

Dr. Peter M. Hines

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PROFILE **A well-established academic with international reputation and experience, working on the interface of computer science and mathematics.** Specialist in category theory and its applications in a range of fields, including the theory of computation, pure mathematics, quantum computing, linguistics, and logic.

Further academic experience and publications in cognitive science, information theory, and communication channels.

Experience teaching a range of subjects in computer science and mathematics. Significant success with grant applications in a collaborative setting. Track record of computer programming in both academic and commercial environments.

OCCUPATIONAL HISTORY **(2012 to present)** *University of York*
Researcher Co-Investigator in categorical linguistics and models of meaning.

(2010-2012)

Combining **childcare responsibilities** with a range of **teaching** and **research** roles:

- **2012 I.P. Lecturer** at US Naval Research Laboratory, Washington D.C., U.S.A.
- Active member of CAP quantum and logic **research network**.
- A variety of **single-course lecturing rôles** on graduate courses.

(2005-2010)

Researcher in quantum computation and foundations. *University of York*

(2002-2005)

Research Associate in the foundations of reversible and quantum computation. *Oxford University*

(2000-2002)

Self-employed programmer on a range of highly mathematical computing projects for commercial clients, including

- An aluminium refinery optimisation algorithm and program, for Rio-Tinto Zinc.
- A document management system and online learning environment, for BTC group consultants.

Further details available on request.

(1999-2000)

Research Assistant on an information theory project based in cognitive science. *University of Wales, Bangor*

- Mathematical models of unsupervised human classification,
- Algorithms for classifying data with non-metric distance functions,
- Computer programs (Matlab, C++) implementing these models and algorithms.

(1997-1999)

Tutor responsible for teaching undergraduate and graduate courses in a variety of of mathematical and computational subjects. *University of Wales, Bangor*

EDUCATION **PhD** Pure Mathematics

University of Wales, Bangor

Thesis title: The algebra of self-similarity and its applications

- Linear logic, Category theory, Inverse semigroup theory, Self-Similarity, Universal Algebra, Order theory.

MSc. Pure Mathematics *University of Wales, Bangor*
Thesis title: Racks and related structures in low-dimensional topology
 - Knot theory, Topology, Invariants, Self-distributive Algebras

BSc. Pure & Applied Mathematics *University of York*

TEACHING
EXPERIENCE

Lecturing, course and exam writing *University of York*
 - Quantum Computation, L^AT_EX, Discrete Mathematics for computer scientists, Introductory Logic, Propositional and Predicate Calculus, Categorical logic.

Demonstrating *Oxford University*
 - Artificial Intelligence, Category theory, Formal Program Verification, Game Semantics, Maple

Lecturing and demonstrating *University of Wales, Bangor*
 - Automata theory, Combinatorics, Statistics, Discrete mathematics, Introductory Computing, Mathematics for Computer Scientists, Parallel Computation, Programming (MatLab, LISP, Java, C, C++, 68000 assembler), Web-authoring.

SUCCESSFUL
GRANT
APPLICATIONS

A Unified Model of Compositional and Distributional Semantics **EPSRC**
 Named Research CoInvestigator
 - An investigation of the relationship between linguistics, grammar and meaning, based on category-theoretic semantics.
 - A joint project between the universities of Cambridge, Edinburgh, Oxford, Sussex and York.

Quantum Computation: Foundations, Security, Cryptography and Group Theory **EPSRC**
 Named Research Associate
 - A multi-site project on the interaction of quantum computation and information with other areas of mathematics and computing.
 - A collaboration between the universities of Herriot-Watt, Newcastle and York.

Foundational Structures for Quantum Information and Computation **EU FP6**
 Named Research Associate
 - A collaboration between a large number of EU sites, on the foundations of quantum computation and information.

Foundations of Quantum and Reversible Computation **LMS / MathFit**
 Named Research Assistant
 - A project, based at Oxford University, on the relationship between reversible and quantum computation.

