EMPG 2015 PADOVA

EMPG Meeting 2015, Padua

September 01 − 03, 2015

Program and Abstracts

University of Padova

Contents

Welcome

Dear Colleague,

it is our great pleasure to welcome you to the 2015 Meeting of the European Mathematical Psychology Group held at the University of Padua, Italy. We hope that, like the previous editions, even this 46th EMPG meeting will be stimulating for new future scientific work. At the same time we hope you will enjoy the city of Padua with its "historic flavor".

This year's conference features two keynote talks by Richard M. Shiffrin and Eric-Jan Wagenmakers and two invited Symposia: the Symposium in memoriam Patrick Suppes, recently passed away, and the Symposium on thirty years of Knowledge Space Theory, initiated by Jean-Paul Doignon and Jean-Claude Falmagne in 1985.

Finally, we would like to acknowledge the financial support by the FISPPA department, and the logistic support by the three departments of Psychology (DPG, DPSS, and FISPPA).

The organizing committee:

Luca Stefanutti
Egidio Robusto
Pasquale Anselmi
Debora de Chiusole
Andrea Spoto

General information

Conference organization

Scientific committee
Hans Colonius (Germany)
Francesca Cristante (Italy)
Jean Paul Doignon (Belgium)
Ehtibar Dzhafarov (USA)
Miguel Angel Garcia Perez (Spain)
Juergen Heller (Germany)
Egidio Robusto (Italy)
Luca Stefanutti (Italy)

Organizing committee
Luca Stefanutti (Chair)
Egidio Robusto
Pasquale Anselmi
Debora de Chiusole
Andrea Spoto

Conference web site and e-mail
Web site: http://psychometrics-laboratory.psy.unipd.it/EMPG2015/
E-mail: empg2015.psicologia@unipd.it

The venue

All *plenary sessions* will take place in the room "Cesare Musatti", located at the ground floor of the building of the Departments of Psychology[1]. On Tuesday, September 1, *parallel sessions* will take place in rooms 2B and 2C, located in the second floor of the building of the School of Psychology[2]. On Wednesday, September 2, *parallel sessions* will take place in rooms 3G and 3H, located in the third floor of the building of the School of Psychology[2].

Addresses:

Departments of Psychology[1]
University of Padua
Via Venezia, 8
35131, Padova (Italy)

School of Psychology[2]
University of Padua
Via Venezia, 12
35131, Padova (Italy)

Registration desk

Partitipants can register to the conference, obtain conference material and all the relevant information at the registration desk, located in the ground floor of the building of the departments of Psychology, via Venezia, 8 (from the main entrance of the building, turn left). During the conference days the registration desk will be open from 8.30 am to 6.00 pm. On Monday, August 31, it will be open from 6.00 pm to 8.00 pm.

Presentation guidelines

Talks

Talks are scheduled for 30 min, including 10 min for discussion. It is important that speakers and chairs strictly adhere to the time schedule to offer everyone the opportunity to switch back and forth between sessions. In all rooms you will find the option to connect your own computer or tablet to the presentation equipment. If you plan to use the local computer (Windows operating system), please hand your presentation in PDF or PPT format to the technical assistant present in the room well before the session starts.

Invited Symposia and Keynotes

This year the EMPG will host two Symposia: the "Symposium in memoriam Patrick Suppes" and the "Symposium on thirty years of Knowledge Space Theory". The former will be held on Tuesday morning right after the opening session at 9.00 am, whereas the latter will be held on Thursday at 10.00 am. Both of them will take place in the room Cesare Musatti, located at the ground floor of the building of the Departments of Psychology (Via Venezia, 8, 35131 Padua).

The two keynote talks by Richard Shiffrin and Eric-Jan Wagenmakers are scheduled on Wednesday and Thursday, respectively, from 9.00 am to 10.00 am. Both of them will take place in the room Cesare Musatti, located at the ground floor of the building of the Departments of Psychology (Via Venezia, 8, 35131 Padua).

Posters

The posters will be on display on Wednesday from 4.00 pm to 5.00 pm, right after the afternoon parallel sessions, in the department hall in front of the room Cesare Musatti (Via Venezia, 8, 35131, Padua). Posters must fit within and be attached with Velcro, which will be provided, to the poster boards, that are 90 cm high (2.95 feet) by 70 cm wide (2.30 feet). Please attach your poster to the board before 2.30 pm.

Welcome session

The welcome session will take place on Monday, August 31 in the entrance hall of the building of the School of Psychology (via Venezia, 12) from 6.00 pm to 8.00 pm. There will be some refreshments and the opportunity to meet other conference participants.

Coffee breaks and lunch

Refreshments and snacks will be provided during coffee breaks on Tuesday, Wednesday and Thursday. Coffee breaks will be found outside the rooms of the conference.

The area surrounding the departments and the School of psychology offers many different lunch options. Close to the Psychology departments there are a number of small snack bars serving pasta, sandwiches or salads. There are also a number of restaurants with typical Italian or international food. The following one is a list of suggested places:

Antico Desiderio (snack bar with pasta, salad and sandwiches)
Via del Portello, Padova
Phone: 049 807 7244

Caffè Ti Amo (student snack bar with pasta, salads and sandwiches)
Via Venezia 9/A, Padova
Phone: +39 349 2952220

F&B (snack bar with pasta, salad and sandwiches)
67 Via Tommaseo Niccolò, Padova, 35131
Phone: 049 807 9319

Pizzeria al Porteo (pizza and pasta)
Via del Portello, 35131 Padova
Phone: 049 772311

Ristorante Venezia (meat and fish restaurant)
Via Venezia, 28, 35131 Padova
Phone: 049 807 4920

Trattoria al Fungo (typical local food "Cucina Veneta")
Via Ugo Bassi, 22, 35131 Padova
Phone: 049 650645
Web site: http://www.trattoriaalfungo.it/

Tre Scalini (student snack bar with pasta, salads and sandwiches)
Via Venezia, 2, Padova
Phone: 049 807 0489
Web site: http://www.bartrescalini.it/

Verba Volant (student snack bar with pasta, salad and sandwiches)
Via Niccolò Tommaseo 114, Padova

Phone: 049 7811251

Zafferano (fish restaurant)
Via Niccolò Tommaseo, 67, 35131 Padova
Phone: 049 807 9389
Web site: http://www.zafferanopadova.it/

Zushi Restaurant (Japanese restaurant)
Via Niccolò Tommaseo, 76/A, 35131 Padova
Phone: 049 663488
Web site: http://www.zushi.eu/

Conference dinner

The conference dinner will take place on Wednesday, September 2 at 7.00 pm inside the *Orto Botanico* (Botanical Garden) of Padova (via Orto Botanico, 15, 35123 Padova). Created in 1545 on the property of the Benedictine monks of St. Justine, the Botanical Garden of Padova is the oldest existing university botanical garden in the world.

Participants will meet at 7.00 pm for an aperitif inside the garden. A guided tour through the wonderful plants of the ancient and modern parts of the picturesque Orto Botanico will accompany participants to the dinner hall (the so-called *Sala delle Colonne*) inside the modern and suggestive greenhouse of the garden.

Travel

Padua can be reached by plane via Venice or Treviso airports:

- Via Venice - Upon arrival at Marco Polo airport you can reach Padua by: (1) private shuttle bus (needs to be booked 24 hours before) or by (2) ATVO public bus to Venezia-Mestre train station and then by train to Padua;

- Via Treviso - Upon arrival at A. Canova airport you can reach Padua by private shuttle bus (needs to be booked 24 hours before) or by

public bus (line 6 of ACTT company) to Treviso train station, and then by train to Padua.

Accommodation

BEST WESTERN PREMIER Hotel Galileo****
Via Venezia 30, 35131, Padua - Italy
Phone: +39 049 7702222
Fax: +39 049 7800762
E-mail: galileo.pd@bestwestern.it
Web site: www.hotelgalileopadova.it/en/wellness.aspx

HOTEL NH MANTEGNA****
Via Tommaseo 61 , 35131, Padua - Italy
Phone: +39 049 8494 111
E-mail: nhmantegna@nh-hotels.com

BEST WESTERN HOTEL BIRI****
Via Grassi, 2, 35129 - Padova - Italy
Phone:: +39 049 8067700
Fax: +39 049 8067748
E-mail: biri.pd@bestwestern.it
Web site: http://www.hotelbiri.com/

HOTEL ALLA FIERA***
Via Ugo Bassi, 20, 35131, Padova - Italy
Phone: +39 049 8755094
Fax: +39 0498759088
E-mail: info@hotelallafiera.com
Web site: www.hotelallafiera.com/en/

HOTEL MAJESTIC TOSCANELLI****
Via dell'Arco, 2, 35122, Padua Italy
Phone: +39 049 663244
Fax: + 39 049 8760025
E-mail: majestic@toscanelli.com
Web site: www.toscanelli.com/index.php/en/

HOTEL RISTORANTE AL SANTO****
Via del Santo, 147, 35123, Padua- Italy
Phone +39 049 8752131
Fax: +39 049 8788076
E-mail: alsanto@alsanto.it
Web site: www.alsanto.it/indexing.htm

ALBERGO VERDI***
Via Dondi dall'Orologio, 7, 35139 Padova - Italy
Phone: 049 8364163
Fax: 0498780175
info@albergoverdipadova.it
Web site: www.albergoverdipadova.it/inglese/indice.htm

