well as Australia.

With ICPA12, submission were openly invited for presentations in “Open Sessions” and were subsequently considered by the Scientific Committee. In addition to those submitted for Open Sessions (the majority), several “Invited Symposia” with associated refereed abstracts were proposed by symposium organisers who had met the challenge of creating a single coherent and integrated theme that could be addressed by the symposium's contributors.

Full papers were submitted for poster presentation and were subject to full review. Accepted poster papers are available in the specially edited book, *Studies*

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<sup>1</sup> see: <http://www.trincoll.edu/depts/ecopsyc/isep.html>

<sup>2</sup> see: <http://www.int.gu.edu.au/%7Ees227447/ICPA-conf/index.htm>

in *Perception and Action VII*, edited by Sheena Rogers and Judy Effken, and published by Lawrence Erlbaum Associates. Submissions of abstracts for oral presentation (these Proceedings) were also subject to full review. Consequently, the quality of the submissions to ICPA12 is of the same high standard as on previous occasions of the conference.

We would like to thank all those who have helped the first ICPA “down under” to become a reality: the Keynote Speakers (Barbara Gillam, Bill Mace, Mandyam Srinivasan), the Invited Symposium organisers (Nobuhiro Furuyama, Kerry Marsh, Michael Richardson, Michael Riley, Phil Sheridan, Kevin Shockley), the Open Session Chairs (Claudia Carello, Bruce Kay, Bill Mace, Claire Michaels, Dean Owen, Mandyam Srinivasan, Mike Turvey, Eric Vatikiotis-Bateson), the Workshop organisers (Bill Mace, Bob Shaw), and all the delegates who made the effort to travel to the conference this year. Special thanks go to Regina Tucker who helped with conference registrations, to Mike Jones for audio-visual technical coordination, and to the Head of School, Greg Cranitch, and Dean, Barry Harrison, from the host institution for their support. We are also grateful to the trade exhibitors, Jumbo Vision, Seeing Machines, VRSolutions, AOK Health, and Boddybubble for their value-adding input to the conference. Special thanks go to James (Jerry) Gibson and family members who located unique 16 mm film footage from 1945 of Lt. Col. James Jerome Gibson who lead the United States Army Air Force Training Unit. This archive will be invaluable to current and future generations of scientists who would like to visualize J. J. Gibson in action. Belated thanks to Kurt Koffka, originator of “Koffka’s Ring”, which inspired Edward Adelson to animate it, which in turn inspired me to turn it into the conference logo and attempt to make an ontological point about mutuality and symmetry<sup>3</sup>. Many thanks go to Mira Peter for her overall support on innumerable matters. Finally, we would like to thank Penny Rogers and the staff at Legends Hotel for their efforts to create an excellent conference location.

Paul Treffner  
July, 2003



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<sup>3</sup> You can always project your conference T-shirt during class for “teaching” purposes. For an animated Koffka’s Ring, see: <http://www-bcs.mit.edu/gaz/demos/koffka.html>

# ICPA12 PROGRAMME

## Conference Location:

Legends Hotel, Surfers Paradise, Gold Coast, Queensland, Australia

*Sunday July 13<sup>th</sup>*

4.00-6.00

**Registration**

*Monday July 14<sup>th</sup> – Friday July 18<sup>th</sup>*

8.30-9.00

**Registration**

9.00-4.00

**Conference Sessions**

12.30

**Lunch**

4.00-6.00

**Poster Sessions**

## Social Activities

*Sunday July 13<sup>th</sup>*

6.30-8.30

**Welcome Party**

*Monday July 14<sup>th</sup>*

1.45

**Conference photo**

6.00

**Free evening in Surfers Paradise**

*Tuesday July 15<sup>th</sup>*

7.30

**Barbeque**

Legends Hotel

*Wednesday July 16<sup>th</sup>*

8.30-11.00

**Complex Active Visualisation (CAV) lab, or Free**

Bus departs 9.00am; returns 11am

6.00

**Free evening in Surfers Paradise**

*Thursday July 17<sup>th</sup>*

7.00

**Banquet**

Mermaids Restaurant, Burleigh Heads

Bus departs 7pm; returns 11pm

*Friday July 18<sup>th</sup>*

4.00

**Farewell Party**

Legends Hotel



**Monday 14th July**

9.00

**Welcome**

9.10-10.30

**Keynote Addresses: Perceptual Ecology***Chair: Michael T. Turvey*

Directly perceiving the environment: The significance of the concept of the occluding edge

*William M. Mace*

Stereopsis for overlapping surfaces

*Barbara Gillam*

Insect navigation: From perception to action using optic flow

*Mandyam V. Srinivasan*

11.00-12.30

**Invited Symposium: Cognitive Constraints on Coordination Dynamics***Organisers: Michael A. Riley & Kevin D. Shockley*

Coordination dynamics during a word-nonword discrimination task.

*Miguel A. Moreno*

Attention and the dynamics of speech-hand coordination

*Paul J. Treffner & Mira Peter*

Information-reduction tasks and the attractive states of interlimb coordination dynamics

*Geraldine L. Pellecchia & Michael T. Turvey*

Memory and interlimb coordination task

*Kevin D. Shockley*

1.45-2.00

**Conference Photo**

2.00-2.15

**Commemorating Eleanor Gibson; James Gibson footage***Chair: Pat Cabe*

2.15-3.45

**Open Session: Visualisation***Chair: Dean Owen*

The timing of imagined actions conform to the same environmental constraints as real movements and predict motor skill performance

*Peter Wilson*

The intentional dynamics of a friction compensation stick-slip haptic control task

*Robert Shaw, Steve Harrison, Jeffrey Kinsella-Shaw, & Mike Richardson*

Virtual reality evaluation of human performance in telerobotic manipulation

*Philip Lamb*

Müller-Lyer and grasping: Illusion or obstacles?

*Marianne Biegstraaten, Denise de Grave, Eli Brenner, & Jeroen Smeets*

4.00-6.00

**Poster Session 1**

**Tuesday 15th July**

9.00-10.30

**Open Session: Coordinated Action***Chair: Bruce Kay*

En route towards juggling dexterity: The assembly of functional subsystems into a task-specific dynamical organization

*Raoul Huys, Andreas Daffertshofer, & Peter Beek*

(De-)stabilization of bimanual coordination due to active inhibition

*Andreas Daffertshofer, C. (Lieke) E. Peper, & Peter Beek*

Long-term memory processes in informationally controlled rhythmic movement

*Theo Rhodes & Richard C. Schmidt*

The ecological meaning of spatial symmetry in bimanual motor coordination

*T. C. Chan*

11.00-12.30

**Open Session: Specification and Recognition***Chair: Eric Vatikiotis-Bateson*

The way you walk: Person and character identification from kinematic information

*Jean Lucy Johnston, Rebekah Gunns, Michael Richardson, & Stephen Hudson*

On the importance of short-time phase spectrum in speech perception

*Kuldip K. Paliwal & Leigh Alsteris*

What aspects of facial motion are beneficial for recognition?

*Karen Lander & Lewis Chuang*

Implicit sensitivity to posed and genuine smiles

*Lynden Miles*

2.00-3.30

**Invited Symposium: Interpersonal Perception-Action Systems***Organisers: Michael J. Richardson & Kerry L. Marsh*

Conversation, coordination, and cooperation

*Kevin Shockley, Marie-Vee Santana, Carol Fowler, & Michael J. Richardson*

The effects of visual and verbal couplings on interpersonal synchrony

*Michael J. Richardson, Richard C. Schmidt, & Kerry L. Marsh*

The affordance structure and dynamics of duo lifting

*Kerry L. Marsh, Reuben M. Baron, & Michael J. Richardson*

Experimental investigations of the emergence of human communication procedures

*Bruno Galantucci, Carol Fowler, & Michael J. Richardson*

4.00-6.00

**Poster Session 1**

**Wednesday 16th July**

8.30-11.00

**Visit to CAV lab / Free Time**

11.00-12.30

**Invited Symposium: Multimodal Dynamical Gestures***Organisers: Paul J. Treffner & Nobuhiro Furuyama*

Coordination among articulations, gesticulations and breathing movements: A case of articulation of /a/ and flexion at the wrist  
*Nobuhiro Furuyama, Hiroki Takase, & Koji Hayashi*

Auditory-visual perception and production of lexical pitch  
*Denis Burnham, Eric Vatikiotis-Bateson, & Hani Yehia*

Faces and voices: Cross-modal identity-specific invariants?  
*Miyuki Kamachi, Harold Hill, Karen Lander, & Eric Vatikiotis-Bateson*

The interactions of static structure and time-varying behavior in communicative behavior  
*Harold Hill, Guillaume Vignali, & Eric Vatikiotis-Bateson*

2.00-3.30

**Open Session: Development and Affordances***Chair: Claire Michaels*

Ecological psychology and transactionalism: Perception as a function of development, and vice versa  
*Jeffrey B. Wagman*

Are individual differences in temperament of relevance to Gibson's theory of affordances?  
*Merrilyn Hooley & Boris Crassini*

Coordination dynamics in preterm and fullterm infants at three stages of development  
*Jan P. Piek, Nicholas C. Barrett, & Paul Loseby*

Perceptual systems considered as creative practice: Arakawa and Gins' architectural body  
*Jondi Keane*

4.00-6.00

**Poster Session 2**

**Thursday 17th July**

9.00-12.30

**Workshop - A new look at situational awareness: The essential ingredients for modeling perceiving and acting by animate and robot agents***Organisers: Robert E. Shaw, William Mace, & Paul Treffner*

Challenges and promises of an ecological approach to robotics

*Robert E. Shaw & William Mace*

Toward smart cars with computer vision for integrated driver and road scene monitoring

*Alex Zelinsky*

Exploring ecological principles in robot soccer

*John Thornton & Joe Leonard*

2.00-3.30

**Open Session: Anticipatory Information***Chair: Mandyam Srinivasan*

Jitter and size effects on vection

*Stephen Palmisano, Fiona Pekin, & Amy Chan*

Jaywalking in virtual reality: Optical information affecting the margin of safety

*Dean Owen, Gordon Simpson, & Stephen Murray*

The information-based regulation of interceptive timing

*Simone Caljouw, John van der Kamp, & Geert Savelsbergh*Time-to-collision (TTC) judgements with off-size objects show that *tau* needs to be integrated with familiar size to explain TTC performance*Simon Hosking & Boris Crassini*

4.00-6.00

**Poster Session 2**

**Friday 18th July**

9.00-10.30

**Invited Symposium:** Invariants in the visual world and their relation to invariants in the visual system  
*Organiser: Phil Sheridan*

A biologically inspired camera  
*Kazuhiko Takemura*

Computing with a hexagonal lattice: How to optimise invariant detection in optic flow  
*Phil Sheridan*

Local and global maps in primary visual cortex  
*David Alexander*

A transformation group approach to optic flow  
*Mark Chappell & William C. Hoffman*

11.00-12.30

**Open Session: Interceptive Action**  
*Chair: Claudia Carello*

A bearing angle strategy predicts how balls are intercepted.  
*Alexandra Chardenon, Gilles Montagne, Reinoud Bootsma, & Michel Laurent*

The effect of affordance on the reach-to-grasp movement after stroke  
*Helen J. Hill, Alan Sunderland, & Paulette van Vliet*

Precision of interceptive action in space and time  
*James R. Tresilian*

Perceptual learning: Assembly of an information-detecting synergy  
*Claire F. Michaels, David Jacobs, & Rob Withagen*

12.30

**Lunchtime ISEP Business Meeting**

2.00-4.00

**Open Session: Complexity of Ecological Experience**  
*Chair: William M. Mace*

Coordination of upper and lower body rhythms during walking  
*Bruce A. Kay, Steven J. Harrison, & Theo Rhodes*

Rope jumping performance variability as a function of rope frequency  
*Flavia Cristina Bueno, Wellington Roberto de Carvalho, & Ana Maria Pellegrini*

Haptic exploratory procedure(s) and nonuniform textured surfaces  
*Barry Hughes*

Direct perception: A matter of non-locality, self-motion, and impredicativity?  
*Michael T. Turvey*

4.00

**Farewell**

## Keynote Addresses: Perceptual Ecology

### Biographical Sketches

William M. Mace: *Trinity College, Hartford, USA*

Barbara Gillam: *University of New South Wales, Sydney, Australia*

Mandyam V. Srinivasan: *Australian National University, Canberra, Australia*

#### William M. Mace

After majoring in Psychology as an undergraduate at Yale University, William Mace enrolled in graduate school at the Institute of Child Development of the University of Minnesota in 1967, intending to study cognitive development, mainly inspired by the work of Piaget. Prof. Mace discovered, however, that the most exciting work on cognition was in Chomsky-inspired psycholinguistics. Late in his graduate school career, Mace began taking courses from Robert E. Shaw, in the Minnesota Psychology Department, and was persuaded that the approach to perception developed by James Gibson would be even more fruitful than psycholinguistics. Shaw became Mace's dissertation adviser in 1970 and the work was completed in 1971.