PERSONNEL
RESPONSIBILITIES

Interview & Selection Panel for Postdoctoral Researchers
 - Evaluating candidates for posts on the Quantum Computation: Foundations, Security, Cryptography and Group Theory project.

Evaluation of grant and fellowship applications
 - Registered referee for grant applications in my specialist fields, for EPSRC.

Writing PhD and MSc. project descriptions
 - For both internal and external prospective students (University of York).

JOURNAL
INVOLVEMENT

Reviewer for *A.M.S. Mathematical Reviews*

Review Editor for *Frontiers in Cognitive Science*

Program Committee Member for *Samson60, A conference in honour of the 60th birthday of Samson Abramsky*

Referee for the following journals and conferences:

- *Computability in Europe, International Colloquium on Automata Languages and Programming, International Journal of Quantum Information, International Journal of Unconventional Computation, LMS Journal of Computation and Mathematics, Logic in Computer Science, Mathematical Foundations of Programming Semantics, Mathematical Structures in Computer Science, Non-Standard Computation, PRS (A), Reversible Computation, Theoretical Computer Science.*

VISITING
LECTURESHIPS,
AND INVITED
CONFERENCE
TALKS

I.P. Lecturer (2012) U.S. Naval Research Laboratory, Washington D.C.

- *A series of talks on topics of interest to US Naval Research*
- By request, the content of some of these talks is being expanded into a graduate-level text for **Morgan & Claypool Publishers**.

Analysis of Informatic Phenomena (2009) New Orleans, U.S.A.

- Talk title: *Using information theory to find hidden structure in datasets*

Mathematical Foundations of Program Semantics (2007) New Orleans, U.S.A.

- Talk title: *Towards a quantum machine semantics*

Logic In Computer Science (2007) Wroklaw, Poland

- Talk title: *Iteration in Models of Reversible Computation*

The Appendix **Invited talks** details a selection of other international invited talks, at a range of meetings and conferences, dating back to 2000

RESEARCH AND
KEY IDEAS

The following single-sentence summaries of aspects of my work are expanded upon in the appendices detailing peer-reviewed publications and invited talks.

- The algebra of fractals allows us to create untyped analogues of logical and computational systems.
- The ‘Geometry of Interaction’ representation of linear logic is based around an untyped form of categorical compact closure, and shares an underlying structure with the dynamics of Turing machines.
- The high-level vs. low-level comparison of computing devices provides a range of representations, from operational to denotational semantics, and the collection of all such representations forms a Scott domain.
- Category theory allows us to construct quantum circuits that provide a solution to Linden & Popescu’s ‘halting problem for QM programs’; such circuits also have an efficient implementation as simple optical circuits based on feedback.
- Information theory may be used to measure how well a clustering fits a data-set, even when the data in question does not have a metric distance function; such measures also provide noise-independent invariants of communication channels.
- Shor’s algorithm is based on an efficient decomposition, via categorical distributivity, of the $!()$ operator of linear logic.
- Categorical coherence theorems are equally applicable in typed and untyped settings; the two are related by a coherence theorem for self-similarity.