BELLUDI37
Via Luca Belludi, 37, 35100 Padua - Italy
Phone: +39 049 665633
Fax: +39 049 658685
E-mail: info@belludi37.it
Web site: http://belludi37.one-lab.it/en/hotel/

HOTEL PLAZA
Corso Milano, 40, 35139 Padova - Italy
Phone: +39 049.656822
Fax: +39 049.661117
Email: info@plazapadova.it
Web site: http://www.plazapadova.it/en

Program

Tuesday, September 1

08.30 – 09.00	**Opening**
09.00 – 11.00	**Symposium in memoriam Patrick Suppes I** Room: Cesare Musatti Chair: E. Dzhafarov Patrick Suppes: a universal scientific giant *Jean-Claude Falmagne (Keynote)* Remembering Patrick Suppes *J. Acacio de Barros* Pat Suppes's joint distribution criterion *Ehtibar Dzhafarov*
11.00 – 11.30	**Coffee break**
11.30 – 13.30	**Symposium in memoriam Patrick Suppes II** Room: Cesare Musatti Chair: E. Dzhafarov From coupling to copula, with applications to multisensory modeling *Hans Colonius* Stochastic foundations of serial and parallel systems *James T. Townsend, Joseph W. Houpt, Brett Jefferson* Quantum decision makers can agree to disagree

Andrei Khrennikov, Irina Basieva

13.30 – 15.00	**Lunch break**
15.00 – 16.00	**Perception & Psychophysics I** Room: 2B Chair: M. Perea An axiomatic study on duration perception: Investigating ratio scalability of visually and temporally structured stimuli *Jana Birkenbusch, Christian Wolff, Wolfgang Ellermeier* Divergence points are not a relevant measurement in survival analyses of latency data *Pablo Gomez, Javier Breithaupt, Manuel Perea, Jeffrey Rouder*
15.00 – 16.00	**Psychometrics I** Room: 2C Chair: P. Anselmi A collective and multi-criteria decision-making procedure in the context of non-uniform qualitative scales *José Luis García-Lapresta, David Pérez-Román* An extension of the gain-loss model to surmise systems *Pasquale Anselmi, Luca Stefanutti, Egidio Robusto, Debora de Chiusole*
16.00 – 16.30	**Coffee break**
16.30 – 18.00	**Perception & Psychophysics II** Room: 2B Chair: J. J. Lentz What are we estimating when we estimate a Stevens' power law? *Michele Bernasconi, Raffaello Seri*

Revisiting Green's energy model: Computational evaluation under varied criterion values and accuracy levels
Jennifer J. Lentz, James T. Townsend

16.30 – 18.00 **Psychometrics II**
Room: 2C
Chair: S. Noventa

Interactive method for building large knowledge structures that are simultaneously content plausible and consistent with response data
Ragnar Steingrimsson, Joanna Williams

An item response theory model of matching test performance
Matthew D. Zeigenfuse, William H. Batchelder, Mark Steyvers

Some considerations on probability factorization in knowledge structures
Stefano Noventa, Luca Stefanutti

Wednesday, September 2

09.00 – 10.00 **Keynote**
Room: 3G
Chair: H. Colonius

Model selection and reproducibility
Richard M. Shiffrin, Suyog Chandramouli, Peter Grunwald

10.00 – 11.00 **Measurement**
Room: 3G
Chair: Y. Matsushita

Meaningfulness as a "Principle of Theory Construction"
Jean-Claude Falmagne, Christopher Doble

A generalized extensive structure with a right action of interest rates
Yutaka Matsushita

10.00 – 11.00 **Cognitive models I**
Room: 3H
Chair: L. Lombardi

Transferred and reflected impetus: Towards a pre-Newtonian intuitive physics of object collisions
Ralf Mayrhofer, Michael R. Waldmann

An information theoretic approach for modeling spatial data from mouse tracker methodology
Antonio Calcagnì, Luigi Lombardi

11.00 – 11.30 **Coffee break**

11.30 – 13.00 **Decision & Choice**
Room: 3G
Chair: R. Suck

Voters preferences in a quantum framework
Polina Khrennikova, Emmanuel Haven

Minority influence in opinion spreading
Ugo Merlone, Davide Radi, Angelo Romano

A general technique of extracting conditions for random utility representations for choice data
Reinhard Suck

11.30 – 13.00 **Cognitive models II**
Room: 3H
Chair: A. Testolin

Reconciling Fitts' law with Shannon's Information Theory
Julien Gori, Olivier Rioul, Yves Guiard

The influence of continuous visual properties on numerosity estimation
Ivilin Stoianov, Marco Zorzi

	Learning orthographic structure with sequential generative neural networks *Alberto Testolin, Ivilin Stoianov, Alessandro Sperduti, Marco Zorzi*
13.00 – 14.30	**Lunch break**
14.30 – 16.00	**Response times** Room: 3G Chair: V. Lerche
	Less biased response times (and less biased RT differences) *Matthias Gondan*
	Comparing the relative processing speed of the recognition heuristic and information integration: extending the r-Model to response times *Daniel W. Heck, Edgar Erdfelder*
	How reliable are the parameters of the Ratcliff Diffusion Model? *Veronika Lerche, Andreas Voss*
14.30 – 16.00	**Statistical Methods** Room: 3H Chair: G. Altoè
	A Bayesian approach to confirmatory factor analysis: Moving beyond dichotomous thinking *Gianmarco Altoè, Massimiliano Pastore*
	Structure estimation for mixed graphical models *Jonas M.B. Haslbeck, Lourens J. Waldorp*
16.00 – 17.00	**Poster session** Department Hall
	A model for Bi-logic *Giulia Battilotti*
	A Poisson random walk model for response time and pure accuracy tasks *Steven P. Blurton, Carsten S. Nielsen, Claus Bundesen, Søren Kyllingsbæk*

Diagnostic of two-factor integration models by lines of subjective equality
Luigi Burigana, Michele Vicovaro

Deriving Weights of items in psychological tools based on fuzzy set theory: Case study of Becks Depression Inventory (BDI)
Hojjatollah Farahani, Yuan Miao, Mayssah El Nayal

Effects of the Psychological Science new Statistical Guidelines, Research Disclosure Statements and Open Practices
David Giofrè, Patrizio Tressoldi, Geoff Cumming, Luca Fresc

Factor model of life satisfaction
Galina Golovina, Tatyana Savchenko

Probabilistic reasoning and quantum cognition: a study on Bell's inequality
Giorgio Gronchi, Elia Strambini

Repeated-measures models of Rasch person parameters. Applications to clinical data to evaluate the effectiveness of a therapeutic treatment
Stefania Mannarini, Floriana Caccamo, Laura Balottin, Marilisa Boffo

Inter-rater agreement in multivariate settings: A Bayesian approach
Massimo Nucci, Andrea Spoto, Gianmarco Altoè

Maximum likelihood parameter estimation for a Dynamical Cognitive Model
Heiko Schütt, Hans A. Trukenbrod, Lars Rothkegel, Ralf Engbert

Formal Psychological Assessment in building a new tool for the evaluation of depression
Francesca Serra, Andrea Spoto, Marta Ghisi, Giulio Vidotto

A hierarchical generative model of letter perception based on recycling of natural image features
Alberto Testolin, Ivilin Stoianov, Marco Zorzi

Thursday, September 3

09.00 – 10.00 **Keynote**
Room: Cesare Musatti
Chair: L. Stefanutti

A predictive perspective on Bayesian inference
Eric-Jan Wagenmakers

10.00 – 11.00 **Symposium on thirty years of Knowledge Space Theory I**
Room: Cesare Musatti
Chair: J. Heller

The beginning, the core ideas, and the assessment spaces
Jean-Claude Falmagne

Families of learning spaces and the construction of Kashiwabara, Nakamura and Okamoto (2005)
Jean-Paul Doignon

11.00 – 11.30 **Coffee break**

11.30 – 13.30 **Symposium on thirty years of Knowledge Space Theory II**
Room: Cesare Musatti
Chair: L. Stefanutti

Past, present and prospective contributions of CSS to KST
Dietrich Albert, Cord Hockemeyer

ALEKS as research platform in ELearning
Xiangen Hu

Probabilistic models in competence-based knowledge space theory

	Jürgen Heller
	Data driven knowledge structure construction: Some recent developments *Luca Stefanutti, Debora de Chiusole, Andrea Spoto*
13.30 – 14.00	**Closing session** Room: Cesare Musatti

Abstracts

Keynote Speakers

Model selection and reproducibility

Richard M. Shiffrin[a], Suyog Chandramouli[a], Peter Grunwald[b]
[a]*Indiana University, United States of America*
[b]*Centrum voor Wiskunde en Informatica, The Netherlands*

There have been many technical advances in recent years concerning methods for scientific induction: updating our beliefs about the way the world works on the basis of data. These include variants of the principles of Bayesian Model Selection and Minimum Description Length that are used to compare models based on our prior beliefs and the current data. In this talk I present an extension of Bayesian Model Selection that infers the probability that a model instance or class is the best approximation to the true generating distribution. The resultant framework simplifies the theory to the point where it can be explained with a single table without equations. The same table can be used to show how Bayesian Model Selection is closely related to an extension of the usual implementation of Minimum Description Length known as Normalized Maximum Likelihood, to show why we recommend that most model class comparisons be carried out by eliminating model instances that are shared between classes, and to show how to assess reproducibility in a replication study.

