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Jose Acacio de Barros · Bob Coecke
Emmanuel Pothos (Eds.)

Quantum Interaction

10th International Conference, QI 2016
San Francisco, CA, USA, July 20–22, 2016
Revised Selected Papers

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Editors
Jose Acacio de Barros
San Francisco State University
San Francisco, CA
USA

Bob Coecke
University of Oxford
Oxford
UK

Emmanuel Pothos
City University of London
London
UK

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Preface

QI 2016, the 10th International Conference on Quantum Interactions, was part of a series of international conferences on applications of the quantum formalism outside of physics. This now traditional conference started in 2007 as part of the Association for the Advancement of Artificial Intelligence, AAAI, Spring Symposia, and has taken place annually ever since, mostly in Europe. The tenth conference was held on the Downtown Campus of San Francisco State University (SFSU), in San Francisco, California, during July 20–22, 2016. It was hosted by the School of Humanities and Liberal Studies, an interdisciplinary unit within the College of Liberal and Creative Arts at SFSU.

The title of the conference, "Quantum Interactions," was concocted by Peter Bruza and William Lawless, who co-organized, together with C.J. van Rijsbergen and Don Sofge, the 2007 symposium at the AAAI at Stanford University. In their original proposal to the AAAI symposium, they were referring to social interactions. Social interactions, so was their argument, were prone to context-dependent effects the same as quantum observables. Therefore, it was reasonable to assume that the conceptual structure of quantum mechanics could shed light on them. Currently, quantum interactions refers more broadly to the use of the quantum mathematical, conceptual, or probabilistic structures outside of physics, often in social and computer sciences. Social sciences, in particular psychology, have many examples where observable quantities are contextual, and as such do not fit well within a classic probability theory. Since quantum mechanics was a theory developed to deal with quantum contextuality, as happens, for example, in the case of the double-slit experiment, researchers started asking whether the extended probabilistic apparatus developed could be used to describe contextual systems outside of physics. As such, we should not think of quantum interactions as the use of quantum mechanics outside of physics, but instead as the use of the *mathematics* of quantum mechanics to non-quantum systems.

In this year's conference we had many distinguished speakers, and we are happy to have contributions to this volume from Professors Bas van Fraassen and Ehtibar Dzhafarov. Professor van Fraassen's paper takes the idea of the quantum formalism as a way to describe contextual systems, and then tries to create a formal theory of epistemology based on it. Professor Dzhafarov, in collaboration with Janne Kujala, developed in detail his theory of contextuality based on classic probability theory and random variables. These papers were grouped in the fundamentals session, along with a paper by Hou Yau. Hou Yau presented a modified theory of the Klein–Gordon equation where time is itself a dynamical variable, with the hopes that such an approach might have some applications outside of physics.

Papers for the conference were naturally grouped into applications of quantum formalism to psychology (quantum cognition), language and applications, and quantum-like measurements outside physics. In the quantum cognition group, Irina Basieva and Andrei Khrennikov discussed the two- and three-slit experiments as metaphors to

the modeling of cognitive processes, especially the difficulties associated with pushing this metaphor to experiments in psychology. J. Acacio de Barros, Carlos Montemayor, and Leonardo De Assis used the results of quantum cognition, in particular of contextuality in quantum cognition, to argue that some empirical theories of consciousness are inadequate and need revision. J. Acacio de Barros, Leonardo de Assis, and Petr Bob used data from experiments in stress research to argue that stress may show order effects in a way that is consistent with the collapse model used by Busemeyer in psychology. Diederik Aerts, Lyneth Beltran, Massimiliano Sassoli de Bianchi, Sandro Sozzo, and Tomas Veloz provided a modified hidden-variable model of quantum mechanics that could describe order effects in a way consistent with experimental findings. Finally, Peter beim Graben and Reinhard Blutner discussed the use of the quantum formalism in music theory.

For language and applications, the paper by David Windridge and Raja Nagarajan discussed bootstrap aggregation in quantum machine learning. Yaared Al-Mehairi, Bob Coecke, and Martha Lewis created a model of categorical compositional cognition by fitting the integrated connectionist/symbolic architecture within categorical compositional semantics. Trevor Cohen, Dominic Widdows, Jason A. Vander Heiden, Namita T. Gupta, and Steven H. Kleinstein extended their previous vector model based on a quantum description to represent protein sequences with graded vectors. Aditya Joshi, Johan Halseth, and Pentti Kanerva used random indexing to identify the language of text samples.

In the quantum-like measurement session, Jacob Denolf attempted to broaden the theory of measurement with operators in a Hilbert space to account for ordinal measurements common in social sciences. François Dubois and Zeno Toffano extended the measurements from a Boolean logic to a fuzzy logic. Kevin Dunne tries to connect two different approaches to quantum theory: topos and monoidal.

This year we also had a very successful special session on "Contextuality and the Foundations of Probability." Contextuality, in line with the meaning put forth in Dzhafarov and Kujala's contribution to this volume, is an essential feature of the quantum formalism used in the applications outside of physics. In this session, the papers by Victor Cervantes and Ehtibar Dzhafarov and by Ru Zhang and Ehtibar Dzhafarov presented a series of experiments to test the existence of contextuality in psychology. Contextuality in database theory was also discussed by Peter Bruza and Samson Abramsky. Finally, some papers addressed modified theories of probability to model contextual phenomena, as, for example, Federico Holik et al.'s contribution on non-monotonic subadditive probabilities, and Mark Burgin's symmetric inflated (signed) probabilities, which may take values outside of the [0, 1] interval of standard probability theory.

From the 39 papers submitted to the conference, 21 were accepted, and are included in this volume. These 21 papers are based on the conference presentations, and incorporate feedback received not only by the peer-review process, but also during the talks. With the exception of the invited presentations and associated papers of Professors Bas van Fraassen and Pawel Kurzinsky, which were reviewed by the editors after the conference, each paper was single-blind peer-reviewed prior to the conference by at least two reviewers, and the conference presentations were based on the revised papers. We thank the Program Committee members for their timely and dedicated work

on reviewing the papers, a particularly daunting task, given the interdisciplinarity of the QI 2016 contributions.

This year we received many submissions of papers whose main authors were students or junior researchers. Owing to their high quality, the conference organizers created for the first time at the QI conference a best paper award by a student or young researcher. This year's recipients were Ru Zhang for Best Post-Doctoral/Young Researchers Paper Award, and Aditya Joshi for Best Undergraduate/Graduate Paper Award. We wish to congratulate both recipients, as well as the many other finalists, for submitting excellent papers to the conference.

We would like to thank the Downtown Campus staff of San Francisco State University, in particular Kasey Wood and Dania Russel, for their hospitality and help, which ensured the success of the conference. Alfred Hofmann and Anna Kramer at Springer provided support for the speedy publication of the proceedings in the Springer series *Lecture Notes in Computer Science*. We also thank the local Organizing Committee, Leonardo Paulo Guimarães De Assis (Stanford University) and Margarida Duque de Castela (SFSU), without whom the conference would not have worked smoothly. Finally, we thank the support of the School of Humanities and Liberal Studies, through its director, Professor Cristina Ruotolo, and of the College of Liberal and Creative Arts, San Francisco State University.

November 2016

J. Acacio de Barros
Emmanuel Pothos
Bob Coecke

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