Appendix: Publications, Talks, and References

- PEER-REVIEWED PUBLICATIONS
- + **Peter Hines, M. V. Lawson**, An Application of Polycyclic Monoids to Rings *Semigroup Forum (56)* (1996) pp. 146-149
 - + **Peter Hines**, *The Algebra of Self-Similarity and its Applications* PhD Thesis, University of Wales, Bangor (1997)
 - + **Peter Hines**, The Categorical Theory of Self-Similarity, *Theory and Applications of Categories 6(3)* (1999) pp.33-46
 - + **Peter Hines**, A Short Note on Coherence and Self-Similarity, *Journal of Pure and Applied Algebra (175)* (2002) pp. 135-139
 - + **Peter Hines**, A Categorical Framework for Finite State Machines *Mathematical Structures in Computer Science (13)* (2003) pp. 451-480
 - + **Peter Hines**, Physical Systems as Constructive Logics, in *Unconventional Computation, C. Calude et. al (ed.s), Springer LNCS* (2006) pp.101-112
 - + **Peter Hines, E. Pothos, N. Chater**, A Non-Parametric Approach to Simplicity Clustering, *Applied Artificial Intelligence 21(8)* (2007) pp. 729-752
 - + **Peter Hines**, Machine Semantics, *Theoretical Computer Science 409(1)* (2008) pp. 1-23
 - + **Peter Hines**, Machine Semantics: From Causality to Computational Models, *International Journal of Unconventional Computation 4(3)* (2008) pp. 249-272
 - + **E. Pothos, A. Perlman, D. Edwards, T. Gureckis, P. Hines, N. Chater** Modelling Category Intuitiveness, *Cognitive Science Journal* (2008) pp. 415-420
 - + **Peter Hines, S. Braunstein** The Structure of Partial Isometries, in, *Semantic Techniques in Quantum Computation, Cambridge University Press* (2010) pp.361-389
 - + **Peter Hines** Quantum circuit oracles for Abstract Machine computations, *Theoretical Computer Science 411* (2010) pp. 1501-1520
 - + **E. Pothos, N. Chater, P. Hines** The simplicity model of unsupervised categorization, in *Formal Models of Categorization, A. Mills & E. Pothos (ed.s)* (2010) Cambridge University Press
 - + **Peter Hines** Can a quantum computer run the von Neumann architecture? in *B. Coecke (ed.) New Structures for Physics, Lect. Notes Phys. 813, Springer Berlin* (2011) pp.941-978
 - + **V. Kendon, A. Sebald, S. Stepney, M. Bechmann, P. Hines, R. Wagner** Heterotic Computing, *Unconventional Computation 2011, Turku, Finland. Springer L.N.C.S. 6714* (2011) pp. 113-124
 - + **E. Pothos, A. Perlman, T. Bailey, K. Kurtz, D. Edwards, P. Hines, J. McDonnell** Measuring category intuitiveness in unconstrained categorization tasks *Cognition 121(1)* (2011) pp.83-100
 - + **Peter Hines, P. Scott** Categorical traces from single-photon linear optics, in *S. Abramsky, M. Mislove (ed.s), AMS Proceedings of Symposia in Applied Mathematics (vol. 71)* (2012) pp. 89-124
 - + **S. Stepney, V. Kendon, P. Hines, A. Sebald** A framework for Heterotic Computing *8th workshop on quantum physics and logic (QPL 2011), Nijmegen, Netherlands, ETPCS (95)* (2012) pp. 263-273