A predictive perspective on Bayesian inference

Eric-Jan Wagenmakers
University of Amsterdam, The Netherlands

In mathematical psychology, Bayesian model selection is often used to adjudicate between competing accounts of cognition and behavior. One of the attractions of Bayesian model selection is that it embodies an automatic Occam's razor a reward for parsimony that is the result of an averaging process over the prior distribution. Here I provide a predictive interpretation of Bayes inference, encompassing not only Bayesian model selection, but also Bayesian parameter estimation. This predictive interpretation supports a range of insights about the fundamental properties of learning and rational updating of knowledge.

Symposia

In Memoriam Patrick Suppes

From coupling to copula, with applications to multisensory modeling

Hans Colonius
Oldenburg University, Germany

Coupling means the joint construction of two or more random variables (or processes) on a common probability space, usually in order to deduce properties of the individual variables or to gain insight into distributional similarities or relations among them. Copulas are functions that join multivariate distribution functions to their one-dimensional margins. Both theories play an increasingly important role in probability and statistics. In this talk, I illustrate how some elementary concepts from both theories can be used to solve problems in developing and testing stochastic models of multisensory interaction, i.e., effects that occur when stimuli from more than a single sensory modality are to be processed by the perceiver.

Remembering Patrick Suppes

J. Acacio de Barros
San Francisco State University, United States of America

Pat Suppes and I collaborated on research projects for more than 20 years. During this time, I got to know him not only professionally, but as a long-term friend. In this talk, I will recollect events throughout our friendship and collaboration, and try to give a fuller picture of Pat's way of seeing the world and interacting with it.

Pat Suppes's joint distribution criterion
Ehtibar Dzhafarov
Purdue University, United States of America

In 1981 Pat Suppes and Mario Zanotti published a little paper (Suppes & Zanotti, 1981) that I had cited several times in my publications before I understood its foundational import: it was the first demonstration that the problem of hidden variables in quantum physics has a purely probabilistic nature, and that Bell-type inequalities are merely conditions that observable random variables should satisfy in order to be joinable in one global distribution. I will discuss this historic insight and its relation to the modern theory of (non)contextuality as developed recently by Janne Kujala and myself.

Patrick Suppes, a universal scientific giant
Jean-Claude Falmagne
University of California at Irvine, United States of America

I begin by describing how Suppes, who came from a family of oil men, in Tulsa, Oklahoma, ended up a graduate student of Ernest Nagel, a famed professor of philosophy at Columbia University. This was not the end of his education, however. He obtained his PhD in philosophy from Columbia in 1950, and was hired by Stanford University, where he met J.C.C. McKinsey, and especially Alfred Tarski. It is from McKinsey and Tarski that Suppes learned the set-theoretical, axiomatic, theorem proving methods which became his stock-in-trade. In this talk, I can only cover four of the multiple scientific and academic fields in which Suppes worked, namely: measurement theory, mathematical learning theory, brain research, and education. At the end, I briefly describe the interactions between Suppes and the EMPG community.

Quantum decision makers can agree to disagree
Andrei Khrennikov, Irina Basieva
Linnaeus University, Sweden

We explore the formalism of quantum mechanics to model generalization of Aumann's framework for agents violating the rules of classical (Boolean) logic and, hence, Bayesian rationality. We found that such agents can agree to disagree even by having common prior and common knowledge. Mathematically our study is based on the calculus of quantum conditional probabilities.

Stochastic foundations of serial and parallel systems
James T. Townsend, Joseph W. Houpt, Brett Jefferson
Indiana University, United States of America

Serial and parallel systems have attracted the attention of psychologists at least since the late 19th century. Pioneers in the information processing approach to cognitive psychology in the 1950's and 1960's reinitiated the theoretical and experimental study of these diametrically opposed processing systems. George Sperling and Saul Sternberg were two such pioneers. More formal treatments began with Townsend (e.g., 1972, 1976a,b) and reached a water mark of generality, using sigma fields in the late 1970's and early 1980's (Vorberg, 1977; Townsend & Ashby, 1983, Chapters 14, 15). In this presentation, we review and expand the stochastic axiomatic foundations, indicating when fundamental distinctions will vs. cannot, lead to testable predictions.

Thirty Years of KST

Past, present and prospective contributions of CSS to KST

Dietrich Albert[a], Cord Hockemeyer[b]
[a] *Graz University of Technology, Austria*
[b] *University of Graz, Austria*

The Cognitive Science Section (CSS) under different names and at different locations contributed for nearly 30 years to Knowledge Space Theory (KST) and its further development. From a theoretical point of view we present (a) a brief overview/summary of what has been done already. Furthermore, the questions will be discussed (b) why KST currently is not as successful as expected 30 years ago and (c) what should/could have been done during this phase. Very briefly (d) also the current KST-related work of CSS is mentioned. The focus of the talk will be however on discussing (e) future challenges and topics which according to our opinion - have to be tackled in order to get finally a sustainable breakthrough of KST.

Families of learning spaces and the construction of Kashiwabara, Nakamura and Okamoto (2005)

Jean-Paul Doignon
Universitè Libre de Bruxelles, Belgium

Learning spaces are the knowledge spaces which are well-graded. They also appear in other contexts under various names, for instance: lower semidistributive lattices, path-independent choice functions, antimatroids, convex geometries, etc. Among the huge variety of examples, there is one which stands out because it is universal: according to a fundamental result of Kashiwabara, Nakamura and Okamoto (2005), each learning space can be obtained in a real affine space through some specific convex construction. We speculate on the consequences of the result for learning spaces, in particular for their storage and for some of their fundamental parameters.

The beginning, the core ideas, and the assessment spaces
Jean-Claude Falmagne
UC Irvine

The talk recalls how the collaboration of Jean-Paul Doignon and Jean-Claude Falmagne evolved from topics in measurement theory to the concepts of knowledge spaces and learning spaces. In the talk, learning spaces are described in terms of the two axioms [L1] *Learning Smoothness* and [L2] *Learning Consistency*. Remarkably, this re-axiomatization took place only around 1998, with the representation theorem of Cosyn and Uzun published in the JMP in 2009. We end up the talk with the question: how suitable are the learning space axioms in somewhat different assessment situations, such as medical diagnosis of the analysis of the malfunction of a machine. I give a possible response by modifying [L1] and [L2], and giving the relevant representation theorem.

Probabilistic models in competence-based knowledge space theory
Jürgen Heller
University of Tübingen, Germany

The basic local independence model (BLIM) is the standard probabilistic approach to modeling data in knowledge space theory. This talk discusses basic properties of its competence-based extension CBLIM, which arises from a given skill multimap. In particular, the identifiability of the CBLIM is crucial for assessing the skills an individual has available. An application of this model to classical data on fraction subtraction via the R-package pks demonstrates the central role of the knowledge structure delineated by the skill multimap. Additionally, a generalization of the CBLIM is outlined where the probabilities of the item-specific response errors depend on the available skills. This generalization is able to model situations where these probabilities are dependent upon the solution path taken, or whether none, some, or all of the skills sufficient for its solution are available.

ALEKS as research platform in ELearning

Xiangen Hu
University of Memphis, United States of America

ALEKS was introduced to West TN Schools in 2004. Since then, ALEKS data were collected from college (Behavior statistics), Inner city school (Charter Schools), Urban School, and rural school students. This presentation will report 1) ALEKS help reducing achievement gap between white and black college students, 2) Correlation between ALEKS performance and state achievement tests scores, 3) Efficacy study of ALEKS in after school program in rural schools in West TN, 4) SOLE (Summer Online Learning Experiences) program powered by ALEKS, 5) ALEKS enhanced with natural language dialog.

Data driven knowledge structure construction: Some recent developments

Luca Stefanutti, Debora de Chiusole, Andrea Spoto
University of Padua, Italy

The construction of a knowledge structure is one of the most difficult tasks in KST. It is also an inescapable step of any realistic application of the theory. In this talk I will first give a brief survey of the existing methods, discussing their pros and cons, with a special focus to the so-called data driven methods. Then a novel data-driven approach is presented, based on an iterated extension of the $K-$modes algorithm to the problem of extracting a knowledge structure from a large data set. The objective-function that the procedure minimizes at each iteration is a weighted discrepancy between the constructed knowledge structure and the data. Theoretical results concerning local and global optimality of the procedure are provided. Finally, in a simulation study, the proposed procedure is compared to some of the existing ones with respect to reconstruction accuracy. Results of the simulations show that the $K-$modes based procedure outperforms maximum frequency-based procedures like the one proposed by Schrepp (1999), especially with relatively large sets of items and noisy data.