In 1971, Mace accepted a faculty position at Trinity College in Hartford, Connecticut. He was invited to teach Child Psychology at Cornell University in the summer of 1974. This made it possible for him to attend James Gibson's seminars and to spend time at the Gibson home as well. The next year, at the urging of Michael Turvey, Robert Shaw moved to the University of Connecticut, making possible collaborations between Mace, Shaw, and Michael Turvey.

In 1981, Mace, Shaw, and Leonard Mark established the International Society for Ecological Psychology (ISEP). Mace has performed the primary duties of the Society ever since. In 1989, the journal, *Ecological Psychology*, was established, with Mace serving as Editor. Mace currently directs ISEP, is editor of the journal, *Ecological Psychology*, and is one of the editors of the Lawrence Erlbaum book series, *Resources for Ecological Psychology*.

#### *Representative publications*

- Mace, W. M. (1974). Ecologically stimulating cognitive psychology. In W. Weimer and D. Palermo (Eds.), *Cognition and the symbolic processes. Vol. 1*. Hillsdale, NJ: Erlbaum.
- Mace, W. M. (1977). James J. Gibson's strategy for perceiving: Ask not what's inside your head, but what your head's inside of. In R. E. Shaw and J. Bransford (Eds.), *Perceiving, acting, and knowing*. Hillsdale, NJ: Erlbaum.
- Mace, W. M. (1985). Johansson's approach to visual event perception - Gibson's perspective. In W. H. Warren, Jr. and R. E. Shaw (Eds.), *Persistence and change: Proceedings of the First International Conference on Event Perception*. Hillsdale, NJ: Erlbaum.
- Mace, W. M. (1986). J. J. Gibson's ecological theory of information pickup: Cognition from the ground up. In T. J. Knapp and L. Robertson (Eds.) *Approaches to cognition: Contrasts and controversies*. Hillsdale, NJ: Erlbaum.

### Barbara Gillam

Prof. Barbara Gillam graduated BA from University of Sydney and Phd from the Australian National University. She lectured at University of Reading UK, and migrated to USA because of her husband's job. Prof. Gillam has held research positions at Columbia University and then held Assoc. Professor and Professor positions at State University of New York (SUNY), College of Optometry, where she taught perception and binocular vision. She was Head of Department of Behavioral Sciences and Public Health SUNY. Prof. Gillam is Member of Basic Behavioral Processes Study Section (NIMH), and is Consulting Editor for the journal, *Perception & Psychophysics*. She is also a Guggenheim Fellow. Barbara returned to Sydney in 1986 to be Professor of Psychology and Head of School of Psychology at the University of New South Wales (UNSW). She is Member of the Australian Research Council's Social Sciences Panel, as well as its Chair of the Cognitive Science Priority Panel. She is a Member of the National Committee for Psychology, and President of the Psychology Foundation of Australia. Prof. Gillam is currently ARC Professorial Fellow, Scientia Professor at UNSW.

#### *Representative publications*

- Gillam, B. (1980). Geometrical illusions. *Scientific American* 242, 102-111, (Reprinted in I. Rock (Ed.), 1990, *The Perceptual World*. New York, NY: Freeman, and in J. Wolfe (Ed.), 1986, *The Mind's Eye*, New York, NY: Freeman).
- Gillam, B., & Lawergren, B. (1983). The induced effect, vertical disparity & stereoscopic theory. *Perception & Psychophysics*, 34, 120-130.
- Gillam, B., & Nakayama, K. (1999). Subjective contours at abutting lines as scene layout analysis. *Journal of Experimental Psychology: Human Perception & Performance*, 28, 43-53.
- Gillam, B. (2001). Varieties of grouping and its role in determining surface layout. In T. Shipley and P. Kellman (Eds.), *From fragments to objects: Segmentation and grouping in Vision*. Elsevier.
- Gillam, B., & Chan, W.-M., (2002). Grouping has a negative effect on both subjective contours and perceived occlusion at T-junctions. *Psychological Science*, 13, 279-283.

**Mandyam V. Srinivasan**

Prof. Mandyam Srinivasan holds an undergraduate degree in Electrical Engineering from Bangalore University, a Master's degree in Electronics from the Indian Institute of Science, a Ph.D. in Engineering and Applied Science from Yale University, and a D.Sc. in Neuroethology from the Australian National University. He is presently Professor of Visual Sciences at the Australian National University's Research School of Biological Sciences and Director of the University's Centre for Visual Science. He is a Fellow of the Australian Academy of Science, a Fellow of the Royal Society of London, and an Inaugural Australian Federation Fellow. Prof. Srinivasan's research focuses on the principles of visual processing in simple natural systems, and on the application of these principles to machine vision and robotics.

*Representative publications*

- Srinivasan, M. V. (1998). Insects as Gibsonian animals. *Ecological Psychology*, *10*, 251-270.
- Srinivasan, M. V., & Zhang, S. W. (2000). Visual navigation in flying insects. In M. Lappe (Ed.), *International Review of Neurobiology (Vol 44): Neuronal Processing of Optic Flow* (pp. 67-92). San Diego, CA: Academic Press.
- Srinivasan, M. V., & Zhang, S. W., Altwein, M., & Tautz, J. (2000). Honeybee navigation: Nature and calibration of the 'odometer'. *Science* *287*, 851-853.
- Srinivasan, M. V. (2002). Visual flight control and navigation in honeybees, and applications to robotics. In J. Ayers, J. L. Davis and A. Rudolph (Eds.), *Neurotechnology for Biomimetic Robots* (pp 593 - 610). Boston, MA: MIT Press.



## Directly perceiving the environment: The significance of the concept of the occluding edge

**William M. Mace**

*Trinity College, Hartford, CT, USA*

James Gibson's claims about direct perception, contrary to Dretske, for example, are claims about the proper objects of perceiving. Gibson talked about directly perceiving the environment as distinct from perceiving surrogates or intermediaries. I argue that the idea of direct perceptual processing, as opposed to indirect processing, follows rather easily, if the environment is established as an object of perceiving, without intermediate objects. Using Gibson's example, one can pose the question, can one distinguish between Niagara Falls and pictures (or other surrogates) of Niagara Falls? The primary basis for direct perception of the environment in Gibson's system, is that environmental structure is different from other sources of structure. To put it another way, the external world can be perceived as such because it is different.

Gibson claimed that the occluding edge was his most radical discovery. I shall review its role in articulating and underwriting Gibson's theses about direct perception of the environment, highlighting its role in clarifying and resolving the problem of the perception of persistence. I argue that if the structure and consequences of Gibson's analysis of the occluding edge are fully grasped, then his more heralded concept of affordances will be seen as a natural, but less revolutionary development.

The realism referred to here, it will be emphasized, is a pragmatic realism closely allied to William James's radical empiricism. It is a reality that is subject to scrutiny, to indefinite clarification and differentiation. It unfolds in experience, but does not sit behind experience.

## Stereopsis for overlapping surfaces

**Barbara Gillam**

*Department of Psychology, University of New South Wales,  
Sydney, Australia*

Some optic array differences resulting from the binocular viewing of overlapping surfaces were investigated in 1979 by Gibson's student Tony Barrand. The present talk will outline the current state of the art with respect to our understanding of these differences and the ability of the human visual system to respond to them in perceiving complex spatial layouts. These include orientation disparities spanning both horizontal and vertical surface boundaries, isolated elements entirely hidden for one eye or partly occluded for one eye and the significance of unpaired regions of background for spatial layout. We shall show that this information can be used to detect surface overlap and also to discriminate curvature in the plane from curvature in depth when the curved contour is visible in one eye only. We also show that contextual information is critical in perceiving depth from local disparities. Array differences are sufficiently powerful to support perception of a contour in the absence of luminance contours.

### *References*

- Gillam, B., & Borsting, E. (1988). *Perception*, 17, 603-608.  
Gillam, B., Blackburn, S., & Nakayama, K. (1999). *Vision Research*, 39, 493-502.

## Insect navigation: From perception to action using optic flow

**Mandyam V. Srinivasan**

*Centre for Visual Sciences, Research School of Biological Sciences, Australian  
National University, Canberra, Australia*

Anyone who has watched a fly make a flawless landing on the rim of a teacup, or marvelled at a honeybee speeding home after collecting nectar from a flower patch several kilometres away, would know that insects possess visual systems that are fast, reliable and accurate. Insects cope remarkably well with their world, despite possessing a brain that carries fewer than 0.01% as many neurons as ours does. What are the secrets of their success?

Although most insects lack stereo vision, they use a number of ingenious strategies for perceiving their world in three dimensions and navigating successfully in it. For example, distances to objects are gauged in terms of the apparent speeds of motion of the objects' images, rather than by using complex stereo mechanisms. Objects are distinguished from backgrounds by sensing the apparent relative motion at the boundary. Narrow gaps are negotiated by balancing the apparent speeds of the images in the two eyes. Flight speed is regulated by holding constant the average image velocity as seen by both eyes. Roll is stabilised by balancing the output signals from the two lateral ocelli, which function as horizon sensors. Bees landing on a horizontal surface hold constant the image velocity of the surface as they approach it, thus automatically ensuring that flight speed is close to zero at touchdown. Foraging bees gauge distance flown by integrating optic flow: they possess a visually-driven "odometer" that is robust to variations in wind, body weight, energy expenditure, and the properties of the visual environment. This presentation will describe some of the research that led to these insights, and highlight some of the unresolved questions and enigmas.

## Symposium

### Cognitive Constraints on Coordination Dynamics

Organisers:

**Michael A. Riley & Kevin D. Shockley**

*Department of Psychology, University of Cincinnati, USA*

In recent years there has been a growing interest in the relation between cognitive activity and coordination dynamics. Interactions between concurrent cognitive and coordination are most typically studied using dual-task methodology. This work has been motivated by the recognition that cognitive constraints are a major factor in shaping the assembly and activity of perception-action synergies. Accordingly, it is important to determine how concurrent cognitive demands affect coordination patterns and their stability. The determination of specific patterns of interference (or facilitation) between cognitive and coordination tasks will provide insights into the extent to which the cognitive and coordination tasks share a common neuro-cognitive basis. Furthermore, the move to understand cognitive tasks in the language of dynamics, rather than in the more typical information processing framework, may eventually serve to enrich the set of constraints required for modeling cognitive dynamics.

In this symposium we will address interactions between various forms of cognitive activity and rhythmic coordination. The symposium draws together a progression of ideas surrounding concurrent cognitive activity and rhythmic coordination. The first speaker, Miguel Moreno, considers the interplay of a traditionally cognitive task, lexical-decision-making and interlimb coordination. Traditionally cognitive tasks are shown to influence coordination dynamics. The degree of similarity between nonwords (illegal, legal, and pseudohomophones) and words systematically influenced mean relative phase and variability of relative phase. The results are interpreted and discussed in terms of strategically assembled cognitive agents based in dynamical systems theory.

The second speaker, Paul Treffner, will consider the dynamics of speech-hand coordination as an paradigmatic example of gestural communication. The effects of direction of attention and performance rate on phase transitions, phase shifts, and serial ordering of the coordinative task are shown to follow from the lawfulness of 1:1 oscillator-based phase-locking dynamics. The role of attention in the underlying dynamics is modeled using Treffner and Turvey's asymmetric HKB model which incorporates additional terms ( $c$  and  $d$  parameters) that capture attentional asymmetry.

The third speaker, Michael Turvey, presents the research of Pellecchia and Turvey (2001) who asked: How does a cognitive load influence interlimb coordination? By varying the level of difficulty of a cognitive task (e.g., simple arithmetic), Pellecchia and Turvey found that cognitive activity magnified the absolute deviation of measured relative phase away from intended phase to a

degree related to the level of difficulty of the cognitive task. The attractor shift was an important finding because it provided a conceptual link between cognitive activities—typically evaluated within the framework of information processing—and coordination dynamics—necessarily evaluated within the theoretical framework of self organization. The finding's special significance is that any general theory of performance must be able to explain why a shift in the attractor location of the coordination dynamic should result from a concurrent cognitive load.

Finally, Kevin Shockley introduces bimanual rhythmic coordination to the study of human memory (Shockley, 2002). Memory is a classic domain for evaluating dual-task performance and the corresponding paradigms provide a useful framework for evaluating attentional trade-offs involved in memory tasks of different cognitive demand (e.g., encoding vs. retrieval). In addition to comparing Shockley's results to traditional findings, types of performance modulation are reported that are not recognized in information processing accounts. Constraints of modeling concurrent cognitive and coordination tasks from a dynamical perspective are considered.