- + **Peter Hines** A categorical analogue of the monoid semiring construction, *Mathematical Structures in Computer Science* 23(1), (2013) pp. 55-94
 - + **Peter Hines** Types and forgetfulness in categorical linguistics and quantum mechanics, in *C. Heunen, M. Sadrzadeh, E. Grefenstette (ed.s), Quantum Physics and Linguistics: a compositional diagrammatic discourse*, Oxford University Press (2013) pp. 1-34
 - + **Peter Hines** Quantum speed-up and categorical distributivity, in *B. Coecke, L. Ong, and P. Panangaden (Eds.) Abramsky Festschrift, LNCS 7860*, pp. 122-138 (2013)
 - + **Peter Hines** Modular Arithmetic Identities from Untyped Categorical Coherence, *proc. RC2013, to appear*
- PUBLICATIONS UNDER REVIEW
- + **Peter Hines** Coherence in Hilbert's Hotel
 - + **Peter Hines** Classical structures based on unitaries *Invited contribution for Lambek Festschrift*
- WORKS IN PROGRESS
- + **Peter Hines** Theoretical Computer Science for Quantum Computer Scientists *Invited book for Morgan & Claypool Publishers*
 - + **C. Heunen, P. Hines, P. Panangaden** An Untyped Geometry of Interaction Construction
 - + **Peter Hines, Keye Martin** An Affine Category of Timed Communication Channels
 - + **Peter Hines** Grammar as a Type Theory for Meaning
- REFERENCED MANUSCRIPTS
- (The following unpublished manuscripts have been referenced by other authors. The material they contain has since appeared in my published work; however, the correspondence is not one-to-one. Please contact me with any questions about these manuscripts).*
- + **Peter Hines** A one-object inverse compact closed category used in the Geometry of Interaction (1996)
 - + **Peter Hines** A hierarchy of finite state machines and their algebraic models (2000)
 - + **P. Hines, P. Scott** Conditional quantum iteration from categorical traces (2006)
 - + **P. Hines** A constructive decision procedure for commutativity of untyped canonical diagrams (2012)
- INVITED TALKS
- A selection of national and international invited talks.*
- **Oxford, U.K.** Categorical coherence in the untyped setting *Abramsky FestSchrift* (2013)
 - **Oxford, U.K.** Reconsidering MacLane: Coherence for associativity in untyped and infinitary settings *OASIS seminar - Joint Mathematics / C.S. invited talk* (2013)
 - **Sussex, U.K.** Logic, Meaning, and Grammar *Dept. Computer Science, invited talk* (2013)
 - **Leibniz-Zentrum für Informatik, Germany** Categorical coherence in Hilbert's hotel *Dagstuhl Seminar: Informatic Phenomena*, (2012)
 - **Washington D.C., USA** Informatic Phenomena Lecture Series *U.S. Naval Research Laboratories* (2012)

- **York, U.K** Information theory: from cognitive science to communication channels *Computer Science Departmental Seminar* (2011)
- **Newcastle, U.K** The category theory of Shor's algorithm *Mathematics Departmental Seminar* (2011)
- **Oxford, U.K.** Types in models of meaning (and elsewhere) *Categorical Methods for Information Flow Conference* (2010)
- **Leibniz-Zentrum für Informatik, Germany** Quantum oracles for space-bounded Turing machines *Dagstuhl Seminar: Semantics of Information* (2010)
- **Oxford, U.K.** Is (categorical) coherence important in quantum computation and information? *QICS Summer School* (2010)
- **Oxford, U.K.** A tale of two programming styles: Comparing quantum and classical approaches to the same problem *QNET Workshop* (2009)
- **New Orleans, U.S.A.** Using information theory to find hidden structure in datasets *Analysis of Informatic Phenomena* (2009)
- **Obergurgl, Austria** Category theory and quantum logic *Foundational Structures for Quantum Information and Computation* (2008)
- **New Orleans, U.S.A.** Towards a quantum machine semantics: *M.F.P.S., Physics, Computation, and Information* (2007)
- **Wroclaw, Poland** The inverse and the trace - iteration in models of reversible computing *L.I.C.S.* (2007)
- **Leibniz-Zentrum für Informatik, Germany** The order theory of iteration *Computational Structures for Modeling Time, Space, and Causality* (2006)
- **York, U.K.** Planar two-way automata - from inverse semigroups to the quantum Jones polynomial *FountainFest: Semigroups, Categories & Automata, in honour of J. Fountain* (2006)
- **Marseille, France** Compact closed monoids - definitions and constructions *GeoCal Semantics Workshop on Geometry of Interaction* (2006)
- **Paris, France** Reversibility and coherence between computational paths *Institut Henri-Poincare* (2006)
- **Bellairs, Barbados** Random thoughts on abstract machines *Categorical Quantum Information, Bellairs Research Institute, McGill University* (2006)
- **London, U.K.** Quantum data and code in computer architectures *QUOXIC seminar, Imperial College* (2004)
- **Ottawa, Canada** The zoology of quantum computers - classical and quantum control structures & data *Fields Institute Summer School* (2003)
- **Oxford, U.K.** Kleene's theorem, star-free languages, and the Geometry of Interaction *Oxford Informatic Seminars* (2000)

REFERENCES

As well as the references provided, the contact details of several well-established academics in appropriate fields, willing to provide additional references, are available on request.