Talks

A Bayesian approach to confirmatory factor analysis: Moving beyond dichotomous thinking

Gianmarco Altoè, Massimiliano Pastore
University of Padua, Italy

In recent years there has been a growing interest in Bayesian inference in numerous scientific disciplines. Structural equation models (SEM) are an important tool in the social and behavioural sciences to evaluate the structure of a model with latent and observed variables. However, the use of a Bayesian approach (BA) in this field is still underexplored. In this work, we illustrate the advantages of using the BA in a relevant SEM submodel, i.e., confirmatory factor analysis (CFA). Specifically, the goals are to (1) compare the traditional maximum likelihood approach (MLA) with the BA in terms of parameter estimation and fit indices; (2) show how the BA allows to estimate further models that may result unidentified via the classical approach, but may better reflect the underlying psychological theory; and (3) present BA-based techniques for model diagnostic in terms of the distribution of estimated parameters as well as single case influence. To address the first aim, a simulation study was performed. Starting from a baseline two-correlated factor model, we manipulated sample size and effect size of a potential cross-loading for a specific item. For each condition, we estimated 2 bayesian CFAs (one including and one excluding the cross-loading) and 2 ML CFAs. Next, a bayesian CFA on a real case-study is presented. The magnitude of cross-loadings and residual correlations were simultaneously evaluated according to different theoretical models through different parameter prior specifications. The most plausible model was selected using the Deviance Information Criteria (DIC). Parameter posterior distributions and predictive posterior distribution of the observed data were used to examine model fit. All analyses were conducted using free software (i.e., R in combination with JAGS). Differences and similarities between the BA and MLA will be discussed. Overall, the formalization of model parameters in terms of prior probability distributions, instead of the less realistic parameters presence-or-absence formalization, provided a more flexible and informative evaluation of the latent structure of the

observed data. To conclude, we will briefly review potential applications of the BA to the broader context of structural equation models.

An extension of the Gain-Loss model to surmise systems
Pasquale Anselmi, Luca Stefanutti, Egidio Robusto, Debora de Chiusole
University of Padua, Italy

The Gain-Loss model was first meant for independent skills, and then it was extended to surmise relations and the corresponding quasi ordinal spaces. This talk presents a more general extension of the model in which skill dependence is established by a surmise system associating each skill $s \in S$ with a collection of subsets of S, called the clauses for s. The surmise system prescribes that s cannot be mastered at a certain assessment step unless at least one of its clauses is mastered at that step. Whenever the surmise system is exclusive (i.e., there are not two skills associated with the same clause), the delineated competence structure is a well-graded space, thus allowing for learning smoothness. The extension of the Gain-Loss model to surmise systems is not straightforward, but requires further assumptions about the learning process for the model to be coherent. An EM algorithm for computing maximum-likelihood estimates of model parameters has been developed. Results of an application of the model to simulated data sets are described.

What are we estimating when we estimate a Stevens' power law?
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In this paper we investigate what happens when a Stevens' power law model is fitted to a dataset obeying instead a separable representation in the style of Luce (2002, 2004, 2012) or Narens (1996). It is well-known that the estimates provided by Stevens were based on the averaging over individuals of

experiments conducted at the individual level. To reconstruct the effects of this method on the estimates, we first suppose that the data are generated by a separable representation (in the stochastic form of Bernasconi et al., 2008, 2011). Then, exploiting the form of the estimator of the exponent of Stevens' power law, we obtain an expression for this parameter as a function of the original psychophysical and subjective weighting functions. The results depend on the kind of data design employed and are different in classical ratio magnitude estimation with a standard, in ratio magnitude estimation with several standards and in ratio magnitude production. The results presented in the paper help clarifying several paradoxes arising with Stevens' power laws, among which the fact that the estimated exponent seems to depend on the range of the stimuli and the regression effect (i.e. the difference in the exponents estimated through ratio magnitude estimation and production).

An axiomatic study on duration perception: Investigating ratio scalability of visually and temporally structured stimuli

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For the perception of short durations, the empirical evaluation of assumptions fundamental to direct scalability by means of mathematical axioms (monotonicity, commutativity and multiplicativity; Narens, 1996) was performed for filled, but unstructured intervals (Birkenbusch, Ellermeier, & Kattner, in press). Because duration perception is assumed to be affected by visual or temporal stimulus structuring, two ratio production experiments were performed, in which the participants were required to adjust the duration of a comparison interval to a certain ratio p to the standard t. Experiment 1 ($N = 42$) used stimuli of two visual complexities (letter matrices), a standard of $t1 = 1800$ ms and fraction ratios ($p = 1/2, 1/3,$ and $1/6$). Experiment 2 ($N = 50$) employed stimuli of two temporal frequencies (moving light), a standard of $t2 = 300$ ms and integer ratios ($p = 2, 3,$ and 6). Both experiments contained a blank control condition. Individual analyses for each participant showed no significant violations of monotonicity, 10% violations of commutativity and 26% violations of

multiplicativity. These findings are in line with previous results from unstructured (auditory) duration intervals. For visually structured intervals, more violations of commutativity and multiplicativity were found with increasing complexity, indicating the visual structure to impair participants' ability to process duration on a ratio scale. Temporally structured stimuli produced fewest axiom violations at a low frequency, showing moderate temporal structuring to facilitate ratio perception.

An information theoretic approach for modeling spatial data from mouse tracker methodology

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Mouse tracking based experiments are becoming popular in cognitive studies over recent years. In general, in behavioural studies computer mouse is used to discover how people perform reaching tasks (e.g., rapid, intermittent, reciprocal aimed movements), choice tasks, and categorization tasks. In particular, mouse tracking methodology helps in monitoring how decisions evolve dynamically during cognitive tasks.

The most often used paradigm to model spatial information in this methodology is the so-called naïve geometric approach. It directly makes use of raw movement trajectories that are analysed by simply considering their Cartesian coordinates. In doing so, simple statistics such as, local means, maximum distances, area under the curves, point-by-point t-tests, are used as typical and basic measures for further statistical analyses. Although such approach is simple and cheap to run, very often it can incur considerable shortcomings with a significant loss of information. For instance, its derived measures might not be sufficiently flexible and accurate to capture more complex structures (e.g., quasi-sinusoidal, multi-peaks, irregular paths) as well as the presence of motor pauses in the movement paths.

To overcome such limitations, we propose a new mathematical approach that is entirely based on an information-theoretic paradigm. Unlike the previous approach, here the empirical movement path is firstly modelled

by using an adaptive cumulative function that captures the direction, amplitude, and eventual friction present in the movement. Next, a set of entropy-based measures which include a movement-pause entropy decomposition provides a way to analytically quantify the most relevant spatial information present in the empirical data. These new measures are provided to be more sensitive, robust, and stable than the naïve geometric measures. In addition, by using suitable distributional distances, the new proposal also provides an appropriate framework to compare different movement patterns. Finally, in order to show some relevant characteristics of our approach, a set of simulation studies are conducted. The ensuing results suggest how the information theoretic perspective can provide a simple, reliable, and sensitive framework for modelling spatial information contained in the mouse movement trajectories recorded during cognitive tasks.

Meaningfulness as a "Principle of Theory Construction"

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In 1959, Duncan Luce published the famous paper entitled "On the possible psychophysical laws." The results presented here were inspired by that paper and by the ensuing controversy centered on the invariance concept of "meaningfulness." We give a formal definition of this concept. As we define it, the condition of meaningfulness is quite potent. In its context, relatively weak additional conditions may suffice for the derivation of precise scientific or geometric laws. We give several examples of such derivations, including the Pythagorean Theorem and Beer's Law.

A collective and multi-criteria decision-making procedure in the context of non-uniform qualitative scales

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In this contribution, we consider a group of agents must take a collective decision by ranking a set of alternatives regarding different criteria. In order to do this, agents judge the alternatives by means of a finite qualitative scale, not necessarily uniform (for instance, the linguistic terms "reject", "major revision", "minor revision" and "accept", used by some journal editors in the evaluation of papers). In this setting, we propose a collective and multi-criteria decision-making procedure where individual assessments are managed in a purely ordinal way through ordinal proximity measures. This proposal can be considered as an extension of the Majority Judgment voting system to the context of non-uniform qualitative scales and to the case of alternatives are judged regarding several criteria. A numerical weight is associated with each criterion and these weights are used for replicating the corresponding linguistic assessments. The procedure is based on the ordinal proximities between the linguistic assessments obtained by each alternative and the highest and lowest linguistic terms.

Divergence points are not a relevant measurement in survival analyses of latency data

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The uncovering of the time course of the influence of different factors in human performance is one of the principal topics of research in cognitive psychology/neuroscience. Over the past decades, researchers have proposed several methods to tackle this question using latency data. This presentation focuses on a recent procedure proposed by Sheridan and cols. (Reingold, Reichle, Glaholt, & Sheridan, 2012, Sheridan et al., 2012). They employed hazard functions and survival analyses on fixation duration to provide "precise estimates" of the timing of the first discernible influence of variables (e.g., word frequency). Because the method is intriguing an

exploration of its strengths, biases and shortcomings is in order. Here we report the results of systematic simulations directed to parameter recovery that revealed that this method tends to over-estimate the divergence point with a realistic number of observations per condition. In addition, we point out that divergence point are a relevant issue in only a very limited set of circumstances, while in most cases, the method is conceptually misguided.

Less biased response times (and less biased RT differences)
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In experimental and applied psychology, the primary variable of interest is often based on the time it takes to find the correct solution to a problem (i.e., response time). In most cases, response speed is determined using the so-called mean correct response time (MCRT) which excludes any problematic responses (e.g., fast guesses, omitted responses, errors, outliers) from the analysis. I demonstrate that MCRT is a biased measure that systematically overestimates response speed. I present cases in which MCRT is even negatively correlated with the participant's performance even though guessing behavior is constant. Based on the classical Kaplan-Meier method and the Mann-Whitney statistic I outline improved methods for measuring RT performance and for comparing RTs between experimental conditions. Formally and using simulations I demonstrate that the new methods systematically increase reliability and validity of RT estimates and RT differences.