## Coordination dynamics during a word-nonword discrimination task

**Miguel A. Moreno**

*Center for the Ecological Study of Perception & Action, University of Connecticut, Storrs, USA*

A series of experiments examined the influence of performance in a word-nonword discrimination task on rhythmic movements by manipulating the similarity of nonwords to real words and word frequency. Nonwords were pseudohomophones (i.e., PURSE), legal (i.e., BURSE) or illegal (i.e., RSEUP) and words had high or low frequency counts. Participants responded verbally only to words in a GO/NOGO paradigm while producing a bimanual coordination (in-phase or anti-phase) with pendulums of equal or different preferred left and right frequencies. Effects of nonword lexicality and word frequency manipulations on rhythmic movements were indexed by changes in mean relative phase and variability across the nonword types. Relative phase and variability systematically increased across illegal, legal and pseudohomophone nonword conditions. Systematic changes in relative phase and variability increased in magnitude nonlinearly between high and low frequency conditions. Interactions between nonword type and word frequency were modulated by coordination conditions and were restricted to conditions of unequal preferred left-right frequencies. The results are interpreted and discussed in terms of strategically assembled cognitive agents based in dynamical systems theory.

## Attention and the dynamics of speech-hand coordination

**Paul J. Treffner & Mira Peter**

*Complex Active Visualisation Laboratory, Griffith University,  
Gold Coast, Australia*

The dynamics of speech-hand coordination, manual laterality, and attention were explored during a rhythmic dual task involving the 1:1 phase-locked coordination of articulatory and manual gestures. Participants synchronised either repetitive speech (/ba/) or finger taps with a pacing signal while rhythmically moving the other articulator in an anti-phase manner. The increase in performance rate not only produced phase transitions from anti-phase to in-phase, but in terms of serial order, for in-phase coordination the finger tap increasingly led jaw movement as frequency increased, while for anti-phase the jaw increasingly led the finger. Importantly, a reliable effect of frequency on phase shift was found for the right hand (left hemisphere) only—in both left- and right-handers. Directed attention influenced unstable left hand tapping in anti-phase only. Issues of perceived temporal synchrony and the locus of articulatory “P-centres” is also addressed by our data. Further, as rate of coordination increased, a progressive *decrease* in variability was observed, and is consistent with an underlying dynamics that involves an increase in attention. The results are modeled using Treffner and Turvey’s asymmetric HKB model which incorporates additional terms (*c* and *d* parameters) that capture attentional asymmetry. This suggests linguistic (gestural) communication, specifically speech-hand coordination, depends on cognitive factors such as attention (Corballis, 2002), but that the resultant behaviour is due to the coherent modes of a dynamical system, rather than “cognitive interference” or processing limitations (Treffner & Peter, 2002).

### *Reference*

- Corballis, M. (2002). *From hand to mouth: The origins of language*. Princeton University Press.
- Treffner, P. J., & Peter, M. (2002). Intentional and attentional dynamics of speech-hand coordination. *Human Movement Science*, 21, 641-697.

## Information-reduction tasks and the attractive states of interlimb coordination dynamics

**Geraldine L. Pellecchia<sup>1,2</sup>, & Michael T. Turvey<sup>2,3</sup>**

<sup>1</sup>*Department ENHP Physical Therapy, University of Hartford, CT USA*

<sup>2</sup>*Center for the Ecological Study of Perception & Action, Department of Psychology, University of Connecticut, Storrs, USA*

<sup>3</sup>*Haskins Laboratories, New Haven, USA*

Everyday expressions of the elementary rhythmic synergy (1:1 frequency locking of two limbs) are often accompanied by some degree of cognitive activity that is essentially unrelated to the synergy. A simple experimental model of the phenomenon is in-phase coordination performed in combination with an arithmetic information-reduction task. Research using this experimental model has provided two primary results. One result is that direction-specific shifts in the temporally stable relative phase due to detuning and movement frequency are amplified by concurrent cognitive activity. The other result is that the shifts may be magnified systematically by the size of the information reduction task. The use of cross-recurrence quantification has provided potentially useful insights. The changes in the location of the coordination's attractor do not appear to be accompanied by corresponding changes in attractor strength but do appear to be accompanied by an increase in noise that is independent of detuning and movement frequency. Of special interest is how these results on the cognition-coordination relation can be accommodated by the theory-constitutive metaphor of self-organization.



## Memory and interlimb coordination

**Kevin D. Shockley**

*Department of Psychology, University of Cincinnati, Cincinnati, USA*

Dual-task performance has been extensively investigated in the domain of memory. Typically, an encoding or retrieval task is performed concurrently with a secondary task (e.g., choice reaction time, visual tracking, card sorting). Decline in performance of either task is attributed to a lack of central processing resources. Performance on the memory task is typically evaluated in terms of recall and performance on the skill task is typically evaluated in terms of chronometric measures, such as reaction time (RT) or movement time. Recent studies, however, have suggested that a compelling theory of performance is unlikely to arise from consideration of chronometric measures alone (Van Soest & Van Galen, 1995; Van Gemmert & Van Galen, 1997). Dynamic and biomechanical constraints on human activity must be integral to a complete theory of performance. It is in this spirit that an interlimb coordination task is introduced to the more traditional paradigm for studying dual-task performance in the context of memory. Experiments requiring concurrent performance of encoding/retrieval and interlimb coordination will be presented to illustrate how the well-documented Haken, Kelso, & Bunz (1985; HKB) model of interlimb coordination may be informative as to whether concurrent cognitive activity and interlimb coordination result in an adjustment to the state, parameter, or graph dynamics of the HKB model.

## The timing of imagined actions conform to the same environmental constraints as real movements and predict motor skill performance

**Peter Wilson**

*Department of Psychology and Disability Studies, RMIT University, City Campus, Melbourne, Australia*

Motor imagery has been shown to conform to the same biomechanical and physical constraints as real movements. In this study, we investigated further the functional relationship between real and imagined movements, and asked whether imagery ability was predictive of individual differences in motor skill performance. Thirty-eight healthy young adults participated in the study. Each participant completed two objective measures of motor imagery [the Visually Guided Pointing Task (VGPT) of Sirigu and colleagues (1996)] and a Mental Rotation task involving hand stimuli. Self-report measures of imagery ability were also obtained. Motor skill performance was assessed using a complex formboard task and dynamic ball-balance. Consistent with previous research, strong speed-accuracy trade-offs were observed on the VGPT for both real and imagined movements. As well, a linear trade-off between response time and angular disparity was observed for the mental rotation task. Hierarchical regression showed that of several measures of motor imagery, performance on the VGPT was a significant predictor of motor skill performance. Results confirm the view that the same informational constraints for action (biomechanical and environmental) that influence the timing of real movements also affect imagined actions; motor imagery is best conceived of as a distributed neural “representation” of an intended action with situationally-appropriate force and timing parameters factored in. Moreover, the integrity of this representation (as indexed on the VGPT) is predictive of individual differences in motor skill performance.

## Virtual reality evaluation of human performance in telerobotic manipulation

**Philip Lamb**

*Department of Psychology, University of Canterbury, Christchurch,  
New Zealand*

An experiment was conducted to evaluate the potential for improved operator performance in a space-based telerobotic manipulation task when the operator's control interface had an egocentric rather than exocentric frame of reference (FOR). Participants performed three tasks of increasing difficulty using a virtual reality-based simulation of the Space Shuttle Remote Manipulation System (SRMS) under four different control interface conditions. These varied in respect of two factors, virtual viewpoint FOR (fixed versus attached to arm) and hand controller FOR (end-effector referenced versus world referenced.)

Results indicated a high degree of interaction between spatial properties of the task and the optimal interface condition. Across all tasks, the conditions under end-effector-referenced control were associated with better performance, as measured by rate of task completion. The mobile viewpoint conditions were generally associated with poorer performance on task completion rate but improved performance with respect to number of collisions between the arm and objects in the environment. Increased head movement and higher number of errors in arm motion indicated that the mobile viewpoint suffered from confounding uncontrolled keyhole effects.

The requirement for telemanipulation interfaces to represent critical kinematic limitations in the interface emerges in discussion of origins of performance differences between conditions. The results provide support for the partial application of an egocentric telepresence control interface to space-based articulated manipulators. Different factorings of ego- and exocentric FORs in order to alleviate poor performance under the mobile viewpoint are discussed along with implications for other space-based telemanipulation applications and fruitful approaches to further studies.

## Müller-Lyer and grasping: Illusion or obstacles?

**Marianne Biegstraaten, Denise de Grave, Eli Brenner,  
& Jeroen Smeets**

*Department of Neuroscience, Erasmus MC, Netherlands*

The influence of the Ebbinghaus illusion on grasping has been attributed to the surrounding circles being considered as obstacles (Haffenden & Goodale, 2000). However, this view is controversial. We examined whether we could verify this view using the Müller-Lyer illusion. With the Müller-Lyer, whether the fins act as an obstacle should depend on the direction of approach. When coming from the side both digits "have to" avoid the fins of the figure. When coming from below the figure the index finger has to avoid the fins, but the thumb has not.

We let subjects grasp a bar which was superimposed over the shaft of a vertically placed Müller-Lyer illusion. The bar had to be grasped either from a starting position below the figure or from one to the right side of the figure. The grasps were analysed in terms of the trajectories of the individual digits. The results showed an effect of the illusion on the deviation of the index finger regardless of the starting position. For the thumb we found a different effect of the illusion depending on the starting position.

We conclude that illusions can induce changes in motor strategy which are unrelated with the spatial attributes the illusion is supposed to change.

## En route towards juggling dexterity: The assembly of functional subsystems into a task-specific dynamical organization

**Raoul Huys, Andreas Daffertshofer, & Peter Beek**

*Vrije Universiteit, Faculty of Human Movement Sciences, Amsterdam,  
The Netherlands*

Proficient performance of complex perceptual-motor tasks requires the subsystems of the human action system to organize into a task-specific dynamical assembly. The dimensionality of such an assembly is fairly high but reduces significantly in the course of learning or practice, probably to allow for efficient control. The reduction of dimensionality reflects the emergence of task-specific correlations among subsystems. During learning to juggle, such correlations evolve gradually between the ball movements as well as between the arm movements. In addition, abrupt changes in correlation patterns have been found between ball movements and body sway components as well as between ball movements and point-of-gaze behavior. The abrupt changes in question appear to have two origins: frequency doubling bifurcations in both body sway directions and Hopf-bifurcations in looking behavior (oscillatory ball-tracking vanishes and a gaze-through (stable fixed point) emerges). Respiration did not reveal any structural correlation with any of the aforementioned subsystems. In sum, correlations either stay constant, indicating their irrelevance for the learning process (e.g., respiration), change structurally (bifurcations), or quantitatively (e.g., balls movements). In the latter case, increasing correlations among subsystems reflect a decrease in dimensionality while diminishing correlations can be viewed as liberation of degrees of freedom. Notice that bifurcations may be viewed as spontaneous increase of a certain correlation with a simultaneous decrease of another correlation. The specific functionality of differential changes in correlations in relation to juggling will be discussed in detail.

## (De-)stabilization of bimanual coordination due to active inhibition

**Andreas Daffertshofer, C. (Lieke) E. Peper, & Peter Beek**

*Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam,  
The Netherlands*

We discuss the relation between magneto-encephalographic signals and behavioral data during polyrhythmic tapping. In view of the complexity of cortical activity, our focus is on qualitative macroscopic changes in performance, that is, phase transitions between different polyrhythms (or frequency ratios  $p:q \rightarrow P:Q$ ). In line with previous studies, spectral analyses reveal distinct contra- and ipsilateral areas of cortical activity that are frequency- and/or phase-locked with respect to the bimanual movements performing the polyrhythm. However, in contrast with the stable bimanual performance the dominance of such bilaterally correlated areas of activation changes markedly in the vicinity of phase transitions. In particular, we find an increased cortical activity locked with and ipsilateral to the slow hand. In view of these consistent spatial distributions and their temporal evolution, a formal model can be constructed that captures essential features of neural activity during unimanual and bimanual rhythmical movements. As central ingredient we introduce an “active” inhibition between cortical areas, which prohibits a crossing over between the two hemispheres. An eventual phase mismatch between these mutually inhibiting areas might generate or, at least, reflect the transition in the coordinative patterns at the behavioral level. The proposed inhibitory mechanism may further explain the well-known preference of in- and anti-phase coordination during iso-frequent movements.

## Long-term memory processes in informationally controlled rhythmic movement

**Theo Rhodes<sup>1</sup>, & R. C. Schmidt<sup>1,2</sup>**

<sup>1</sup>*Center for the Ecological Study of Perception and Action, University of Connecticut, Storrs, USA*

<sup>2</sup>*College of the Holy Cross, Worcester, USA*

The prevalence of long-term memory processes in natural systems has been demonstrated in a wide variety of phenomena including human movement processes such as finger tapping and walking. While the presence of long-term memory has been often discovered, little, if any progress has been made on understanding its underlying processes. The present study seeks to elaborate the connection between rhythmic human movement systems, information feedback, and heuristic measures of long-term memory. Subjects swung a weighted wooden dowel (pendulum) in the sagittal plane using the wrist joint for 5 minutes, either with visual feedback of the room and limb, no visual feedback at all, visual timing feedback from a pulsing visual metronome or visual timing feedback indicating how far they were deviating from a requested frequency. Of interest is how environmental information (either tonic or task specific) affects the long-term persistence of fluctuations in timing and spacing.

