



# COGSCI'19

*Creativity+Cognition+Computation*

24 - 27 JULY 2019 MONTREAL, CANADA

Invited Speakers

Elizabeth Churchill | Mary Lou Maher | Takeshi Okada

Co-Chairs

Ashok Goel | Colleen Seifert | Christian Freksa

# Introduction

Dear Cognitive Science Colleagues,

Welcome to the 41st Annual Conference of the Cognitive Science Society in Montreal, Canada! Our meeting brings together some of the most innovative and exciting research in Cognitive Science today, and highlights the conference theme of *Creativity + Cognition + Computation*.

In addition to the Rumelhart Prize presentation by Michelene Chi and the Carvalho-Heineken Prize presentation by Nancy Kanwisher, the program features three plenary speakers: Elizabeth Churchill (Google Research), Mary Lou Maher (University of North Carolina), and Takeshi Okada (University of Tokyo). Further, the program includes the Jacobs Foundation Symposium, *How Curious? The Need for Exploration and Discovery*, as well as an invited symposium on *Creativity in the Arts* in addition to the Rumelhart Symposium on *Translation Research in STEM Learning* and the Glushko Ph.D. Dissertation Awards Symposium. These invited symposia and talks showcase the conference theme.

The program committee for CogSci 2019 received 1110 submissions, including 810 full papers, 256 member abstracts, 13 publication-based short papers, as well as 14 proposals for symposia, 10 for workshops, and 8 for tutorials. After a rigorous review process, the committee selected 202 papers for oral presentation and inclusion in the conference proceedings (25%), 306 papers for poster presentation and inclusion in the proceedings (38%), and 163 papers for poster presentation with inclusion of abstracts in the proceedings (20%). We also selected 204 submitted member abstracts and accepted another 19 abstracts from full paper submissions as invited member abstracts. In addition, we accepted 12 publication-based talks, 10 symposia, 7 workshops, and 4 tutorials to make for a very rich and inclusive program.

We hope that you enjoy the program this year as well as the beautiful city of Montreal!

Your Program Co-Chairs,  
Ashok Goel (Georgia Institute of Technology, USA)  
Colleen Seifert (University of Michigan, USA)  
Christian Freksa (University of Bremen, Germany)

# Acknowledgements

We are very grateful to everyone who contributed to the planning and organization of this year's Cognitive Science meeting, to all authors who submitted their contributions, and to all reviewers who generously donated their expertise and time to evaluate the submissions. We thank the members of the Program Committee who coordinated the reviews and made the tough decisions about submissions, and the members of the conference organizing subcommittees who showed initiative in completing their demanding tasks. These Organizing and Program Committee members are listed below.

We are especially grateful for the assistance of a number of individuals and groups critical to handling the many organizational aspects of the meeting. We thank Michael Frank, the Chair of the Cognitive Science Society, Anna Drummey, the Executive Officer of the Society, and the entire Governing Board of the Society, for their advice and support throughout the process. Lily Chang at *International Conference Services*, Jude Ross at *Podium Conferences*, and James Stewart at *Precision Conference Solutions* have been helpful, effective, and constant partners during the long process. Chuck Kailish and Timothy Rogers, two of the Co-Chairs of last year's conference, offered help whenever we needed them. Additional help included key contributions from Thomas Barkowsky for the reviewing process, Andrea Patalano for the awards organization, and Sungeun An for creating the conference poster.

Finally, we are grateful to the Cognitive Science Society and to the sponsors of this conference, including the Robert J. Glushko and Pamela Samuelson Foundation, the Jacobs Foundation, Facebook AI, DeepMind Technologies and the Weinberg Institute of Cognitive Science for their support.

Enjoy!