Reconciling Fitts' law with Shannon's Information Theory

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Shannon's information theory has had a tremendous impact on various scientific fields in the 1950s and 1960s, including psychology. In this period of time there has been a strong reaction of Shannon and colleagues against the exaggerated use of information theoretic ideas in fields such as psychology, biology and linguistics. The fact is, Shannon's mathematical theory of communication has been more or less put aside in psychology and is no longer considered useful. What seems to be an important exception is Fitts' law, a well-known empirical rule which predicts the average time T it takes people, under time pressure, to reach with some pointer a target of width W located at distance D. The movement time is a linear function of the index of difficulty ID which is generally given by the Shannon formulation $ID = log_2(1 + D/W)$ (an ISO standard) yet other similar formulations can also be considered. Despite an attempt to theoretically explain Fitts' law in terms of information theory, many different aspects are still unclear and it seems that the only justification is a vague analogy with Shannon's capacity theorem. Based on, we go beyond the analysis of and derive a new mathematical approach that attempts to derive Fitts' law from information-theoretic arguments: 1) we first present combinatorial arguments in various geometric frameworks to account for different formulations of the index of difficulty. 2) we then propose a simple communication channel model for rapid aimed movement leading to Fitts' law, with discrete input (the intention of the participant) maximizing the information to be transmitted, uniform additive noise (maximizing entropy under the simple assumption of zero error) and continuous output representing the endpoint coordinates. 3) finally, we show that the formulation $ID = log_2(1+D/W)$ can be obtained anew by a rigorous derivation of Shannon's capacity theorem for our simple channel model, reconciling Fitts' law with Shannon's theorem 17 $C = W \log(1 + S/N)$.

Structure estimation for mixed graphical models

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Undirected graphical models are used widely for modeling, visualization, inference and exploratory data analysis in various areas such as epidemiology, computer vision, and more recently psychology. In many of these areas it is of significant interested to estimate the edge-structure of the graphical model underlying a joint distribution over different types of variables. Despite the need for such an estimation method it is not yet available for applied researchers. We improve this situation by combining a structure estimation method based on the inverses of generalized covariance matrices with a new class of mixed exponential Markov random fields. We thereby provide a method that estimates the underlying graph-structure of a joint distribution over any combination of univariate members of the exponential family. We report the performance of our method in simulations that resemble realistic situations in exploratory data analysis, illustrate the method with a dataset on Autism Spectrum Disorder (ASD) and provide an implementation as an R-package.

Comparing the relative processing speed of the recognition heuristic and information integration: extending the r-Model to response times

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Within the field of fast-and-frugal judgment and decision making, the recognition heuristic (RH) was proposed as a cognitive strategy for comparative judgments. When faced with two alternatives only one which is recognized, the RH states that participants choose the recognized object without consideration of any further knowledge. To disentangle use of the RH and integration of further information, Hilbig, Erdfelder, and Pohl (2010) developed the r-model. This multinomial processing tree model refers to choice frequencies only and does not allow for testing whether RH use is faster

than information integration. Therefore, we extend the r-model to account for choices and response times (RTs) simultaneously. We assume that RH use and information integration are mutually exclusive cognitive processes associated with separate, latent RT distributions. These latent processing speeds are estimated nonparametrically by categorizing responses as fast or slow based on observed RTs. Using this RT-extended r-model, we test whether pure RH use is actually faster than information integration, as predicted by the fast-and-frugal decision making account (e.g., Goldstein & Gigerenzer, 2002).

Voters preferences in a quantum framework

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Politics is regarded as an vital area of social science and is strongly relying on the assumptions of voters rationality and as such, stability of preferences; at least in decisions that are made simultaneously. The phenomenon of Divided Government that was dominating the US political arena for many election periods in the last 40 years is not consistent with the notion of stable preferences of voters that are following the axioms of Expected Utility and have a well defined ranking of their preferences on their utility function of "political preferences". Recently, this problem was handled by using the novel approach based on the formalism of quantum mechanics. Theory of quantum decision making is applicable for modeling of irrational and biased behavior of voters as well as non-separability of their preferences. Irrationality, biases, and non-separability lead to a deeper uncertainty than classical probabilistic uncertainty. In particular, quantum probability describes well violation of Bayesian rationality. We model this nonclassical uncertainty in voters' preferences by using fundamental quantum information structures such as superposition and entanglement. This paper is an introduction to quantum modeling of behavior of an electorate with unstable preferences (contextual preferences) with the aid of the most potent theory of adaptive dynamics, namely, the theory of open quantum systems. In this model a voter's decision is created in the

process of interaction with an information bath in which mass-media plays a crucial role.

Revisiting Green's energy model: Computational evaluation under varied criterion values and accuracy levels

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For many decades, psychophysicists have employed models of parallel systems to describe accuracy behavior. One of the first models was developed by David Green in 1958, and is commonly referred to as the energy model. Green measured the detection of one and two tones in the presence of background noise and compared detection sensitivity of the two tones with predictions obtained from various parallel models. He concluded that a summation model, in which detection sensitivity of the two tones is described by $d'^2 = d'^2_1 + d'^2_2$, where 1 and 2 represent the two different tones. Numerous studies have replicated Green's seminal work, and the energy model is commonly employed to describe a host of behaviors in psychophysical tasks. However, studies replicating Green's work have all adopted forced-choice tasks and have evaluated performance at near-threshold levels. Consequently, they have not evaluated all conditions in which Green's model may apply. Here, we show here that the summation model does not always yield higher accuracy scores when compared to a model in which the channel with the maximum value determines performance. Cases in which a summation model is not superior occur when accuracy is very high and when a lax criterion is adopted. Although there may be a very small number of conditions under which the maximum model predicts better accuracy, it appears that Green's model does not always predict superior performance.

How reliable are the parameters of the Ratcliff Diffusion Model?
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The Ratcliff Diffusion Model (1978) is applied to response time data from binary decision tasks and aims at separating different cognitive processes (e.g., speed of information accumulation, decision bias) by mapping them on distinct parameters. Recently, the idea of applying the model for diagnostic purposes has been expressed. This requires a systematic analysis of the reliability of the parameters. We conducted a retest reliability study with two tasks that are frequently used for Diffusion Model Analyses: a lexical decision task and a recognition memory task. For these tasks, we present retest reliability coefficients depending on different estimation procedures. In particular, we compared three optimization criteria (Kolmogorov-Smirnov, Maximum Likelihood and Chi-Square) and different trial numbers (ranging from 32 to 5000 trials). The empirical study is accompanied by simulation studies which serve at disentangling the proportions of parameter estimation error from state and trait proportions.

A generalized extensive structure with a right action of interest rates
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Matsushita (2014) devised a generalized extensive structure with identity, which is a left nonnegative concatenation structure with left identity that satisfies two conditions, and for which the explicit description of the associative condition is not required. Consequently, he constructed a weighted additive model:

$$u(ab) = \alpha u(a) + u(b), \quad \alpha \geqslant 1,$$

where ab is the concatenation of commodities a and b, which represents a two-period temporal sequence. The left identity element e plays an important role in this construction. If a preference for advancing the timing of future satisfaction (i.e., impatience; Koopmans 1960; Koopmans, Diamond

and Williamson 1964) is observed, then it is logical that the utility value of ae is expressed as the magnifying form of the utility value of a. Indeed, the multiplicative form $\alpha u(a)$ in the weighted additive model reflects impatience. However, the following question arises: Is it allowable that the impatience effect is always represented by constant magnification $\alpha \geq 1$? The following situation will be a factor in changing magnification. On receiving a commodity in advance, several interests are often paid out with it. That is, when one receives a commodity n periods earlier, n interests are also paid out with the commodity in the successive n periods. The magnification varies according to the magnitude of each interest rate. To address this problem, this study develops an axiom system to construct a generalized weighted additive model:

$$u((ap/e)b) = \delta(p)u(a) + u(b),$$

where p is an interest rate and δ is a weight function of a set of interest rates. To achieve this goal, the concept of the action of a set of interest rates on a left nonnegative concatenation structure with left identity is introduced. First, multiplication of a commodity by interest rates from the right is devised, which implies advanced receipt of the commodity with interest rates following, and a left nonnegative concatenation structure with left identity is generated by the commodities multiplied by interest rates from the right. Second, several axioms are provided so as to make the left nonnegative concatenation structure with left identity an extensive structure with identity with respect to a newly defined operation. Finally, the generalized weighted additive model is derived from an additive representation of the extensive structure.

Transferred and reflected impetus: Towards a pre-Newtonian intuitive physics of object collisions

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In recent research, it has been suggested that mass perception, causal ascriptions, and predictions in simple interactions between solid objects

(e.g., billiard balls) can be modeled as inductive Bayesian inference over a noisy Newtonian representation of physical processes. However, other well-established empirical phenomena, such as the asymmetrical ascription of forces that the objects exert on each other, are conceptually incompatible with the symmetry of Newtonian physics and therefore resist an integration into such a framework. We propose that human inference in physical scenarios operates over a pre-Newtonian representation that is based on impetus intuitions. According to this pre-Newtonian framework, the impetus of moving objects is transferred and reflected in causal interactions (i.e., collisions), which captures the intuition of causal asymmetry but can also explain other phenomena previously presented as evidence for a noisy Newton theory. We present a mathematical model that implements a variant of impetus theory and show that it can explain both the motor objects bias in mass perception and causal force asymmetry within one integrated framework.