## The ecological meaning of spatial symmetry in bimanual motor coordination

**T. C. Chan**

*Department of Psychology, Chinese University of Hong Kong, Shatin, NT Hong Kong SAR, China*

Kelso (1981) showed that in swinging two index fingers, when the oscillation frequency is systematically increased only the in-phase mode is stable. To explain such phase difference, Mechsner, Kerzel, Knoblich, and Prinz's (2001), revealed that spatial symmetry is a more comprehensive explanation than co-activation of homologous muscles. Two experiments were conducted to explore the ecological meaning of this spatial symmetry. In Experiment 1, I tested the hypothesis that spatial symmetry is related to complimentary movement of hands to keep body balance. If so, when anti-phase movement upset body balance more seriously, critical phase would occur at a lower frequency. Two groups of participants attempted to maintain anti-phase coordination of forearms by sitting on rotating and stable chairs with systematically increasing frequencies. Results showed that phase shifted significantly earlier with rotating chair (2.6 Hz) than with stable chair (2.9 Hz). In Experiment 2, I tested the hypothesis that spatial symmetry is related to constraints that occur in daily task of holding or grasping with two hands. If so, anti-phase coordination can be maintained longer if the finger motion is engaged with a specific task. Participants attempted to maintain anti-phase coordination of index finger either by oscillating freely or by tapping two vertical poles on one side with systematically increasing frequencies. Results showed that phase shifted significantly later when engaged in the hitting task (3.5 Hz) than when swinging freely (2.7 Hz). Indeed, both experimental results confirm that spatial symmetry has ecological meaning in motor coordination.



## The way you walk: Person and character identification from kinematic information

**Lucy Johnston, Rebekah Gunns, Michael Richardson,  
& Stephen Hudson\***

*Department of Psychology, University of Canterbury, Christchurch,  
New Zealand*

Point-light techniques (Johansson, 1973) were used to investigate the ability of perceivers to identify characteristics of, and the identity of, strangers solely from kinematic information produced while walking. The first series of experiments investigated whether movement style specified vulnerability to physical attack. Both female and male walkers could be differentiated according to ease-of-attack based solely on the kinematic information provided whilst walking. Specific walking style features predicted ease-of-attack and profiles of prototypically “easy to attack” and “difficult to attack” walkers were identified. Variations in walking style as a function of clothing and footwear style were also shown to predict differences in ease-of-attack ratings. Further, individual-based training led to changes in both walking style and perceived vulnerability.

The second series of experiments investigated whether observers could correctly recognize others from their natural and deceptive walking styles based solely on the kinematic pattern produced when walking. Participants watched pairs of video-clips of unknown young male actors and judged whether the video-clips in each pair were from the same actor or not. Each pair consisted of one clip of an actor walking naturally across a room and one of an actor attempting to walk deceptively (as an elderly man). Results from the two experiments demonstrated that participants were fairly accurate at recognizing whether the actors in the 2 video-clips were the same or different (65% correct). In addition, an invariant of walking style (weight shift) was shown to be an important kinematic feature for the identification of walkers.

\*The late Stephen Hudson contributed to the reported research programme prior to his death in 2001.

## On the importance of short-time phase spectrum in speech perception

**Kuldip K. Paliwal & Leigh Alsteris**

*School of Microelectronic Engineering, Griffith University,  
Brisbane, Australia*

Short-time Fourier transform of speech signal has two components: magnitude spectrum and phase spectrum. In this paper, relative importance of short-time magnitude and phase spectra on speech perception is investigated. Human perception experiments are conducted to measure intelligibility of speech tokens synthesized either from magnitude spectrum or phase spectrum. It is traditionally believed that magnitude spectrum plays a dominant role for shorter windows (20-30 ms); while phase spectrum is more important for longer windows (128-256 ms). It is shown in this paper that even for shorter windows, phase spectrum can contribute to speech intelligibility as much as the magnitude spectrum if the shape of the window function is properly selected.

## What aspects of facial motion are beneficial for recognition?

**Karen Lander & Lewis Chuang**

*University of Manchester, Department of Psychology, Manchester, UK*

In the real world faces move in a variety of ways, some of which are to do with their signal-sending functions (smiling, nodding, and speaking) and some with other functions (looking, chewing). Information provided by dynamic (time-varying) parameters is known to be particularly salient in the understanding of speech and interpretation of emotional expressions. Additionally, dynamic information from the face seems to provide important information when recognising a person's identity (Knight & Johnston, 1997; Lander & Bruce, 2000). Here, we report a number of experiments, using personally familiar faces, designed to investigate which aspects of motion are beneficial for the recognition of identity—rigid head movements? expression type movements? speech movements? Recent work has suggested that the eyes are particularly important for face processing. However, in terms of motion, it is the mouth area that moves the most. Our results suggest that benefits of motion can be found when viewing just the top or bottom half of the face (rest of face blacked out), indicating that motion advantages are not confined to one part of the face. Results are discussed in relation to current models of face recognition. Furthermore, we consider the possibility that the representations underlying recognition are themselves dynamic in nature (Freyd, 1987).

## Implicit sensitivity to posed and genuine smiles

**Lynden Miles**

*Department of Psychology, University of Canterbury, New Zealand*

The ability to accurately perceive facial expressions of emotion is a significant modulator of social interaction and behaviour. The visual information conveyed by such expressions specifies to the perceiver qualities of the sender's internal psychological state, and effects appropriate responses. For instance, a smile signals that the sender is happy and affords approaching. This perception-action cycle may, however, be compromised if the sender attempts to deceive by exhibiting a particular affective facial expression without experiencing the corresponding psychological state. The sensitivity of the perceiver to such attempts at deception has important implications for social interactions.

The reported research investigated the sensitivity of perceivers to the differences between posed and genuine smiles. Genuine smiles involve the characteristic up-turned mouth, as well as 'crow's feet' around the eyes caused by recruitment of eye sphincter muscles. Posed smiles, on the other hand, do not exhibit any eye wrinkling. Using a computer-based presentation participants were primed (at both subliminal and supraliminal levels) with a variety of facial expressions, including genuine and posed smiles, that were replaced by semantically positive and negative words. Participants indicated, with a key press, the valence of each word. Results indicated that, as predicted, participants responded differently when primed with genuine smiles compared to posed smiles. Genuine smiles facilitated identification of positive words compared to a control condition, whereas posed smiles did not. Findings will be discussed in relation to information about social affordances communicated by facial expressions, with a focus on the role of the perceiver when detecting deception.

## Symposium

### Interpersonal Perception-Action Systems

Organisers:

**Michael J. Richardson & Kerry L. Marsh**

*Center for the Ecological Study of Perception and Action,  
University of Connecticut, Storrs, USA*

The proposed symposium includes a number of novel projects examining the perception and action processes of interpersonal systems. Until recently, the areas of interpersonal and social interaction have been largely ignored within the fields of ecological and perception-action psychology. However, drawing from the combined understanding that one of the most significant environmental interactions an organism has are those with conspecifics, a number of researchers from the areas of coordination dynamics, psycholinguistics, ecological, and social psychology have started to examine interpersonal systems in an attempt to broaden our understanding of how we, as social organisms, coordinate with the world.

At its essence, interpersonal and social behavior can be deconstructed into a number of elements that are essential for coordinating oneself with the social environment. These elements are: the physical presence of two or more people, visual or verbal information that is emitted from one or several individuals to another, a set of task constraints that either facilitate or impede co-action, and the presence of dyadically defined goals, whereby the actions of one organism bring about changes (both psychologically and behaviorally) in the actions of another. With this in mind, each speaker will present recent work that tackles one or several of these elements, highlighting the importance of studying perception and action at a level above that of the individual, as well as describing new methodologies that facilitate the investigation of interpersonal perception-action systems and the phenomena that surround them (e.g., coordination dynamics, social and interpersonal affordances, and communication systems).

Kevin Shockley will begin by presenting recent findings demonstrating how physical entrainment emerges between co-actors when engaged in cooperative conversation and how differing task constraints and individual goals (degree of cooperation) affect this entrainment. Such findings are intriguing because they appear to index the level of interpersonal coordination that must occur if joint activities are to be completed.

Using this work as its foundation, Michael J. Richardson will then discuss a number of findings that uncover how the interpersonal synchrony of locally controlled movements emerge unintentionally by means of visual and verbal coupling. In particular, this presentation will attempt to answer the question of

how visual and verbal couplings affect rhythmic movements and set the stage for interpersonal synchrony.

In like fashion, Kerry L. Marsh will introduce a new line of research aimed at identifying how the possibilities for action (affordances) can be affected by the presence of others in ways that differ quantitatively as well as qualitatively from those possible in solo action. She will present research that examines the scaling relationship and intrinsic dynamics of affordances at the individual and interpersonal levels - examining whether the same perception-action coupling that constrains individual action also operates in the same way at the interpersonal level.

Finally, Bruno Galantucci will focus on how communication systems emerge during social interaction. More specifically, drawing from his research into the emergence of natural languages, he will present results that suggest that this process of emergence, far from being accidental or due to a biological endowment peculiar to humans, is an unavoidable consequence of the joint increase in complexity of an animal's interpersonal and social actions.

By combining the above research projects together into one symposium, it is hoped that other researchers will begin to see how one can study perception and action at a social or interpersonal level. More importantly, the symposium seeks to demonstrate how such investigation can lead to a greater understanding of epistemic intentional perception-actions systems and organism-environment (organism-organism) mutuality.

## Conversation, coordination, and cooperation

**Kevin Shockley<sup>1,2,3</sup>, Marie-Vee Santana<sup>2,4</sup>,  
Carol Fowler<sup>1,3</sup>, & Michael J. Richardson<sup>1,3</sup>**

<sup>1</sup>*Department of Psychology, University of Cincinnati, Cincinnati, OH, USA*

<sup>2</sup>*Center for the Ecological Study of Perception and Action, University of  
Connecticut, Storrs, USA*

<sup>3</sup>*Haskins Laboratories, New Haven, USA*

<sup>4</sup>*Health Care Research Center of the Proctor & Gamble Company,  
Mason, USA*

Investigations of the coordination that results from cooperative conversation have demonstrated that conversers converge in speech characteristics, such as speaking rate, vocal intensity, and pausing frequency (see Hatfield, Cacioppo, & Rapson, 1994, for a review). Furthermore, listeners to a speaker whom they find engaging tend to mirror the postures of the speaker (LaFrance, 1982) and are also reported to move in time with the rhythms of a speaker's speech (exhibiting "interactional synchrony"; Condon & Ogston, 1971; Newton, 1994). Findings of movement entrainment among conversational partners are intriguing because they appear to index the interpersonal coordination that must occur if the joint activities are to be completed. Most findings of movement entrainment, however, are based on fairly subjective observational procedures (e.g., hand scoring videotapes of listener movements). Recent investigations using nonlinear analyses of postural trajectories, however, have provided objective evidence that persons engaged in cooperative conversation to identify differences between two pictures, tend to coordinate their postural activity (Shockley, Santana, & Fowler, in press). Recent experiments extending this paradigm evaluate the question: Does the degree of cooperation among conversers influence the degree of interpersonal coordination? For example, Giles (1973) found that during somewhat hostile interactions dialect 'divergence' is observed. The findings of Shockley, Santana, & Fowler (in press) and ongoing experiments manipulating the degree of cooperation among participant-pairs in a mutual map navigation task will be presented with respect mutual postural coordination.

## The effects of visual and verbal couplings on interpersonal synchrony

**Michael J. Richardson<sup>1,3</sup>, Richard C. Schmidt<sup>1,2</sup>,  
& Kerry L. Marsh<sup>1,3</sup>**

<sup>1</sup>*Center for the Ecological Study of Perception and Action, University of Connecticut, Storrs, USA*

<sup>2</sup>*College of the Holy Cross, Worcester, USA*

<sup>3</sup>*Department of Psychology, University of Connecticut, Storrs, USA*

Past research has shown how rhythmic movements between people become synchronized through vision following coupled oscillator dynamics (Schmidt & O'Brien, 1997, Schmidt & Turvey, 1994). More recently, similar findings have emerged which demonstrate how the exchange of verbal information in conversation brings about postural entrainment between individuals (Shockley, Santana & Fowler, 2002). Consequently, a number of studies were conducted to examine whether the interpersonal synchrony of locally controlled movements emerge unintentionally when people are visually or verbally coupled. Pairs of participant's completed simple puzzle tasks while performing rhythmic movements under instructions that minimized intentional coordination but facilitated social interaction (either visually or verbally). Nonlinear analyses of the pairs' movement trajectories revealed differences between visually and verbally coupled pairs in the degree of phase entrainment, frequency locking and movement variability. The results support the hypothesis that the unintentional coordination of rhythmic movements between individuals is organized through vision by a coupled oscillator dynamic, but raises questions about how verbal information affects the emergence of unintentional synchrony and coordination.