Ashok Goel, Colleen Seifert, and Christian Freksa  
Co-Chairs, Cognitive Science 2019

# Sponsors

The Robert J. Glushko and Pamela Samuelson Foundation  
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**Thank you again for your support!**

# How to Cite Your Paper

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# Awards

## Robert J. Glushko Dissertation Prizes

The Cognitive Science Society and the Glushko-Samuels Foundation award up to five outstanding dissertation prizes in cognitive science each year. The goals of these prizes are to increase the prominence of cognitive science and encourage students to engage in interdisciplinary efforts to understand minds and intelligent systems. The hope is that the prizes will recognize and honor young researchers conducting ground-breaking research in cognitive science. The eventual goal is to aid in efforts to bridge between the areas of cognitive science and create theories of general interest to the multiple fields concerned with scientifically understanding the nature of minds and intelligent systems. Promoting a unified cognitive science is consistent with the belief that understanding how minds work will require the synthesis of many different empirical methods, formal tools, and analytic theories. 2011 was the inaugural year of this prize, and a new competition is held annually. The 2019 recipients of the Robert J. Glushko Prizes for Outstanding Doctoral Dissertations / Theses in Cognitive Science are:

**Kirsten Adam – University of Chicago, 2018**

*Characterizing the Limits of Visual Working Memory*

**Max Kleiman-Weiner – Massachusetts Institute of Technology, 2018**

*Computational Foundations of Human Social Intelligence*

**Martin Maier – Humboldt University, 2018**

*Language, Meaning, and Visual Perception: Event-Related Potentials Reveal Top-Down Influences on Early Visual Processing*

**Jean-Paul Noel – Vanderbilt University, 2018**

*Leveraging Multisensory Neurons, Circuits, Brains, and Bodies to Study Consciousness: From the Outside-In and the Inside-Out*

**Katharine Tillman – University of California, 2017**

*Constructing the Concept of Time: Roles of Language, Perception, and Culture*



## **Marr Prize**

The Marr Prize, named in honor of the late David Marr, is awarded to the best student paper at the conference. All student first authors were eligible for the Marr Prize for the best student paper. The Marr Prize includes an honorarium of \$1000 and is sponsored by The Cognitive Science Society. The winners of the 2019 Marr Prize for the Best Student Paper is:

**Jose M. Ceballos, University of Washington, *The Role of Basal Ganglia Reinforcement Learning in Lexical Priming and Automatic Semantic Ambiguity Resolution***

**Nicolas Oliver Riesterer, Universität Freiburg, *Modeling Human Syllogistic Reasoning: The Role of "No Valid Conclusion"***

## **Computational Modeling Prizes**

Four prizes worth \$1000 each are awarded for the best full paper submissions to CogSci 2019 that involve computational cognitive modeling. The four prizes represent the best modeling work in the areas of perception/action, language, higher-level cognition, and applied cognition. These prizes are sponsored by The Cognitive Science Society. The winners of the 2019 Computational Modeling Prizes are:

### ***Applied Cognition:***

**Douglas Guilbeault, University of Pennsylvania, *The Social Network Dynamics of Category Formation***

### ***Higher-Level Cognition:***

**Ardavan S. Nobandegani, McGill University, *A Resource-Rational Process-Level Account of the ST. Petersburg Paradox***

### ***Perception & Action:***

**Yunyan Duan, Northwestern University, *A Rational Model of Word Skipping in Reading: Ideal Integration of Visual and Linguistic Information***

### ***Language:***

**Benjamin Peloquin, Stanford University, *The Interactions of Rational, Pragmatic Agents Lead to Efficient Language Structure and Use***

## **Sayan Gul Award**

Sayan Gul was an undergraduate at UC Berkeley studying cognitive science and computer science, and had great potential as a cognitive scientist. He died tragically while traveling to the Annual Conference of the Cognitive Science Society for the presentation of his research. This award is intended to support similarly outstanding undergraduates conducting research in cognitive science. In honor of Sayan Gul, the Sayan Gul Award supports undergraduate students with travel related costs who are presenting authors at the conference. The Sayan Gul Award includes a cash award of \$500. This year's winner of the award is:

**Megumi Sano, Stanford University, *Graphical Convention Formation During Visual Communication***

## **Diversity & Inclusion Travel Awards**

Five prizes will be awarded to support travel to the conference for graduate students who bring diversity to the society, in particular under-represented racial/ethnic groups and citizens of under-represented countries (Zone B Society members) who are presenting at the conference. Each travel award includes a cash award of \$1,000. This year's travel awards recipients are:

**Jose M. Ceballos, University of Wisconsin, *The Role of Basal Ganglia Reinforcement Learning in Lexical Priming and Automatic Semantic Ambiguity Resolution***

**Tania Delgado, University of California San Diego, *Differences in Learnability of Pantomime Versus Artificial Sign: Iconicity, Cultural Evolution, and Linguistic Structure***

**Nianyu Li, Peking University, *A Conceptual Model of Self-Adaptive Systems Based on Attribution Theory***

**Che Lucero, Cornell University, *Unconscious Number Discrimination in the Human Visual System***

**Mukesh B. Makwana, Centre of Behavioural and Cognitive Sciences, Mumbai, *Hands in Mind: Learning to Write with Both Hands Improves Inhibitory Control, but Not Attention***

**Guilherme Sanches de Oliveira, University of Cincinnati, *Bee-ing In the World: Phenomenology, Cognitive Science, and Interactivity in a Novel Insect-Tracking Task***

**Staci Meredith Weiss, Temple University, *Individual Differences in Bodily Attention: Variability in Anticipatory Mu Rhythm Power Is Associated with Executive Function Abilities and Processing Speed***

## **Student Travel Awards**

The Robert J. Glushko and Pamela Samuelson Foundation generously sponsored \$10,000 for student travel awards. Travel awards have been provided to students whose submissions were accepted as full papers, received high rankings, and who indicated a need for travel funding. This year's travel awards went to:

Nicolas Collignon, University of Edinburgh  
Douglas Guilbeault, University of Pennsylvania  
Ethan Hurwitz, University of California, San Diego  
Akila Kadambi, University of California, Los Angeles  
Kei Kashiwadate, Deniki University  
Lara Kirfel, University College London  
Sang Ho Lee, Ohio State University  
Ashley Leung, University of Chicago  
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Jennifer Sloane, University of New South Wales  
Leila Straub, ETH Zurich  
Karina Tachihara, Princeton University  
Charley Wu, Max Plack Institute for Human Development  
Yueyuan Zheng, University of Hong Kong

## **Rumelhart Prize Presentation**

**Michelene Chi, Arizona State University**

*Translating the ICAP Theory of Cognitive Engagement Into Practice*

## **Carvalho-Heineken Prize Presentation**

**Nancy Kanwisher, MIT**

*Functional Imaging of the Human Brain: A Window in the Architecture of the Human Mind*

## **Keynote Talks**

**Elizabeth Churchill, Google Research**

*Cognition, Collaboration, and Creativity: Google's Material Design as a Case Study*

**Mary Lou Maher, University of North Carolina**

*Computational Models of Creativity: Curiosity, Novelty, and Surprise.*

**Takeshi Okada, University of Tokyo**

*Inspiration and Artistic Creation*

## **Rumelhart Symposium**

*Translation Research in STEM Learning*

**Jim Slotta, University of Toronto, Moderator**  
**Kristy Boyer, University of Florida**  
**Kirsten R Butcher, University of Utah**  
**Percival G Matthews, University of Wisconsin**  
**Jodi Davenport, WestEd**

## **Jacobs Foundation Symposium**

*How Curious? The Cognitive Need for Exploration and Discovery*

**Elizabeth Bonawitz, University of New Jersey, Rutgers**  
**Tobias Hauser, University College London**  
**Allyson Mackey, University of Pennsylvania**  
**Celeste Kidd, University of California, Berkeley**

## **Invited Symposium**

*Creativity in the Arts*

**David Kirsh, University of California San Diego, Moderator**  
**Gil Weinberg, Georgia Tech**  
**Brian Magerko, Georgia Tech**  
**Valentina Nisi, University of Madeira**

## **Glushko Awards Symposium**

**Kirsten C. S. Adam, University of California San Diego**  
**Martin Maier, Humboldt-University Berlin**  
**Jean-Paul Noel, Vanderbilt University and New York University**  
**Katharine A. Tillman, University of Texas**  
**Max Kleiman-Weiner, Harvard University**