Minority influence in opinion spreading

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Social influence has been object of interest of social psychology for a long time. More recently, sociophysics and Galam's model, in particular, provide an explanation of rumors spreading and opinion dynamics in a population and explain some interesting social phenomena as diffusion of false information. Although Galam's original model and its recent formalizations are suitable to describe some social behavior, they take into account only populations with homogeneous agents. Some recent contributions consider agents who do not change opinion and in some cases are able to persuade the others. Starting from social psychology studies about the role of specific seat occupation we provide an heterogeneous model in which minority can strategically choose its seats. We simulate the opinion dynamics comparing situations in which the minority is present to others with homogeneous agents. Our results show how the opinion dynamics is dramatically affected by the presence of such a minority.

Some considerations on probability factorization in knowledge structures

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Knowledge Space Theory (see, e.g., Doignon and Falmagne 1985, 1999; Albert 1994; Falmagne and Doignon 2007) assumes that individuals are described by a knowledge state, which is the collection of all the items, in a given domain, they are capable to master. Its combinatorial approach, however, implies that for large set of items some structure can even possess millions of states, posing a problem of parameters estimation. Application of the basic local independence model (BLIM), for instance, requires (in addition to lucky guesses and careless errors parameters) the estimation of a number of parameters which is equal to the number of states, in order to describe the probability distribution of the relevant population. A common approach to reduce the number of parameters is to constraint state probabilities: in learning spaces, for instance, probability of each knowledge state can be factorized by means of a simple learning model (SLM, see, e.g., Doignon and Falmagne 1999, pp. 198-202) that assume the existence of independent probabilities associated to the mastered items in the knowledge state and to any failed item in the outer fringe. Such a model, however, requires a well-graded knowledge structure to be applied. In the present work, the behavior of factorizations, which are similar in scope to the BLIM and the SLM, is explored to obtain conditions under which a factorization of state probabilities, based on item probabilities like the SLM, can be further extended to knowledge spaces and structures. In particular, considerations are given to explore conditions under which the knowledge states probabilities can be factorized into product of conditional probabilities associated to the items of the domain (or to group of items) or to the atoms of the base. In addition, considerations are also provided about the concept of independence between items and the relation between items and atoms of the base.

Interactive method for building large knowledge structures that are simultaneously content plausible and consistent with response data

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An accurate knowledge structure is a primary requirement for a knowledge space theory founded assessment. In practice, this is not a trivial problem, evidence by the numerous approaches for their constructions residing in the literature. Expert derived structures suffer from inter-expert judgment heterogeneity as well as intra-expert contradictions (e.g., failure of transitivity). Deriving knowledge structures from data overcomes expert judgment inconsistencies and is therefore an attractive information sources. Possible data sources include to-the-purpose collected data (typically costly), available assessment data (not necessarily well suited), and assessments using extant structure(s) that incorporate embedded validation questions (requires an operational assessment). Controlling for sampling bias in all cases is (surprisingly?) difficult, complicating the process of deriving information from the data. Together, three categories of obstacles need to be overcome: 1) constructing a knowledge structure suitable for assessment purposes requires specialized understanding of the task, which a content expert may not readily possess; 2) data may be noisy and contain spurious or implausible lack of evidence for a surmise relation; 3) humans can generally only deal with a small number of conceptsrelative to a total number for a typical domainat any one time. We developed a general, interactive, and software implemented solution. First, a content expert may suggest surmise relations between a limited number of concepts, have these evaluated for empirical evidence as well as logical consistencies. The latter include transitivity, correlation, and the contrapositive and concern both the relations itself as well as consistency with previously asserted relationships. Second, the expert may be presented with empirically supported relationships not expert identified. Third, the approach generalizes to data stemming from any, or combinations of, the aforementioned sources, which in turn requires addressing some non-trivial matters of deriving the desired empirical evidence. Fourth, an approach based on transitive consistency is employed to automate a stitching together of small, suitable to a human expert, segment of knowledge structures, while ensuring assessment desirable features including well-gradedness. This approach is equally ap-

plicable to building a novel knowledge structure as it is to for incremental update/change to an existing one. Examples from mathematics and early reading are presented.

The influence of continuous visual properties on numerosity estimation

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Numerosity estimation is an evolutionary ancient cognitive ability (e.g., Agrillo, Piffer, Bisazza, & Butterworth, 2012) that is foundational to our sense of numbers but the underlying mechanism is hotly debated. A series of recent studies put forward the hypothesis that numerosity judgments are based on the integration of information from multiple visual cues (e.g., Gebuis & Reynvoet, 2011; Gebuis, Gevers, Cohen Kadosh, 2014), questioning the existence of an Approximate Number System (ANS) that represents numerosity in an abstract way (e.g., Nieder & Dehaene, 2009). Here we investigated this challenge using our recent computational model of the ANS (Stoianov & Zorzi, 2012), in which numerosity is an emergent high-order statistical feature of images that is coded by specialized number-sensitive neurons. We extended our previous simulations by systematically and jointly varying all critical continuous visual properties, including size, cumulative surface, and occupied area, and showed, first, that abstract numerosity emerges in the deep network model even with this much more extensive stimuli variability. Second, we showed that the modulation of numerosity estimation performance due to the specific manipulations of the continuous visual properties by Gebuis and Reynvoet can be readily accounted for by the model. The results supported the models assumption that numerosity is extracted from visual primitives through a hierarchical computation that leads to an internal representation of approximate number. We conclude that the influence of continuous visual properties on numerosity judgments does not challenge the existence of the ANS but reveals the boundary conditions of the process that yields invariance in numerosity perception.

A general technique of extracting conditions for random utility representations for choice data

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There is a long tradition to explain choice data by random utility variables. Let $(A, \mathcal{X}, p)$ be a choice system, i.e., A is a set of stimuli, $\mathcal{X} \subseteq 2^A$ the set of subsets of A which is presented to the subject from which he or she has to choose the best stimulus, $p(x, X)$ the probability that x is chosen if $X \in \mathcal{X}$ is presented. A random utility model assumes that each stimulus can be represented by a random variable (describing the possibly fluctuating utility of the stimulus). Then one wants to express the probabilities of particular choices (estimated from experimental procedures) by properties of the random variables in the following sense: $p(x, X) = P(U_x \geq \max_{a \in X} U_a)$. Surprisingly, for this simple model to work many testable conditions must be satisfied. The derivation of these conditions is in most cases a challenging mathematical problem, unsolved in many of the most interesting cases. The case $\mathcal{X} = 2^A$ was solved by Falmagne. Colonius and Fiorini explained Falmagne's derivation in terms of the Möbius function for a partial order. The partial order in question is $(2^A, \subseteq)$. In this paper we explore how the Möbius function can be utilized to derive necessary conditions for general choice experiments, i.e., general subsets $\mathcal{X} \subseteq 2^A$ regarded as a partial order under set inclusion. The technique is applied in an example which can be completely solved by this technique.

Learning orthographic structure with sequential generative neural networks

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The ability to extract statistical regularities from the environment is a powerful and general learning mechanism of the brain, which operates across domains, modalities, and development. In the present study we tackle the issue of learning sequences of elements within the framework of probabilistic generative models, which can be implemented as stochastic recurrent

neural networks that learn to reconstruct the sensory input through feedback connections. We investigated whether the statistical structure that is implicitly contained in letter sequences can be learned by a recently proposed sequential extension of Restricted Boltzmann Machines, the Recurrent Temporal Restricted Boltzmann Machine (RTRBM). RTRBMs use a common layer for encoding both the input and the model's prediction, and learn to process sequential information in an unsupervised way by trying to accurately reproduce the training sequences. RTRBMs can therefore produce top-down activations on the sensory units from internal representations through their intrinsically stochastic dynamics. We also present a modified version of deterministic, Simple Recurrent Networks (SRNs), which uses a logistic sampling process over the output units to generate the next element of the sequence to be fed back to the network. Our findings show that both RTRBMs and the extended SRNs can successfully learn the orthographic structure of English words, by building a probabilistic model of letter sequences that can be used to predict the next letter given a certain context, as well as to autonomously generate high-quality (i.e., graphotactically correct) pseudowords. We compared the prediction performance of these models with that of other non-connectionist generative models (n-grams and hidden Markov models). We then evaluated the generative ability of the considered models in terms of quality of the letter strings produced in comparison to existing pseudoword generators. Our results suggest that sequential generative neural networks are promising candidates for modeling cognition in the temporal domain.

An item response theory model of matching test performance
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In a matching test, a test taker is presented with a list of test items and a list of response alternatives and asked to match each response alternative with a test item. The response alternatives can be given as a response to at most one test item, inducing dependence between any individual's response to the items of such a test. Consequently, existing item response theory methods, a popular means of measuring latent traits and abilities

from tests, are not applicable to matching tests. This paper presents the matching Rasch model, an adaptation of the Rasch model, a well-known item response model, to matching tests. The matching Rasch model separates an individual's knowledge of the correct responses to the items of a matching test from his or her responses to those items. This decomposition is shown to allow the matching Rasch model to estimate the parameters of the Rasch model from matching test data better than applying existing methods to each individual's pattern of correct versus incorrect responses. Additionally, it is shown to allow the matching Rasch model to estimate the parameters of the Rasch model using matching test items nearly as accurately as existing methods estimate the same parameters using dichotomous items.