## The affordance structure and dynamics of duo lifting

**Kerry L. Marsh, Reuben M. Baron,  
& Michael J. Richardson**

*Center for the Ecological Study of Perception and Action, University of  
Connecticut, Storrs, USA*

Possibilities for action can be affected by the presence of others in ways that differ quantitatively as well as qualitatively from those possible in solo action. Another individual allows us to extend our effectivities (e.g., in order to move larger objects), but emergence of a higher-level action unity (“we”) may also provide affordances that differ from the mere sum of affordances available to solo actors. Experiments are presented that examine the scaling relationship and intrinsic dynamics of affordances at the individual and interpersonal levels—examining whether the same perception-action coupling that constrains individual action also operates in the same way at the interpersonal level. Prior research has examined how gripping of an object changes as a function of qualities of the individual (hand size) and qualities of the object (length, mass, density) (Cesari & Newell, 1999; Newell, McDonald, & Baillargeon, 1993; van der Kamp, Savelsbergh, & Davis, 1998). Our studies demonstrate that the principles that predict affordances in single action systems (the fit between qualities of the individual—arm span, and qualities of the environment—object length) similarly apply for affordances of dual-person action systems, for tasks involving a nested affordance structure. Moreover, we find phase transitions and characteristic qualities of dynamical systems (e.g., hysteresis) for shifts from solo to joint perception and action. Although joint perception-action systems operate somewhat differently from solo perception-action systems, the affordance methodology provides a novel means of examining entirely neglected phenomena—the self-organization of cooperation out of basic perception-action principles.

## Experimental investigations of the emergence of human communication procedures

**Bruno Galantucci<sup>1,2</sup>, Carol Fowler<sup>1,2</sup>,  
& Michael J. Richardson<sup>1</sup>**

<sup>1</sup>*Center for the Ecological Study of Perception and Action,  
University of Connecticut, Storrs, USA*

<sup>2</sup>*Haskins Laboratories, New Haven, USA*

We present a method for exploring how humans establish and develop communication procedures. Two participants play a game with two interconnected computers. They are located in different rooms but share the virtual environment of a game that requires them to coordinate their moves. Success depends on establishing effective communication procedures but the experimental set-up does not support conventional communication systems. Spoken language is not possible because there is no microphone-speaker connection. Either visual or acoustic signals are allowed but occur through the use of devices that do not support conventional communication procedures (e.g., script or spoken language).

In a pilot study using the method, we observed players develop interpersonal procedures of communication that supported successful performance in the game. This paper will report the results of a series of experiments that use the method to study the interplay between the constraints of the game's environment and the specific characteristics of the communicational channel.

## Symposium

### Multimodal Dynamical Gestures

Organisers:

**Paul Treffner<sup>1</sup> & Nobuhiro Furuyama<sup>2</sup>**

<sup>1</sup> *Complex Active Visualisation Lab, Griffith University,  
Gold Coast, Australia*

<sup>2</sup> *National Institute of Informatics, Hitotsubashi, Chiyoda-ku,  
Tokyo, Japan*

When a person speaks, movements can be seen in various parts of the body and face. Some of the movements are seemingly connected to articulation directly and others less directly or only incidentally. The former are called articulatory gestures and the latter merely gestures (broadly construed here to include so-called manual gestures, facial expressions, head nodding, etc.). The boundary between the two has not been clear, however, both in terms of perception-action coupling and in terms of communicative function. Regarding perception-action coupling, it is not deniable, for one thing, that the articulatory system overlaps with the gesticulatory system (e.g., respiratory and postural systems). With respect to communicative function, it is well documented that speech and gestures, by meaningfully mediating each other, co-express similar or related aspects of one and the same state of affairs or events - they are spatiotemporally coordinated and constitute two poles or aspects of a single coordinative system of communication. But what is the ecological or dynamical basis of such multimodal coordination of speech and gesture? How are these two modalities coordinated with one another? To what extent and in what way are they perceived by listeners and viewers? More specifically, what are the invariants in communication? This symposium discusses recently research conducted on multimodal communicative systems from ecological and dynamical systems approaches.

The first speaker, Nobuhiro Furuyama, will describe his recent research revealing a relation between hand gestures, speech gestures, and respiration. Of interest is how this relates to the recent discoveries of how attention underlies multimodal gestures such as the speech-hand coordination task of Treffner and Peter (*Hum. Mov. Sci.* 21, 641-697).

Denis Burnham will present data showing that an understanding of the perception and production of speech is to be found when the problem is approached as a multimodal auditory-visual phenomenon. That is, speech perception by eye and ear is not only possible but also the norm.

The third speaker, Miyuki Kamachi, seeks to demonstrate that there may be bimodal invariant information sufficient to specify speaker identity across the two modalities of moving faces and moving voices and that performance is more a function of the way in which people speak rather than of what they say. Thus, it is shown that the dynamic invariants with regard to speech production (i.e., articulatory gestures) also underlie speech perception.

The fourth speaker, Eric Vatikiotis-Bateson, investigates multimodal speech perception and production and focuses upon the existence of invariant patterns underlying facial spatio-temporal dynamics. He asks, firstly, to what extent the physical structure of the face shapes the development and execution of a given speaker's behavior, and secondly, to what extent perceivers can recover structural information from behavior?

## Coordination among articulations, gesticulations and breathing movements: A case of articulation of /a/ and flexion at the wrist

**Nobuhiro Furuyama, Hiroki Takase, & Koji Hayashi**

*National Institute of Informatics, Hitotsubashi, Chiyoda-ku,  
Tokyo, Japan*

This paper describes a study on coordination of articulations, gesticulatory limb movements, and breathing movements at the abdomen and the chest from the viewpoint of a dynamical systems approach. The participants were each instructed to synchronize articulations of /a/ and movements of the right-hand wrist at increasing frequencies specified by a metronome in two different modes of coordination. In one mode, the participant articulated the /a/ sound while flexing the wrist and produced no speech while extending (mode A). In the other mode the participant articulated the /a/ sound while extending the wrist and produced no speech while flexing (mode B). The means and the standard deviations of phase lag between the wrist movement and the articulation were calculated and were used as indices of the degree of equilibrium of coordination at different frequencies in the two modes of synchronization.

This research seeks to discover which control parameters contribute to the dynamics of the coordination, a macroscopic state characterized by the phase lags as order parameters. The following results have been confirmed so far. There were phase transitions in both modes of synchronization of articulation and gesticulation, and the standard deviation of phase lag between articulation and gesticulation in mode B was larger than that in mode A. These results plus further analyses of the data (including those of breathing movements) will be presented and discussed in terms of their implications for the emerging interest in an ecological approach to communication.

## Auditory-visual perception and production of lexical pitch

**Denis Burnham, Eric Vatikiotis-Bateson, Hani Yehia, Rua Haszard Morris, Valter Ciocca, & Helen Tam**

*MARCS Auditory Laboratories,  
University of Western Sydney, Sydney, Australia*

Speech perception and production are auditory-visual phenomena, but this has only been established for consonants and vowels, not for lexical tone. Here, we examine the auditory-visual perception and production of lexical tone.

*Perception:* A native Cantonese speaker stimulus person was recorded saying words from Cantonese tone sextuplets, e.g., /fan55/ 'divide', / fan25/ 'powder', / fan33/ 'lecture', / fan21/ 'grave', / fan23/ 'angry', / fan22/ 'portion'. These were presented to adults in auditory-only (AO), visual-only (VO), or auditory-visual (AV) modes. Cantonese speakers identified VO-presented words significantly better than chance (Experiment 1), and made correct 'same'/'different' judgements significantly better in AV than AO, especially in auditory noise (Experiment 2). In this same-different task, tonal Thai (Experiment 3), and even non-tonal Australian English (Experiment 5 & 6) speakers also perceived visual information for tone.

*Production:* Vatikiotis-Bateson et al. (2002) have shown good estimation of face movement from auditory speech and vice versa, and Yehia, et al. (2002) good correlations between F0 and head movement. To investigate distinctive visual features in tone production, we collected face movement data for the six Cantonese tones, the four Mandarin tones, the two Japanese pitch-accents, and two English stress patterns (distinguishing some nouns and verbs). We have now reliably estimated tone categories from auditory parameters - F0, rms amplitude etc., and in the next step, tone categories will be estimated from auditory, visual, and auditory-visual features. This involves the construction of an ecologically valid face model, so that appropriate visual parameters can be derived.

## Faces and voices: Cross-modal identity-specific invariants?

**Miyuki Kamachi, Harold Hill, Karen Lander,  
& Eric Vatikiotis-Bateson**

*ATR Human Information Science Laboratories, Hikaridai, Seika-cho, Soraku-gun,  
Kyoto, Japan*

We know that people can recognize moving faces and voices independently. Here we explore whether there is bimodal invariant information sufficient to specify speaker identity across the two modalities. For all the experiments reported we utilized an XAB task where a face (or a voice) speaking a short sentence was learned as X, and people choose between two voices (or faces), A and B, at test. When faces and voices were played normally people were able to identify the correct face (or voice) significantly better than chance. However, when the same video and audio was played backwards or only a single, static frame was shown performance dropped to chance. This shows that the cross-modal information needed to do this task is both spatiotemporal and direction specific.

In a second series of experiments, we showed that performance was largely independent of the overlap between the sentences used for learning and test. This suggests that performance is more a function of the way in which people speak rather than of what they say. This raises questions as to the extent to which performance is dependent on knowledge of the language or on the manner of speaking. We conclude that there are dynamic invariants specific to identity available from both faces and voices.

## The interactions of static structure and time-varying behavior in communicative behavior

**Harold Hill, Guillaume Vignali, & Eric Vatikiotis-Bateson**

*ATR Human Information Science Laboratories, Hikaridai, Seika-cho, Soraku-gun, Kyoto, Japan*

One of the small but critical issues in auditory-visual speech processing (AVSP) we have attempted to address recently is the co-dependence of static structure and time-varying behavior in the production and perception of multimodal speech. Individual faces vary in static detail sufficiently for different faces to be easily discriminated. At the same time, all faces share the same features and geometry. Individuals also differ in the details of speech production; indeed there is variability within an individual across multiple repetitions of the same utterance. Perceivers do not require that utterances be identical in order to perceive two utterances as the same in content, style, or form. Our question has two parts. First is to ask to what extent the physical structure shapes the development and execution of a given speaker's behavior? The second is to explore whether perceivers recover structural information from behavior?

In this talk, we report results of two sorts of study: 1) the correspondence between perceived and actual classification of ethnicity, gender, and expressive gesture using multilinear analysis (e.g., LDA) of a large database of static 3D faces (male & female, Japanese & non-Japanese) for which there are 9 postural variants; and 2) the perceptual effects of animating abstract (cuboid) substitutes for facial and head structures using measured kinematics. For example, we know that head motion correlates with vocal pitch and facilitates lexical processing [Munhall et al., in press, Psych. Sci.]. What happens when natural head motion is used to animate a face-like cube whose abstractness or, in this case, ecological validity is varied systematically?



## Ecological psychology and transactionalism: Perception as a function of development, and vice versa

**Jeffrey B. Wagman**

*Center for the Ecological Study of Perception and Action, University of Connecticut, Storrs, USA*

In the ecological approach to perception and action, structured ambient energy arrays provide information about meaningful environmental properties to a given organism. Thus, perception is viewed not as a cognitive achievement but as a lawful state of affairs that exists in an organism-environment system. In the transactionalist approach to behavioral development (in the tradition of Daniel Lehrman, Gilbert Gottlieb, and colleagues), behavior itself is a system property, and behavioral development is an emergent phenomenon regulated jointly by organism and environment. Thus, development is viewed not as a consequence of the unfolding of a genetic program, but rather as a consequence of the ongoing activity across the many levels of the organism-environment system. These levels include but are not limited to genetic activity, cellular activity, neural activity, behavior itself, social interactions, and environmental exigencies.

Despite their independent development as meta-theoretical points of view, ecological psychology and transactionalism shared the goal of seeking law-based explanations of perception and behavioral development in which the responsibility for these respective phenomena is distributed across the organism-environment system. These two perspectives have much to offer each other as ecological sciences. For example, ecological psychology offers transactionalism an account of the epistemic contact between animal and environment that promotes the continual development of the organism-environment system, and transactionalism offers ecological psychologists an account of development explicitly grounded in animal-environment reciprocity. This talk will further explore these commonalities and their consequences for both perceptual and developmental science.

## Are individual differences in temperament of relevance to Gibson's theory of affordances?

**Merrilyn Hooley & Boris Crassini**

*School of Psychology, Deakin University, Australia*

The ambitious scope, complexity, and difficulty of Gibson's project in proposing the theory of affordances are captured nicely by the words of Gibson's biographer, Ed Reed:

“Gibson was convinced that the theory of affordances, in conjunction with the concepts of information, persistence, and change, would enable him to transcend the ancient debate between subjectivity and objectivity and to resolve the mind-body problem. ... [H]e was offering a new approach to problems of psychology, one that he believed would not sink in the morass that have engulfed previous psychologies.” (Reed, 1988, p. 280).