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## On the nature of creative processes: performativity as a missing algorithm

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### The creative role of performativity

In our project the performance is a product of performativity. Performativity is the cognitive ability to produce physical or mental actions. Studying performance and studying performativity sets different scientific activities. Studying how to enhance performance belongs to the behavioral science. On the contrary, studying performativity belongs to a general cognitive procedure that must not be confused with the description of behaviors, requiring instead a specific theorization in the cognitive sciences. The aim of this research project is to focus on the hypothesis that performativity is not a property confined to certain specific human skills, or to certain specific acts of language. Instead, the executive and motor component of cognitive behavior should be considered an intrinsic part of the physiological functioning of the mind and as endowed with self-generative power (Pennisi A., 2019; Pennisi A.-Falzone, 2016).

We believe that performativity has evolved alongside with those natural selection processes which have led the human species to develop articulated language and the embodied simulation (Pennisi A.-Falzone, 2016; Falzone 2018). In such framework, cognition is a form of mediated action rather than the link between inner thought and overt behavior. According to our model, thus, action is not the mere externalization of a mental process, but is the process itself (Pennisi A., 2018 and 2019; Pennisi A.-Falzone, 2019; Gallese, 2019). Since such process is carried out through the body, we think that the species-specificity of the bodies occurring in nature paves the way for every individual's knowledge of reality.

Performativity as a physiological tool of cognitive creativity has precise neural correlates and procedural properties.

From the point of view of procedures, performativity is a cognitive property that arises from the absence of an algorithm designed to carry out a given performance. Acting in a non-planned way, learning by trial and error, applying familiar behavioral patterns to new situations: these are just a

few examples of what is performativity and of how it works.

Thus, performativity is intrinsically creative because its nature is to face situations that cannot be solved by the application of already known algorithms. In a nutshell, performative creativity is a procedural system that is somewhere between what Chomsky called "rule governed creativity" and "rule-changing creativity". Performativity however bears a peculiar kind of creativity, which is different from the one generated by the competence but still shares some features with the latter: in fact, it is a fully embodied and free-from-rules process that is carried out through trial and error, that is to say it depends on the bodily practice (locomotion, language, perception, etc.) made in everyday experience (Pennisi A., 2019; Pennisi A.-Falzone, 2016; Gallese 2018; Matteucci, 2018; Montani 2018). In functional terms, hence, the brain is a powerful biological instrument which permits continuous reorganization of the activity of organisms. An incessant activity of biological agents that move and act, that perceive and explore the world around them through a network of sensors and nerves, whose complexity of articulation is directly dependent on the species-specific structure. This activity relentlessly stimulates the rewiring of sensorimotor networks and remodeling of cognitive interactions. Our mind is the result of this close cooperation between the performative competence triggered by sensory-motor systems and the readjustment of the computational procedures of our deep brain to allow the survival and growth in the fitness of individuals and the entire species within environmental variation.

### Insights from neurolinguistics

A large amount of literature has been devoted to the aforementioned mapping process, carried out through both brain imaging (Monchi et al. 2001, 2006; Nagano-Saito et al. 2008) and the study of the biochemical reactions involved in the plasticity of synaptic processes (Thivierge et al. 2007; Ko et al. 2013; Tamburrini-Prevete, 2018). Such researches have demonstrated "that the caudate nucleus and the putamen are particularly important, respectively, in the planning and the

execution of a self-generated novel action, whereas the subthalamic nucleus may be required when a new motor program is solicited independently of the choice of strategy” (Monchi et al. 2006, 257). Examining the biolinguistic aspects of these discoveries in depth, Lieberman and his team have shown that the neural circuits connecting different brain parts during human speech exploit the putamen for neuromotor control, changing “on the run” - that is, during verbal action performance - “the direction of our thought processes based on new stimuli such as the understanding of meaning conveyed by the syntax of language” (Lieberman & McCarthy 2007, 16).

Furthermore, a similar activation of brain motor components is registered when language data are processed in the absence of grammatically well-tested algorithms, such as when a second language is learned (Klein et al. 1994), or when a subject switches from listening to informal speech to a more formal one (Abutalebi et al. 2007).