Posters

A model for Bi-logic
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Bi-Logic, introduced by Matte Blanco, has two modes: the asymmetric mode, which deals with non-symmetric relations, can separate objects and permits sound logic with two distinct truth values; and the symmetric mode of the Unconscious. The symmetric mode has symmetric relations only, it gathers, identifies objects, has an unsound logical behaviour, and treats all sets as infinite. Total symmetrization characterizes the "indivisible mode", where "the endless number of things tends to become, misteriously, only one thing". We find a formal approach to the symmetric mode, considering a quantum logical model derived from a common platform for extensional logics, termed basic logic. Logical constants are obtained putting equations, that allow to import some metalinguistic links between judgements into the object language. So one can import judgements concerning quantum physics into logic, and then discuss the features of such judgements. Random variables are represented by first order logical variables, which characterize pure quantum states since the variable acts as a "glue" for the state. Propositional connectives characterize mixed states, namely the sets of states obtained after quantum measurement. Negation, expressed in terms of duality, is discussed by the spin model of quantum mechanics. Due to the uncertainty, duality is substituted by "symmetry", namely one has a new operator on judgements which cannot negate. The arising of symmetry is given by the gap between the metalinguistic and the linguistic level, that permits to see that quantum states prior to measurement correspond to infinite sets, and in particular to conceive "infinite singletons" which correspond to the infinite sets of Bi-logic. So one characterizes the logical aspects of the symmetric mode, corresponding to condensation, absence of time, displacement. Displacement has a counterpart in the asymmetric reasoning: one could consider logical implication as an asymmetric correlation between two certainties, once infinite singletons disappear. Further consequences could be the "structural rules" of sequent calculus, and in general one could investigate the symmetric origins in different logics, including classical, intuitionistic and linear logic, and see how normative judgements play a role in destroying symmetry.

A Poisson random walk model for response time and pure accuracy tasks

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Based on a simple "what first comes to mind" rule, a Theory of Visual Attention (TVA; Bundesen, 1990) has been successful in explaining human performance in pure accuracy tasks with non-confusable stimuli. However, for mutually confusable stimuli a "what has the most evidence" rule is more suited (Kyllingsbæk et al., 2012). Based on this work we propose and test a common model of the time course of visual identification of mutually confusable single stimuli in two-alternative, response time and pure accuracy tasks. The central model assumption is that during the analysis of a single stimulus in the visual field, tentative evidence for one of two categorizations of the stimulus is generated by a Poisson process at a constant rate in such a way that a tentative categorization automatically counts against the other categorization. Visual identification is thus assumed to follow a simple random walk with exponential distributed interstep times. An identification is conclusively made if and when evidence reaches one of two thresholds. If a threshold is not reached before the analysis is stopped, then an informative guess will be made based on "what has the most evidence". One important question that is to be addressed in an application of the model is whether it is possible to identify invariances of model parameters across conditions of pure accuracy task and speeded responses. With Poisson rate estimates being in the same range across conditions, our common model provides a close fit to individual data on identification of Gabor patches in a two-alternative, response time and pure accuracy task.

Diagnostic of two-factor integration models by lines of subjective equality

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When the stimuli in a psychophysical experiment differ from one another in two main dimensions (e.g., physical volume and mass in the size-weight

illusion), the psychophysical method of constant stimuli yields a psychometric function on the plane (rather than on the line), and the ordinary concept of "point of subjective equality" (PSE) is replaced by the notion of "line of subjective equality" (LSE). LSEs may be different in various respects, such as location, direction, and form. In this contribution we present ideas and examples of how the characteristics of a LSE may be diagnostic about the shape of a surface representing an ideal psychometric function on two independent variables, and ultimately about two-factor integration models that may be hypothesized underlying the data from a psychophysical experiment.

Deriving weights of items in psychological tools based on fuzzy set theory: Case study of Becks Depression Inventory (BDI)

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Psychological tools have a crucial role in psychological research and decision making in practical settings.Psychological tools usually consist of different items whose weights are the same and it can be provided a biased interpretation of data .For example; the crying item and suicidal thoughts item of the Beck's Depression have the same weight. It is questionable. Locher (2007) presented that self-weighting of items did not substantially improve the performance of the questionnaire. In this research items were weighted by participants and based on crisp data thus, the purpose of this paper is to introduce a method of item-weighting based on fuzzy logic and entropy method. In this paper item are weighted based on 5 main aspects of an item (Item-total correlation, Discriminant coefficient of items, Loading Factor of Item, Mean of Item, Experts' Items weight).Then using fuzzy set the weight of these aspects are determined and then by combining the fuzzy and entropy method the weight of the items are determined.
The Item-total correlation, Discriminant coefficient of items, Loading Factor of Item, Mean of the Items for Beck's Depression Inventory obtained from Farahani et al. (2012)(a sample of 250 university students, 184 male

and 66 female) and for the experts' item weighting this inventory was assigned to 7 clinical psychologists and 3 psychiatrists and were asked to weight the items based on 5 point Likert scale (Very Low to Very High), then the data were fuzzified and then the items were analysed and the weight of items were determined. For the sensitivity analysis the weighted items and unweighted items of the BDI, a sample of 30 (15 normal and 15 clinical depressive) cases was used.
Results indicated the sensitivity of the data obtained from weighted-item questionnaire is 94% and for the regular form is 83%.
Item weighting can be lead to increase the accuracy of psychological tools and fuzzy logic as a mathematical method is useful for this purpose.

Effects of the psychological science new statistical guidelines, research disclosure statements and open practices

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As a response to the crisis of confidence in psychological science, Psychological Science adopted new statistical guidelines and mandatory research disclosure statements for all papers submitted from 1 January 2014. In this preliminary report we documented selected methodological practices in all empirical articles published in Psychological Science from 2013 to 2015 (up to the date of the conference). This period comprises 2013 with the old guidelines, 2014 with approximately half papers accepted with the old guidelines and 2015 where all papers were accepted with the new ones. In order to estimate the effects of these new submission guidelines, we examined all empirical articles published in the same period in two comparable journals which did not adopt similar guidelines: APS's Clinical Psychological Science and APA's Journal of Experimental Psychology: General. Every empirical study was examined with respect to the reporting of the following statistics: confidence intervals applied both to dependent variables and effect sizes; the following statistical approaches: cumulating meta-analysis, data interpretation based on the estimates of parameters and not on the dichotomous NHST statistical vs non-statistical significance; the following research practice disclosures: sample size determination and/or

stopping rule and the following Open Practices: raw data and materials availability, and preregistered design and analysis plan.

Factor model of life satisfaction

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As it was shown in author's studies of life satisfaction's (LS) structure and dynamic, two main factors of this phenomenon are cognitive and social ones. Therefore the dynamic psychodiagnostic techniques for different types of "self-acceptance" and "social establishment" were used to define two-factor model of LS. To reveal the psychological content of each type and to verify the topic's accordance with the content, the psychological differences of types in presented techniques, which determine "cognitive" and "social" factors degree, were analyzed. Looking back, for the dynamic psychodiagnosis of the current state two binary characteristics were used (Golovina & Savchenko, 2004; Savchenko & Golovina, 2006). In the present study these ones are: the LS (binary satisfied or no) and one of two factors: social establishment (established or no) and self-acceptance (accepting or no). Also we would like to remind that each question of these techniques is a description of one of four possible situations and three options to choose a one way out. As the result, there are six possible combinations of four presented states. Mentally moving from one state to another, the subject finally comes back to initial state, the cycle is done. The last transition is called the terminal cycle. The psychological analysis of the unstable balance between the first ant last states allows us to pre-identify the personality type. The diagnostic tools based on this approach allowed to define six types of self-acceptance and six types of personality establishment (Savchenko, Golovina, & Sochivko, 2012). During the techniques development these types were named by experts according to the descriptions of hypothetical states (situations), where the subject can transfer from one state to another one from three rest ones. To reveal the psychological content of each type, the psychological differences between these types from empirical study were analyzed. In addition, other techniques were used: the "Mini-mult" questionnaire, the short version of MMPI, Holmes and

Rahe's "Social readjustment rating scale" (SRRS), Crumbaugh and Macholik's "Purpose in life" (PIL) test (adapted by D. Leontiev). The present study validate the dynamic psychodiagnostic tools, developed by authors: as the result of general data analysis, the dynamic personality types of subjects were identified and previously obtained data from standard diagnostic techniques were corrected. Therefore, these tools for the dynamic personality type's identification can significantly reduce time expenses and simplify the survey procedure for subjective quality of life determination. Data from the present study is insufficient for additional conclusions about LS, and allow to plan further empirical studies. With the help of ANOVA was defined influence of cognitive and social factors on LS.