These characteristics of the theory of affordances are further evidenced in the debates about the nature of affordances presented in the suite of papers in *Ecological Psychology*, Volume 12(1). In this paper we propose an elaboration of the notion of affordance by suggesting that those persisting individual differences in behaviour described as temperamental differences (e.g., differences on a dimension of temperament anchored at one end by behaviour described as 'outgoingness' and at the other by behaviour described as 'avoidance') can be integrated into the theory of affordances. We argue that such integration is consistent with Gibson's project as reflected in Reed's words, and as part of our argument, draw parallels between the integration of temperament with the theory of affordances and the way in which individual differences in body dimensions are incorporated in the theory. We also outline some empirical tests of our proposition.

## Coordination dynamics in preterm and fullterm infants at three stages of development

**Jan P. Piek, Nicholas C. Barrett, & Paul Loseby**

*School of Psychology, Curtin University of Technology, Perth, Australia*

Early spontaneous activity is thought to be essential for later motor development, yet the link between early motor activity and later skill acquisition has not been investigated. For example, longitudinal studies using motion analysis techniques have investigated spontaneous kicking in infants, the transition from crawling to creeping, and the development of independent walking in infants. The current study is significant in that it investigates longitudinally the transitions in coordination and skill development by tracing the developmental course at three stages, namely, the early stages of spontaneous movements, the first forward progression which is usually creeping or crawling, and then when infants become independent walkers. Using 3-D motion analysis, angular displacement curves were determined for the joints of all four limbs during these three stages of development. Joint comparisons were then made using cross-correlation functions and principal component analysis to investigate the dimensionality of the data at each stage of development. Changes in dimensionality were investigated both between each of the stages of development as well as within each stage. Both preterm and fullterm infants were investigated. Analysis of preterm infants who are at risk of later motor disability and delay provides insight into the different developmental course for these infants. An important variable examined was the degree of synchrony between joints which has been identified as a factor which distinguishes fullterm and preterm infants.

## Perceptual systems considered as creative practice: Arakawa and Gins' architectural body

**Jondi Keane**

*School of Arts, Griffith University, Gold Coast, Australia*

This paper was written to introduce and correlate the importance of James J. Gibson's and Stuart Kauffman's work for creative research and creative practice, but will also serve to introduce the work of Arakawa and Gins to students of human perception, movement, and ecological psychology. The paper will discuss the art and architectural practice(s) of Arakawa and Gins, specifically, their notion of the "architectural body". They propose that we may realise the architectural body through an ecological approach to art practice as daily research, which aims to observe, learn about, and reconfigure the relationships between organism-person and environment

The paper will examine how ideas and approaches in ecological psychology and self-organisation both inform and are extended by Arakawa and Gins' "procedural architecture". Examples will be drawn from their 35 year collaboration on writing projects, installations, site-specific works, large-scale land-works, houses, community housing, and small cities. Their commitment to studying complex interactions of the organism-person-surround, will be developed in two discussions:

1. What is involved in observing, learning and transforming modes of perception? How do Arakawa and Gins' architectural procedures address recognition and interaction with the organisation of our own organism?
2. How does an ecological approach within creative practice/creative research contribute toward understanding self-organising systems and perceptual systems in complex environments such as culture, history, and physical surrounds.

This is an attempt to make use of a transdisciplinary research, attempting to enact the convergence of research across the arts and sciences concerned with the relationship of the organism to the environment.

## Jitter and size effects on vection

**Stephen Palmisano, Fiona Pekin, & Amy Chan**

*Brain and Behaviour Research Institute, Department of Psychology, University of Wollongong, Australia*

Coherent perspective jitter and changing-size cues have both been shown to improve the visually induced illusions of self-motion induced by radial flow (Palmisano, 1996; Palmisano, Gillam & Blackburn, 2000). The current study examined whether these jitter and changing-size advantages: (i) interact to determine vection; and (ii) depend on participant expectations about the likelihood of self-motion perception and the purpose of the experiment. Displays were jittering and non-jittering patterns of radial flow either with/without explicit changing-size cues to motion in depth. While Experiment 1 found that only changing-size cues increased passive perceptions of display depth, Experiment 2 showed that both jitter and changing-size cues independently increased active ratings of perceived egospeed and perceived self-displacement. In Experiment 3, participants were randomly assigned into two groups—one where cognitive conditions biased participants towards self-motion perception and another where cognitive conditions biased them towards object motion perception. While vection was less likely in ‘object motion bias’ conditions than in ‘self-motion bias’ conditions, significant jitter and size advantages for vection were still found in both cognitive conditions. The current results suggest that if a sufficiently large vection advantage can be produced when participants are expecting to experience self-motion, it will be likely to persist in object motion bias conditions.

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## Jaywalking in virtual reality: Optical information affecting the margin of safety

**Dean Owen, Gordon Simpson, & Stephen Murray**

*Department of Psychology, University of Canterbury, Christchurch,  
New Zealand*

The experiments to be reported examine “darting,” in which the pedestrian commits to crossing in a gap and chooses an appropriate crossing speed, a strategy that accounts for over 40% of pedestrian accidents. Testing was conducted in an immersive virtual environment, where the participant can perceive and behave in the same way as in an actual crossing situation, but with no risk.

Time-to-arrival of an oncoming vehicle is scaled relative to each participant’s walking and rushing speeds, so that opportunities for road-crossing are set to the same levels for every participant. The safety ratio (time to arrival of an approaching vehicle divided by the time taken to cross) captures sensitivity to the affordances of the road-crossing situation (crossing and avoiding being hit) relative to effectiveness in taking advantage of each opportunity to cross or choosing not to. The margin of safety (in %) = 100 (the safety ratio – 1.00). The intention to dart is simulated by requiring the participant to cross the virtual road on every trial. The events are selected to include the conditions under which accidents occur, and collisions are recorded.

The results indicate that irrelevant vehicle size and its distance in space (which can be detected in a glance) are often used, in addition to relevant distance in time (information which takes longer to unfold and detect). As a consequence, attention to optical size rather than rate of optical expansion is likely to contribute to unsafe crossings. Future research will determine whether performance can be improved with training.

## The information-based regulation of interceptive timing

**Simone Caljouw<sup>1</sup>, John van der Kamp<sup>1</sup>,  
& Geert Savelsbergh<sup>1,2</sup>**

*<sup>1</sup>Perceptual-Movement Coordination: Development, Learning, and Performance  
Group, Institute for Fundamental and Clinical Human Movement Studies, Vrije  
Universiteit Amsterdam*

*<sup>2</sup>Centre for Biophysical and Clinical Research into Human Movement,  
Manchester Metropolitan University*

The original time-to-contact (TTC) model (Lee, 1976; Fitch & Turvey, 1978) fitted well with the dominant view that the process of perception precedes the control of action. From this perspective a performer is dependent on an accurate perceptual prediction of when an object arrives at a certain point in order to prospectively control the action to this future interception point. Hence, interceptive timing was assumed to be based on the perception of TTC as is specified by an optical variable (e.g., tau).

It is now well accepted that actors regularly do not initiate their interceptive movements at a constant TTC. The finding that timing is dependent on object size and approach velocity eventuated in the conviction that interceptive timing may be based on the pick up of optical variables that do not co-vary with TTC (e.g. Michaels, Zeinstra, & Oudejans, 2001; Caljouw, Van der Kamp, & Savelsbergh, submitted). Hence, we can no longer uphold the assumption that the perception of TTC is an intermediate phase in interceptive timing. We propose that multiple information sources directly regulate action depending on the task-constraints (Caljouw, van der Kamp, & Savelsbergh, 2003). A variable that does not specify TTC is not necessarily a useless variable, since it might be accurate enough to regulate an action given the performance settings. Recent experiments will be presented that show how task-constraints influence the information-movement coupling.

## Time-to-collision (TTC) judgements with off-size objects show that tau needs to be integrated with familiar size to explain TTC performance

**Simon Hosking & Boris Crassini**

*School of Psychology, Deakin University, Melbourne, Australia*

Observers judged TTC with computer-generated displays simulating an approaching object in three familiar-size conditions:

- (1) Real-size (smaller, larger objects depicted as tennis, soccer balls respectively).
- (2) Off-size (smaller, larger objects depicted as soccer, tennis balls respectively).
- (3) Ambiguous-size (smaller, larger objects depicted as texture-less black balls of different size).

Displays simulated objects approaching observers' viewpoint from 24.96 m, and disappearing at 5.76 m. Manipulation of approach velocities (4.8-19.2 msec<sup>-1</sup>) produced viewing times from 1.0 to 4.0 sec, and delays between object disappearance and tau-based TTC ranging from 0.3 to 1.2 sec. Motion characteristics of smaller and larger objects in the three familiar-size conditions simulated those of approaching real-sized tennis and soccer balls respectively; that is, for each approach velocity, tau-based TTC was the same across the three conditions for smaller and larger objects.

Results showed that, consistent with the proposition of tau-determined TTC, TTC estimates in the real-size condition were uninfluenced by object size. This is contrary to previous reports that TTC for larger objects is underestimated relative to TTC for smaller objects. However, such size-dependent TTC differences were found in the ambiguous-size condition, with even larger differences in the off-size condition; TTCs for the 'larger' tennis ball were much less than TTCs to the 'smaller' soccer ball compared to corresponding TTCs in the ambiguous-size condition. These results are problematic for the proposition that tau solely determines TTC. We discuss the role of perceptual learning in resolving this problem.



## Symposium

### Invariants in the visual world and their relation to invariants in the visual system

Organiser:

**Phil Sheridan**

*School of Computing and Information Technology,  
Griffith University Logan, Australia*

This symposium explores a set of related models of the primate retina and the primary visual cortex and the role of invariants in direct perception by the visual system. A guiding assumption of this symposium is that invariants in the visual world, and detection of invariants by the visual system, are central to visual perception. The first speaker, Kazuhiko Takemura, will discuss perceptual implications of optical input to the primate retina, and how a hexagonal lattice of light detectors improves signal detection. The second speaker, Phil Sheridan, will discuss the structure of the retina and primary visual cortex in relation to the detection of pseudo-invariants in optic flow. Speaker three, David Alexander, will discuss the mapping of the visual field at a smaller scale of primary visual cortex, and what this reveals about visual invariants. The fourth speaker, Mark Chappell, continues the theme of invariants in a manner that is independent of architecture.

The first speaker, Kazu Takamura, will discuss characteristics of information delivery to visual systems—a first step in the transition from the environment to the internal, subjective image. There are physical limitations to collecting light for the purposes of creating a visual image. Since these limitations are due to the invariant physical properties of light propagation and detection, they apply equally to biological retinas and the physical hardware of cameras. Just as the human observer moves within a complex environment, camera image fidelity must be maintained over a wide range of conditions, including low light levels prevalent in the built environment. The core trade-off that applies to each of these systems is the requirement for high resolution versus good signal to noise ratio. The higher the resolution, the poorer the signal to noise ratio and *vice versa*. An improved balance point in this trade-off can be achieved by use of a hexagonal lattice rather than the usual square lattice. The universality of these improvements is illustrated with respect to both biological retinas and camera hardware.

The second speaker, Phil Sheridan, will argue that the retinal field and the V1 cortical field can be described naturally in terms of a hexagonal lattice. Computer models based on such a lattice have advantages over other methods. The adjacency relations of points within the hexagonal lattice provide the means by which rotation and scale invariants can be captured. The mapping from the retina to the global structure of monkey primary visual cortex is distorted by a complex-log transformation. This enables rotation and scaling changes during visual interactions to be simplified, becoming mere translations of activations across the cortical surface. Rotation and scale invariance have been interpreted in terms of

changing properties of the stimulus, but applying the model to real-time robotics problems reveals a more general, ecologically valid interpretation. The invariants also arise from the movements of the viewer—both in terms of tilting and movement toward and away.

The third speaker, David Alexander, will present evidence that the surface of the primary visual cortex contains repeated tilings of a local map of orientation preference. The 180 degree symmetry in the local map has been interpreted as due to symmetries in the appropriate stimulus i.e. an oriented line. A more general interpretation suggests this symmetry is due to the scan path of the eye, which constantly reverses back on itself producing 180 degree symmetries in the viewed world. Consistent with this interpretation, our analyses suggest that the local map of orientation preference makes use of signals from the entire extent of the primary visual cortex i.e. is itself a re-mapping of the viewed world. By way of contrast, the emphasis in the mainstream visual literature on isolated stimulus properties has led to the assumption that the local map of orientation preference confines itself to local interactions of a few degrees of visual angle.