In short, the management of neurocerebral performative strategies seems to be responsible for the most dynamic processes of linguistic behavior. This kind of behavior needs an attempt, or an active effort, that cannot be accomplished only through the mechanical application of already known and stabilized rules because it requires “the execution of a self-generated action among competitive alternatives” (Lieberman 2013, 80): an activity that is prolonged virtually forever, after the first acquisition step of ontogenetic speech, moving from mechanical physiology to the physiology of thought.

This overall framework also explains why the paths of speech often follow the hesitational phenomena of breaking up, recomposition, reunion, syncretism, propositional chiselling, semantic and lexical refinement: that is, all that is stigmatized by Chomsky’s idea of performance as the deposit of cognitive junk produced by externalization devices (to repeat his words: “numerous false starts, deviations from rules, changes of plan in mid course, and so on”, 1960, 530). On the contrary, the most advanced neurolinguistic research reveals the close interconnection between motor performativity and the continuous reorganization of propositional and abstract thinking: “the cortico-striatal regions that regulate language comprehension also regulate many aspects of behavior such as motor control and abstract reasoning” (Simard, Monchi et al. 2010, 1092). Evolutionarily, in fact, the performative motricity of thought could have been decisive for understanding the subsequent development of human language, “because it indicates that our modern brains may actually have been shaped by an enhanced capacity for speech motor control that evolved in our ancestors” (Lieberman & McCarthy 2007, 16).

### **Schizophrenia as the realm of anti-performativity**

Another field of research which supports our idea of performativity is phenomenological psychopathology. Authors like Sass (1992), Stanghellini (2004) and Fuchs (2005), in fact, claim that one of the core symptoms of schizophrenia is a sort of “disembodiment”, the onset of a

problematic relationship between the patient and his own body in which the parts of the latter become heavy, distorted and even “stranger”. This peculiar kind of corporeity is reflected in a total lack of fluidity in any patient’s performance: “patients frequently experience a disintegration of habits or automatic performances, a «disautomation». Instead of simply dressing, driving, walking, etc., they have to prepare and produce each single action deliberately, in a way that could be called a «Cartesian» action of the mind on the body” (Fuchs & Röhrlich 2017).

Such schizophrenic tendencies might be described as the attempt to apply procedural rules - algorithms - to the everyday and well-mastered situations that make up our “being in the world”, as the following words by a schizophrenic patient show: “If I do something like going for a drink of water, I’ve to go over each detail – find cup, walk over, turn tap, fill cup, turn tap off, drink it” (Chapman 1966, 239). As we have already claimed (Pennisi G. 2018), schizophrenia might be read as the disruption of the mechanisms that make a performance efficient, namely the selective target control, the softly conscious monitoring of one’s bodily configurations and the implicit sense of body-as-subject (Gallagher 2018).

Instead of having this tacit, self-transparent and immediate relationship with their own bodies, patients often exercise a thematic control on the latter that goes from repetitively touching their own body parts – as if they try to verify if their body still «belongs» to them – to the fragmentation of every goal-related movement in many sub-movements, like in the previous example. Schizophrenics’ inability to get in the flow of the action is what makes such illness “the realm of anti-performativity” (Pennisi G. 2018): this is why we think that the study of the role of performativity on human cognition cannot be separated from the phenomenological analysis of psychopathologies.

### **Conclusion**

In the light of the above, we will define performativity as a constituent component of the cognitive processes. The actions that we perform in the environment, in fact, allow us to know both the surrounding world and our physical possibilities. In such model, the body is not only the means by which the individual explores and acts on the environment, but the precondition for the development of any cognitive ability.

Our intention is to validate our ideas on the role of the body and on performativity by applying the interdisciplinary methods of Cognitive Science. The issues we have raised, in fact, not only are the subject of a debate between the embodied/extended mind models and the mentalist hypotheses carried out by cognitive psychology and computationalism, but can only be clarified by providing an overview of the scientific literature on psychopathology and on cognitive neuropsychology.



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