Probabilistic reasoning and quantum cognition: a study on Bell's inequality

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Quantum probability theory has recently shown its effectiveness in constructing mathematical models of cognition and decision, predicting a variety of psychological phenomena, from probability judgment biases to conceptual combination. Within quantum theory, Bell's inequality has played a fundamental historical role providing an empirical test to compare classical probability and quantum probability predictions. Given three dichotomous variables A and $\bar{A}$, B and $\bar{B}$, C and $\bar{C}$, Bell's inequality consists in comparing $Pr(A \cap \bar{C})$ with $Pr\left((A \cap \bar{B}) \cup (B \cap \bar{C})\right)$. Classical probability always predicts $Pr(A \cap \bar{C}) \leq Pr\left((A \cap \bar{B}) \cup (B \cap \bar{C})\right)$. On the contrary, quantum probability theory provides for cases in which $Pr(A \cap \bar{C}) > Pr\left((A \cap \bar{B}) \cup (B \cap \bar{C})\right)$. Given the importance of this property in the confirmation of quantum theory within physics, this work aims to investigate human probabilistic reasoning in tasks based on Bell's inequality. We developed a quantum model able to predict when $Pr(A \cap \bar{C})$ is judged higher or lower than $Pr\left((A \cap \bar{B}) \cup (B \cap \bar{C})\right)$. Given the quantum model, two different scenarios were created. Each scenario was manipulated in order to have a first condition predicting $Pr(A \cap \bar{C}) > Pr\left((A \cap \bar{B}) \cup (B \cap \bar{C})\right)$ and a second scenario condition predicting $Pr(A \cap \bar{C}) < Pr\left((A \cap \bar{B}) \cup (B \cap \bar{C})\right)$.

Each condition was tested with two different modality of response (forced choice and probability rating of a single sentence). Participants (n = 540) were randomly assigned to a single scenario, condition and modality of response. Results confirmed that the proposed quantum model is able to predict Bell's inequality response in Bell's inequality-based tasks. This work supports the effectiveness of the quantum cognition approach in modelling human probabilistic reasoning.

Repeated-measures models of Rasch person parameters. Applications to clinical data to evaluate the effectiveness of a therapeutic treatment.

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Measurement instruments based on Latent Trait Rasch Models are often used to estimate the location of a person on a latent trait. This may be done once or at successive time points or under different conditions to investigate change processes. In the clinical context, monitoring patients' change over time is of fundamental importance to evaluate the effectiveness of a therapeutic treatment. This study presents and compares repeated measures models based on Rasch modeling to measure person parameters change (e.g. Hoijtink, 1996; Wright, 2003; Paek, Baek & Wilson, 2012, Embretson 2015). Empirical examples are used to illustrate the models and their applications, to data collected during group therapy interventions wherein patients and therapists within therapeutic groups interact along therapeutic sessions held at different times. Results show that by incorporating inter session time interval into the latent trait model, it is possible to track individual and therapeutic group changes at any time point of the therapeutic process. Further it is possible to compare different individuals (e.g. patients vs therapists) and therapeutic groups in a longitudinal perspective.

Inter-rater agreement in multivariate settings: A Bayesian approach

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The evaluation of the agreement among a number of experts about a specific topic is an important and scarcely explored issue, especially in multivariate settings. The classical indexes (such as Cohen's kappa) have been mainly proposed for evaluating the agreement between two experts in the univariate case. The evaluation of the agreement among more than two experts in the multivariate case is a still under-explored topic. This problem is particularly crucial in the Formal Psychological Assessment (FPA) where the so called *clinical context* can be described as a Boolean matrix where the presence of a 1 in a cell ia means that the item i investigates the attribute a. The construction of the clinical context can be carried out through the query to a number of experts about the assignment to each item of the set of attributes it investigates. We propose a model evaluating the agreement of a number of experts in a task of clinical context construction. The model takes into account two main factors that could intervene in explaining observed differences in the task completion by the experts: first, the experts may have different theoretical believes with respect to how items and attributes are related; second, given a certain strength of a specific link, experts may have different thresholds in performing the attribute assignment to each item. By means of a Bayesian approach a number of models have been simulated in order to estimate the role of both theoretical believes and experts' threshold in a wide range of potential scenarios that may occur. Results show how the proposed approach may be fruitfully applied in carrying out an evaluation of agreement among experts accounting simultaneously for the two factors. The application of the proposed approach to a number of research situations, different from the FPA, is discussed.

Maximum likelihood parameter estimation for a Dynamical Cognitive Model

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Recently, we proposed a dynamical model for the generation of scanpath statistics (e.g., saccade length distributions and clustering of fixations) during free viewing of natural scenes (Engbert et al., 2015, J Vision). Here we study important aspects of the model using a new parameter-fitting procedure. We compare different methods to fit the dynamical model to data based on a direct maximum likelihood approach and Bayesian Markov chain Monte-Carlo sampling (MCMC). Experimental data and modeling results are compared based on point process statistics and spatial correlation functions. Our results indicate that variations of model parameters between different viewing conditions can be interpretation as strategic variations in viewing behavior.

Formal Psychological Assessment in building a new tool for the evaluation of depression

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A systematic review of the most widely used self-report questionnaires on depression, in Italy, was carried out. This review highlighted a number of limitations of such questionnaires in relation to their ability to investigate all the diagnostic criteria for major depressive episode as depicted by DSM-5 and literature. More in general, self-evaluating questionnaires (non-adaptively) provide only quantitative scores that do not necessarily account for qualitative information. Formal Psychological Assessment (FPA) attempts to overcome these limitations. FPA is the formal conjunction and the clinical application of two theories of mathematical psychology: Knowledge Spaces Theory and Formal Concepts Analysis. Through the FPA methodology, a new 46 items tool for depressive episode was built. The application of this methodology allowed us to include items investigating all the 23 identified theoretical criteria about depressive symptoms. The

matrix, called *clinical context*, allowed us to define the relations among the items and the 23 attributes. Each item investigates one or more attributes. Moreover, the matrix allowed us to depict the prerequisite relations among items: if an item q, explores an attribute a investigated by another item p, which explores also attribute b, then q will be a prerequisite for p. These relations can be fruitfully used in building an adaptive questionnaire. The *clinical state* of a patient consists of the subset of items he/she answered affirmatively. Thus, even if two patients respond affirmatively to the same number of items (same score), the representation of their two states, in terms of attributes, may be different. Then, the states may have the same clinical score, even including different attributes. This is fundamental from a clinical perspective, since it allows for analyzing, and treating, each patient individually, according to his/her symptoms configuration. The new tool, when adaptively implemented, would be able to both go beyond the individual score of a test and investigate the specific diagnostic features. Such a tool would allow for both an idiographic and nomothetic diagnosis. The new tool aims at integrating all the diagnostic criteria and obtaining prerequisite relations, and it represents the starting point for the application of a computerized assessment.

A hierarchical generative model of letter perception based on recycling of natural image features

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Letter identification has been extensively studied by cognitive psychologists because it is a key component of the reading process as well as a circumscribed example of the more general problem of object recognition, which implies invariance to a broad range of changes in visual input. How abstract letter identities might be computed from vision is still debated and computational accounts are based on toy models that cannot handle realistic visual input. In the present study we developed a large-scale connectionist model that learns to recognize letters presented as real images in a variety of fonts, styles, sizes and spatial alignments. The model is based on a stochastic recurrent neural network with many layers of hidden

neurons (a "deep network"), which builds a hierarchy of progressively more complex distributed representations of the sensory input by fitting a hierarchical generative model. Crucially, earlier processing levels in the model exploit the recycling of domain-general visual features that are learned through the exposure to thousands of small patches of natural images. Accordingly, the first layer of neurons developed receptive fields that efficiently encode natural image statistics (e.g., Gabor filters). We show that this internal representation contains sufficient information for decoding letter identity with high accuracy on a large dataset of letter images. Domain-specific feature detectors resembling abstract letters can emerge in later layers through learning on a sample of letter images, thereby yielding robust and invariant letter perception. We conclude that the statistical information extracted from natural scenes can be readily re-used to represent visual symbols like those used in writing systems and that learning to recognize them only requires a more simple, domain- and culture-specific tuning. These results also support the hypothesis that the shapes of written symbols have been culturally selected to match the statistical structure found in natural environments.

List of Authors

Time	Tuesday		Wednesday		Thursday
08:30 – 09:00	Opening				
09:00 – 09:30	Symposium in memoriam Patrick Suppes I [Room: Cesare Musatti]		Keynote: Richard Shiffrin [Room: 3G]		Keynote: Eric-Jan Wagenmakers [Room: Cesare Musatti]
09:30 – 10:00					
10:00 – 10:30			Measurement [Room: 3G]	Cognitive models I [Room: 3H]	Symposium "Thirty years of KST" I [Room: Cesare Musatti]
10:30 – 11:00					
11:00 – 11:30	Coffee Break				
11:30 – 12:00	Symposium in memoriam Patrick Suppes II [Room: Cesare Musatti]		Decision & Choice [Room: 3G]	Cognitive models II [Room: 3H]	Symposium "Thirty years of KST" II [Room: Cesare Musatti]
12:00 – 12:30					
12:30 – 13:00			Lunch Break		
13:00 – 13:30					
13:30 – 14:00	Lunch Break				Closing
14:00 – 14:30					
14:30 – 15:00			Response times [Room: 3G]	Statistical Methods [Room: 3H]	
15:00 – 15:30	Perception & Psychophysics I [Room: 2B]	Psychometrics I [Room: 2C]			
15:30 – 16:00					
16:00 – 16:30	Coffee Break		Poster Session		
16:30 – 17:00	Perception & Psychophysics II [Room: 2B]	Psychometrics II [Room: 2C]			
17:00 – 17:30					
17:30 – 18:00					