A Lie algebra for visual perception makes an appearance in the final paper on the programme by Mark Chappell, who reviews a theory by Hoffman (1966; 1998). This theory is based on modeling the psychological constancies—shape, size, motion, and so on—as invariances of continuous (“Lie”) transformation groups that act over the visual manifold. It was Sophus Lie’s fundamentally new idea to consider not the often badly nonlinear transformations involved in forms like visual contours but rather their locally linear form near the identity of the transformation. Here the local tangent to the curve generates a so-called infinitesimal transformation, or Lie derivative, which “drags the flow” along the path-curve. If the curve is invariant under the transformation group, the Lie derivative annuls it—inhibition rather than excitation. If the Lie derivatives comprise a Lie algebra, then the curves in the manifold are integrable, and a visual contour is constructible at the global-percept scale from the locally linear one. The table of Lie transformation groups corresponding to the visual constancies is reviewed. In addition to the rotation and size constancies involved in the previous two presentations, the hyperbolic transformations of binocular perception are included as well as those of the Lorentz transformation for invariant motion perception. Predictions and confirmations of the theory are listed.

## A biologically inspired camera

**Kazuhiko Takemura**

*Product Planning & Development Division, Electronic Imaging Products  
Division, Fuji Photo Film Co., Ltd., Japan*

The distribution of cones on primate retina is directly related to primate's high visual acuity. This paper describes the theoretical issues that effect resolution, sensitivity, dynamic range and signal to noise ratio and how the primate retina optimises these parameters. The empirical evidence of the theory is presented in description of a digital camera recently developed by Fuji Films Co. In camera design there is a trade-off between decreasing pixel size (to improve image resolution) and increasing pixel size (to maximise optical input to each pixel). In a similar fashion to the primate retina, a hexagonal array of pixels provides an improved balance-point in the trade-off between these two competing requirements.

## Computing with a hexagonal lattice: How to optimise invariant detection in optic flow

**Phil Sheridan**

*School of Computing and Information Technology,  
Griffith University Logan, Australia*

Bees have exploited for a considerable amount of time, humans have conjectured for centuries, and recently Hales (in Peterson, 1999) has explored further how the hexagonal lattice provides an architecture by which a maximum of honey can be stored with a minimum of wax. This phenomenon, formally known as the Honeycomb Conjecture, is also critical to invariants in optic flow to the human vision system. It is generally accepted that the distribution of cones on the primate retina (Williams, 1986) and the arrangement of neurons in the cortex are described by a hexagonal lattice (Calvin, 1987). This paper argues that the hexagonal lattice captures invariants in a manner that simultaneously maximises the acuity of invariants and minimises the error in its representation. A mathematical structure, known as the Spiral Honeycomb Lie Algebra (SHLA), which is implied by retinal and cortical architecture, is described. It is demonstrated that SHLA captures translation, rotation and scale pseudo invariants and explains why the resulting representation of these invariants is optimal with regard to acuity and error. The importance of this structure is that it is computational and can therefore be implemented in digital technology for the construction of artificial vision systems.

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## Local and global maps in primary visual cortex

**David Alexander**

*Brain Dynamics Centre, Westmead Hospital, Sydney, Australia*

The local-global mapping (LGM) theory of the organisation in the primary visual cortex suggests the patterns of various response properties may be accounted for by the interactions of two visuotopic mappings, one global and the other local. The global map supplies retinotopic response properties and allows rotation and scaling invariance. The local map can be considered to allow “visual scan-path reversal” invariance, and supplies modulatory response properties such as orientation preference. Computer modelling of V1 in tree shrew shows that all the key geometrical features of orientation preference (e.g., singularities, linear zones, saddle-points), emerge from the double visuotopic mapping. The LGM theory suggests that, in the macaque, CO blobs are the local map representation of the central field of vision. A number of testable predictions arise for the macaque: CO blobs and singularities will coincide when imaging is done in the fovea, and in parafovea/periphery, CO blobs and singularities will not coincide. A corollary of this prediction is that when large injections of HRP tracer are made in fovea, CO blobs and “lacunae” will coincide. Existing results, at 10 degrees retinotopy, show non-coincident CO blobs and lacunae (Rockland & Lund, 1983). When optical imaging is done in the parafovea/periphery, the orientation preferences within CO blobs will be systematically biased depending on the polar angle of the site of imaging.

## A transformation group approach to optic flow

**Mark Chappell**

*School of Applied Psychology, Griffith University, Mt Gravatt, Australia*

The invariances of optic flow are of two kinds: geometricophysical ones stemming from motion phenomena in the outside, physical world that are governed by diffusion (Lindeberg, 1994; Olver, Sapiro, & Tannenbaum, 1996) and internal, psychological invariances. The latter aspect refers, broadly speaking, to object constancy, and consists of the several psychological constancies: shape, size, motion, color, pitch, loudness, and kinesthetic-sensorimotor constancy. The connection between these perceptual invariances and corresponding mathematical continuous transformation groups was first established by Hoffman (1966) and his work has continued to this day (e.g., Hoffman, 2003). Particularly pertinent to the perceptual aspect of optic flow is the prediction of Hoffman's theory that, owing to a maximal finite velocity  $c_n$  of nerve signal propagation in the CNS ( $< 10 \text{ ms}^{-1}$ ), velocity perception is Lorentzian rather than Galilean (Caelli, Hoffman, & Lindman, 1978) and so departs from a linear relation between object velocity and apparent length/time near  $c_n$ . The Lie transformation group theory of neuropsychology (L.T.G./N.P.) is reviewed, and some of its accomplishments to date are surveyed.

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## A bearing angle strategy predicts how balls are intercepted

**Alexandra Chardenon, Gilles Montagne, Reinoud Bootsma, & Michel Laurent**

*UMR "Movement & Perception", CNRS & University of the Mediterranean,  
Faculty of Sport Sciences, 163 Avenue de Luminy Case 910,  
13288 Marseille, France*

The majority of the studies on the visual control of goal-directed locomotion has focused on the informational substrate of the task while the control law ·the way information is involved in the control of action· has not received much attention. The aim of our study is to test information and a control law for how people locomote to intercept a ball. We propose that the only thing an actor has to do to intercept a ball is to keep the bearing angle constant by modulating its own displacement velocity. The proposed information is the bearing angle which is the angle subtended by the current position of the ball and the direction of displacement. The control law we propose is that the actor compensates any change in the bearing angle by producing the required acceleration. The model was tested using a virtual reality set-up in which the displacements of the participants on a treadmill were linked to a visual scene. This set-up allowed easy manipulation of the components of the strategy (i.e., angle of approach, ball speed, looming, optic flow). We asked participants to intercept a ball ·approaching an angle· with the head when it was crossing the axis of displacement. Note that participants could freely modify their velocity. Mean displacement velocity profiles, mean current error profiles and regression analyses are compatible with predictions of the proposed strategy, showing that the bearing angle strategy can be involved in the visual control of interceptive tasks including locomotor displacements.

## The effect of affordance on the reach-to-grasp movement after stroke

**Helen J. Hill, Alan Sunderland, & Paulette van Vliet**

*Division of Stroke Medicine, University of Nottingham, United Kingdom*

Arm rehabilitation following stroke comprises actions involving objects. Clinical practice is moving towards using meaningful objects, from using meaningless objects, with little evidence (Wu et al., 1998). Data from healthy and post-stroke volunteers indicates that both object and context influence the reach-to-grasp movement. We compared movement towards a high-affordance object with that towards a low-affordance control object.

A convenience sample of 10 participants who had returned home following unilateral stroke was recruited. Inclusion criteria were Rivermead Motor Assessment (arm section) > 5, and able to give informed consent. A repeated-measures counterbalanced design. Kinematic recordings of reaching movements to the participants own mug or a size-, weight- and contrast-controlled cylinder were made using a MacReflex motion analysis system. Matlab programs were written to analyze data. Wilcoxon signed-rank tests on the temporal parameters reaction time (RT), movement time, time of peak acceleration, of peak velocity and of peak deceleration used a significance level of  $p < 0.05$ .

Unexpectedly, analyses indicated participants found it easier to reach to the low-affording control cylinder, demonstrated by shorter movement times and relatively shorter deceleration phases, with both arms. Further, reaches with the ipsilesional arm had longer RTs to the cylinder, indicating more pre-planning and less reliance on on-line feedback. These results suggest that familiar, affording objects may prime knowledge-based schemas for action, requiring choice, whereas low-affording objects may prime more primitive schemas. Progress towards the clinical goal, to initiate an action or refine it, could be influenced by object type.

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## Precision of interceptive action in space and time

**James R. Tresilian**

*Perception and Motor Systems Laboratory, School of Human Movement Studies,  
University of Queensland, Brisbane, Australia*

A major league hitter in baseball is capable of striking (with a bat's sweet-spot) balls pitched at speeds that may exceed 40 m/s. This requires the hitter to move the bat with great accuracy and precision, both in space and time (Regan, 1992). A large body of experimental literature suggests that you can only be fast at the expense of reduced accuracy. Nevertheless, professional hitters are able to achieve a very high level of accuracy with very rapid movements that last only about 150-250 ms. If only slow movements can be precise and accurate, the hitter appears to achieve the impossible. However, it has been established that brief movements aimed at stationary targets are less temporally variable than movements of longer duration (Newell, Hoshizakio, Carlton, & Halbert, 1979), indicating that briefer movements can be temporally controlled with greater precision. It has recently been confirmed that interceptions demanding greater temporal precision elicit faster responses and that these are more temporally precise (Tresilian & Lonergan, 2002; Tresilian, Oliver, & Carroll, 2003). However, fast movements are expected to be spatially imprecise. We report the results of recent experiments that have examined how people deal with simultaneous requirements to be both spatially and temporally precise. It was found that participants adopted one of three strategies when demands for spatial precision increased with temporal precision demands constant: (a) briefer, faster movements when greater spatial precision was required; (b) slower movements when greater spatial precision was required; (c) no tendency to change duration or speed in response to changing spatial precision demands.

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## Perceptual learning: Assembly of an information-detecting synergy

**Claire F. Michaels, David Jacobs, & Rob Withagen**

*Faculty of Human Movement Sciences, Vrije Universiteit, Amsterdam,  
The Netherlands*

Ecological psychologists have sought variables that specify object and event characteristics that are important to perception and to the control of activity. Some have been mathematical derivations (e.g., tau); others variables are based on observations of properties of things (e.g., aging heads and growing trees) that are presumably preserved in the light. In addition to the education of attention to such variables, there is evidence that perceivers can converge on other variables by searching and optimizing in a multidimensional variable space (Jacobs, 2001; Smith, Flach, Dittman & Stanard, 2001). We portray the process as assembling a perceptual synergy sensitive to the compound variable. Perceptual laws, which relate judgments to the information, and control laws, which relate action parameters to information, are then calibrated. We present results that illustrate perceivers navigating through informational space and calibrating their judgments. This approach shares some superficial similarities with cue-theory, probabilistic functionalism, and Bayesian inference, but we defend its credentials as direct perception.

## Coordination of upper and lower body rhythms during walking

**Bruce A. Kay, Steven J. Harrison, & Theo Rhodes**

*Center for the Ecological Study of Perception and Action, University of Connecticut, Storrs, USA*

What is the nature of the coordination between rhythms produced by the upper and lower body, and how are such patterns of coordination produced? Kay & Warren (2001) found that for rhythmical postural adjustments produced while walking, posture and gait frequency-locked to each other for certain low-integer frequency ratios (e.g., with 2 gait cycles produced for each cycle of sway), but only in barely more than the majority of trials. A nonlinear coupled oscillator model accounted for much of the data, both locked and not locked. In the current study, we investigate (a) whether such frequency-locks occur while performing other upper body tasks, specifically, rhythmically swinging pendula simultaneously with walking, on a treadmill and over open ground; and (b) inquire into the precise nature of the coordination between the two in the absence of such locking. In the treadmill data, no overall effect of one girdle's (upper or lower) rhythm on the other's basic oscillatory parameters (e.g., frequency, amplitude, phase) was observed, with a more complex pattern present in the overground data. For both regimes, we observe frequency-locking and non-mode-locking between the two girdles. Using linear and nonlinear measures of cross-correlation (e.g., cross average mutual information, cross recurrence quantification analysis) combined with surrogate data analysis, we find for many of the non-locked trials that the girdles have significant linear and nonlinear dependencies. We make detailed speculations about the coupling functions that could give rise to such a pattern of observed frequency lockings and dependencies.

### *Reference*

Kay, B. A., & Warren, W. H. J. (2001). Coupling of posture and gait: Mode locking and parametric excitation. *Biological Cybernetics*, 85, 89-106.

## Rope jumping performance variability as a function of rope frequency

**Flavia Cristina Bueno, Wellington Roberto de Carvalho,  
& Ana Maria Pellegrini**

*IB/RC - Universidade Estadual Paulista, FUNDUNESP, Brazil*

To be successful in rope jumping the performer must adjust his jump to rope trajectory with a precise timing. He needs information about rope trajectory, information directly available when turning the rope. This presentation will focus the stability of the spatial-temporal relationship between jump and rope in four rope frequencies: the first one was chosen by the participant, and the other three (1.80 Hz, 1.66 Hz, 1.53 Hz) were imposed by a digital auditory metronome. The participants were 10 graduate students in Physical Education and were filmed (video digital camera, 120 Hz) performing sequences of ten rope jumps initially at the participant's chosen frequency followed by the other three frequencies with the order counterbalanced across subjects. A short rest period was given between rope jump sequences. Marks were placed at the ankle and in the middle of the rope for rope-jumping performance video analysis. Data were decoded through DVideo 4.0, smoothed and spectral analysis performed in Matlab 5.3, which gave us the maximum value of rope and jump trajectories. Relative phase was computed as  $[(R1-A1/R2-R1)*360]$ , R1 being the maximum value of the rope, A1 the maximum value of the ankle at the same cycle, and R2 the maximum value of the rope at the following rope cycle. Statistical analysis did not indicate differences in relative phase, or its mean and standard deviation among the frequencies used in this study, thus suggesting stability in the performance of this motor skill.

## Haptic exploratory procedure(s) and nonuniform textured surfaces

**Barry Hughes**

*Department of Psychology, University of Auckland, Auckland,  
New Zealand*

The textures of surfaces are typically perceived by active touch via the selection of a particular haptic “exploratory procedure” (EP), fingerpad-surface contact with (often repetitive) lateral motion. The nature of this exploratory procedure is unclear (e.g., is it a stable form of procedural knowledge, or are exploratory decisions made during exploration?). Understanding its nature requires measuring perceptual accuracy when more complex, nonuniform textures are explored, and by contrasting performance under unconstrained and constrained explorations. We created sets of circular, raised-dot textured surfaces (using photo-etched nylon plates) in which the orientation of the dots was varied in the left and right hemispheres of the circle. We measured participants’ perceptual sensitivity to the difference in orientation, with and without constraints on the exploration durations and trajectories (explorations that we recorded and digitized).

We found that perceptual accuracy was a function of the magnitude of the orientation difference and of the configuration of the texture elements. Detecting a difference in hemispheric orientation depended on both the magnitude of that difference and the global configuration of the texture elements. The patterns of exploration were heterogeneous through early explorations but became more homogeneous with time. In a second experiment we found that constraining the exploration duration and the exploratory trajectories only modestly reduced perceptual accuracy but did not change the overall pattern of results. The data have implications for models of haptic texture perception and suggest that this EP is highly labile, perhaps comprising intentionally guided sub-processes to extract information during its execution.

## Direct perception: A matter of non-locality, self-motion, and impredicativity?

**Michael T. Turvey**

*Center for the Ecological Study of Perception and Action, University of  
Connecticut, Storrs, USA*

*and*

*Haskins Laboratories, New Haven, USA*

Perceptual theories bear the stamp of assumptions advanced in the 17th century by the founding fathers of the mechanistic hypothesis. Key assumptions are local, contiguous cause, inert matter (no self-motion), and predicative (syntactic, recursive) explanation. Perception as “indirect” accords with these assumptions, perception as “direct” does not. Arguably, direct perception presumes conceptions of matter and cause to which the modern century is especially heir. These include non-locality, self-organization, and explanation in terms of closed loops of entailment (impredicativities). Advances in the theory of direct perception should follow from an explicit grounding of the theory in the physical assumptions of the 21st century rather than the 17th century.



## Poster Session 1: Monday and Tuesday

The effect of field-of-vision on coordination in virtual environments

*Amin, M., Bidwell, B., Johnson, B., McLaughlin, M., Pecorak, K., Riggs, M., Otten, E., Smith, D., & Smart, L. J.*

Miami University, USA

Contribution of the inertia tensor to manual multi-joint pointing

*Bernardin, D., Isableu, B., Dietrich, G., & Cremieux, J.*

University Paris-Sud, France

An intentional dynamics assessment procedure for discrete tasks

*Boonstra, T., Harrison, S., Richardson, M. J., & Shaw, R.*

Vrije University, Netherlands

Task-constraints and movement possibilities influence the timing of hitting

*Caljouw, S., Van der Kamp, J., & Savelsbergh, G.*

Vrije University, Netherlands

Learning and transfer across different effector systems: The example of goal-directed displacements

*Camachon, C., Montagne, G., Buekers, M.J., & Laurent, M.*

University de la Mediterranee, France

Heaviness perception depends on movement

*Carello, C., Shockley, K., Harrison, S., Richardson, M., & Turvey, M. T.*

University of Connecticut, USA

The ecological meaning of spatial symmetry in bimanual motor coordination

*Chan, T.-C., Tse, C.-Y., Yue, H.-Y. & Fan, L.-Y.*

Chinese University of Hong Kong

Scaling reach boundaries with respect to distance and mass of the target object

*Choi, H. J., & Mark, L. S.*

Miami University, USA

The Ebbinghaus figure is more than a size illusion

*de Grave, D., Biegstraaten, M., Brenner, E., & Smeets, J.*

Erasmus MC, Netherlands

A neural control structure for hitting

*Dessing, J., Caljouw, S., Peper, C E., & Beek, P. J.*

Vrije University, Netherlands



A comparison of real catching with catching in a CAVE

*Dessing, J., Peper, C. E., & Beek, P. J.*

Vrije University, Netherlands

Feature detection: An adequate meta-theory for fear responding

*Dickie, A., & Lipp, O.*

University Queensland, Australia

Sports expertise influences learning of postural coordination

*Ehrlacher, C., Bardy, B. G., Faugloire, E., & Stoffregen, T. A.*

University of Paris-Sud, Paris

The dynamics of learning new postures

*Faugloire, E. & Stoffregen, T. A.*

University of Paris-Sud, Paris

Phase transitions in human posture

*Fourcade, P., Bardy, B.G., & Bonnet, C.*

University of Paris-Sud, Paris

How do we reach and grasp a virtual image?

*Fukui, T., Ishii, A., & Inui, T.*

Kyoto University, Japan

Experimental investigations of the emergence of communication procedures

*Galantucci, B., Richardson, M., & Fowler, C.*

Haskins Laboratories, USA

“Mind the gap”: False memories as a case of event cognition

*Gerrie, M., & Garry, M.*

Victoria University of Wellington, New Zealand

Does exploration promote convergence on specifying variables?

*Hajnal, A., Michaels, C., & Zaal, F.*

University of Connecticut, USA

Notation about the interior of houses build in Japan after 1950

*Hiroki, S.*

University of Tokyo

Behavior of a harbor porpoise in an unfamiliar environment

*Honno, Y., Ito, K., Matsuishi, T., Okura, M., & Sasaki, M.*

Hokkaido University, Japan

Linguistic background and perception of ambiguous figures

*Hudry, K., Lacherez, P., Broerse, J., & Mora, D.*

University of Queensland, Australia

“Representational momentum” and the perception of complex biological motion

*Jarraya, M., & Amarin, M.-A.*  
University of Paris-Sud, France

Stereoscopic 3D visualization using gaze-contingent volume rendering:

Exploratory perception in action  
*Jones, M., & Treffner, P. J.*  
Griffith University, Australia

Viewing pictures from too far: When are tiles perceived square

*Juricevic, I., & Kennedy, J. M.*  
University of Toronto, Canada

Measuring exploratory learning with minimal instruction as drift

*Kadar, E., Virginas, B., & Effken, J.*  
University of Arizona, USA

Spectral analysis in human synchronization tapping

*Kadota, H., Miyazaki, M., Kudo, K., & Ohtsuki, T.*  
University of Tokyo, Japan

Viewing pictures: Similar triangles show how viewing distance increases size

*Kennedy, J., & Juricevic, I.*  
University of Toronto, Canada

Effects of texture and surface corrugation on perceived direction of heading

*Kim, N.-G.*  
William Paterson University, USA

Logical structure of visual information

*Kim, N.-G.*  
William Paterson University, USA

Altered depth perception in stereoscopic visualization

*Krumins, R., & Treffner, P. J.*  
Griffith University, Australia

Environmental coupling effect on rhythmic bimanual coordination

*Kudo, K., Park, H., & Turvey, M. T.*  
University of Tokyo, Japan

## Poster Session 2: Wednesday and Thursday

Effects of contrasting color patterns of the ball in volleyball reception

*Lenoir, M., Mazyn, M., Vansteenkiste, J., Vermeulen, J., & De Clercq, D.*  
Ghent University, Belgium

Perception-action coupling and expertise in interceptive acts

*Le Runigo, C., & Benguigi*  
University Paris-Sud, France

Tau guidance for mobile soccer robots

*Leonard, J., Treffner, P. J., & Thorton, J.*  
Griffith University, Australia

Sensitivity to emotional events

*Makeig, P., & Owen, D.*  
University of Canterbury, New Zealand

Calibration of critical boundaries for sitting and bipedal climbing

*Mark, L. S.*  
Miami University, USA

Inter- and intra-limb coordination in one-handed catching under varying temporal constraints

*Mazyn, L., & Leno, M.*  
Ghent University, Belgium

Binocular depth vision in the timing of one-handed catching

*Mazyn, L., Savelsbergh, G., Montagne, G., & Lenoir, M.*  
Ghent University, Belgium

Recruitment in a synchronisation task: A coalition of constraints

*Millieux, L., Calvin, S., Temprado, J. J., & Coyle, T.*  
University de la Mediterranee, France

The road-crossing safety ratio as an index of reduced mobility

*Murray, S., & Owen, D. (Paper presented in Session 1)*  
University of Canterbury, New Zealand

Effect of predictability of stimulus on visually-induced-motion-sickness

Otten, E. W., Smart, L. J., Amin, M., Bidwell, B., Johnson, B., McLaughlin, M., Pecorak, K., & Smith, D. L.  
Miami University, USA

- Mobile phones and driving: Affordances and attention  
*Petersen, A. J., Treffner, P. J., & Barrett, R.*  
Griffith University, Australia
- Do auditory illusions affect auditory action control? A first exploration  
*Repp, B. H.*  
Haskins Laboratories, USA
- Identification of sources of interlimb coordination: method and preliminary results  
*Ridderikhoff, A., & Peper, C. E.*  
Vrije University, Netherlands
- Musculoskeletal dynamics of the wrist during rhythmic activity  
*Ridderikhoff, A., Peper, C. E., Carson, R., & Beek, P. J.*  
Vrije University, Netherlands
- Postural sway decreases during performance of a digit rehearsal task  
*Riley, M. A., Baker, A. A., & Schmit, J. M.*  
University of Cincinnati, USA
- Frequency and amplitude are inversely related in circle drawing  
*Ringenbach, S. D. R., Amazeen, P. G., & Amazeen, E. L.*  
Arizona State University, USA
- Evidence for two visual pathways: Differences in walking and talking perceived distance  
*Rogers, S., Andre, J. T., & Brown, R.*  
James Madison University, USA
- The Mona Lisa effect: Perception of gaze direction in real and pictured faces  
*Rogers, S., Lunsford, M., Strother, L., & Kubovy, M.*  
James Madison University, USA
- Property of human locomotion in animations and biomechanics  
*Saburi, T.*  
University of Tokyo, Japan
- Visual basis of directional constraint in hand-foot coordination dynamics  
*Salesse, R., Temprado, J. J., & Laurent, M.*  
University de la Mediterranee, France
- Bi-manual haptic attention  
*Santana, M.-V.*  
Proctor & Gamble Company, USA
- Comparative study of “feedback” and affordance theory  
*Takashi Shibata*  
University of Tokyo, Japan

- Investigating behavioral modes of postural control and coordination  
*Smith, D. L., Smart, L. J., Otten, E. W., Pecorak, K., Amin, M., & Bidwell, B.*  
Miami University, USA
- Body-shape contributions to perception of point-light displays  
*Snyder, R.*  
Denison University, USA
- The role of visual & kinesthetic information in bimanual coordination  
*Summers, J. J., Wade-Ferrell, R., & Kagerer, F.*  
University of Tasmania, Australia
- Movement sequences for cracking an egg  
*Takahashi, A., Hayashi, K., & Sasaki, M.*  
University of Tokyo, Japan
- Alcohol affects grasping, but not reaching, in a simple manual prehension task  
*Timney, B., Johnston, K., & Goodale, M.*  
University of Western Ontario, Canada
- Intention and attention in gestural coordination: Asymmetric HKB model  
*Treffner, P. J., & Peter, M.*  
Griffith University, Australia
- Kinematic comparison of discrete and rhythmic reaching movements  
*van Mourik, A. M., Zaal, F. T. J. M., & Beek, P. J.*  
Vrije University, Netherlands
- Hierarchical control of the bimanual gallop  
*Verheul, M., & Geuze, R. H.*  
Manchester Metropolitan University, UK
- What is the sound of one rod dropping?  
*Wagman, J.*  
University of Connecticut, USA
- Transfer of calibration in dynamic touch: Length and sweet-spot perception  
*Withagen, R., & Michaels, C. F.*  
Vrije University, Netherlands
- Perception for inhibition: A dorsal-frontal pathway for sensorimotor regulation  
*Yang, S.-N.*  
Brain Sciences Institute, Japan

## Notes



























