Brandon Shapiro

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Research Interests

Higher categories, algebraic K-theory, applied category theory, combinatorial homotopy theory.

I am especially interested in algebraic higher category structures with arbitrary cell shapes, the K-theory of finite sets, combinatorial and algebraic models for the homotopy theory of spaces and (∞, n)-categories, generalized frameworks for K-theory, and polynomial functors as a formalism for open dynamics and category theory.

Employment

2023-Present **Whyburn Research Associate and Lecturer**, *University of Virginia*, Charlottesville, VA.

2022-2023 **Research Associate**, *Topos Institute*, Berkeley, CA.

Education

2022 **PhD in Mathematics**, *Cornell Unversity*, Advisor: Inna Zakharevich.
Thesis: Shape Independent Category Theory.

2019 **Master of Science in Computer Science**, *Cornell Unversity.*

2017 **Bachelor of Arts with Highest Honors in Mathematics**, *Brandeis University.*

2017 **Bachelor of Science in Computer Science**, *Brandeis University.*

2017 **Bachelor of Arts in Physics**, *Brandeis University.*

2016 **Brandeis India Science Scholars Program**, *Indian Institute of Science.*

Honors and Awards

2021 **Bättig Prize for Excellence and Promise in Mathematics**, Cornell University.

2017-2021 **National Defense Science & Engineering Graduate Fellowship**.

2017 **Summa Cum Laude**, Brandeis University.

2017 **Arnold Shapiro Prize in Mathematics**, Brandeis University.

2017 **Michtom Prize in Computer Science**, Brandeis University.

2016 **Phi Beta Kappa**, Brandeis University Chapter, Junior Year Inductee.

2016 **Outstanding Presentation Award**, MAA MathFest 2016.

2013 **Presidential Merit Scholarship**, Brandeis University.

2013 **National Merit Scholarship**, Brandeis University.

Papers

2023 **All Concepts are $\mathbb{C}\mathrm{at}^{\#}$.** *Preprint*. With David Spivak. [arXiv:2305.02571]

2023 **Structures in Categories of Polynomials.** *Submitted for publication*. With David Spivak. [arXiv:2305.00167]

2023 **A Compositional Account of Motifs, Mechanisms, and Dynamics in Biochemical Regulatory Networks.** *Submitted for publication*. With Rebekah Aduddell, James Fairbanks, Amit Kumar, Pablo Ocal, and Evan Patterson. [arXiv:2301.01445]

2022 **Duoidal Structures for Compositional Dependence.** *Submitted for publication*. With David Spivak. [arXiv:2210.01962]

2022 **Dynamic Operads, Dynamic Categories: From Deep Learning to Prediction Markets.** *Electronic Proceedings in Theoretical Computer Science*, 2022. With David Spivak. [arXiv:2205.03906]

2022 **A Shape Independent Theory of Enrichment.** *Preprint*. [arXiv:2205.12235]

2021 **Familial Monads as Higher Category Theories.** *Preprint*. [arXiv:2111.14796]

2021 **A Gillet-Waldhausen Theorem for Chain Complexes of Sets.** *Submitted for publication*. With Maru Sarazola. [arXiv:2107.07701]

2021 **Weak Cartesian Properties of Simplicial Sets.** *Journal of Homotopy and Related Structures*, 18, **477-520**, 2023. With Carmen Constantin, Tobias Fritz, and Paolo Perrone. [arXiv:2105.04775]

2021 **Partial Evaluations and the Compositional Structure of the Bar Construction.** *Theory and Applications of Categories*, Vol. 39, No. 11, **322-364**, 2023. With Carmen Constantin, Tobias Fritz, and Paolo Perrone. [arXiv:2009.07302]

2018 **Densities of Hyperbolic Cusp Invariants.** *Proceedings of the American Mathematical Society*, Volume 146, Number 9, **4073-4089**, 2018. With Colin Adams, Rose Kaplan-Kelly, Michael Moore, Shruthi Sridhar, and Josh Wakefield. [arXiv:1701.03479]

2017 **specgen: A Tool for Modeling Statecharts in CSP.** *Nasa Formal Methods* **282**, 2017. With Chris Casinghino.

2016 **Nonstandard Neutrino Interactions In Supernovae.** *Physical Review D* **94**, 093007, 2016. With C.J. Stapleford, D.J. Väänänen, J.P. Kneller, and G.C. McLaughlin. [arXiv:1605.04903]

Event Organizing

2023 **Special Session on Category Theory and Machine Learning.** CALCO, Bloomington.

Conference Talks

2023 **Finite Posets as Algebraic Expressions in Duoidal Categories.** Category Theory OctoberFest, Online.

2023 **A Dynamic Monoidal Category for Deep Learning.** CALCO, Bloomington.

2022 **Polynomial Functors for Categorical Open Dynamics.** Joint Math Meetings, Special Session on Applied Category Theory, Boston.

2022 **Double Presheaf Categories via Polynomial Functors.** Virtual Double Categories Workshop, Online.

2022 **Dynamic Operads for Evolving Organizations.** Applied Category Theory, Glasgow.

2022 **Familial Monads for Higher and Lower Category Theory.** Workshop on Polynomial Functors, Online.

2021 **Compositional Structure of Partial Evaluations.** Categories and Companions Symposium, Online.

2019 **Shape Independent Category Theory.** Category Theory OctoberFest, Baltimore.

2019 **Types as Weak ω-Groupoids.** School and Workshop on Univalent Foundations, Birmingham.

2018 **Cell Shapes for Higher Structures.** Young Topologists Meeting, Copenhagen.

2016 **The Geometry of Knots.** With S. Sridhar. MAA MathFest, Columbus.

2016 **Cusp Density: Dense or Knot?** Unknot III, Columbus.

Seminar and Colloquium Talks

2023 **Higher Category Theory in $\mathbb{C}\mathrm{at}^{\#}$.** Topos Institute Colloquium, Online.

2023 **Combinatorial Homological Algebra and K-Theory.** University of Minnesota Topology Seminar.

2020 **Compositional Structure of Partial Evaluations.** MIT Categories Seminar, Online.

2020 **Cubical ω-Categories and Cubical Θ.** MSRI Cubical Sets Seminar, Online.

2020 **Test Category Structure of Cubes.** MSRI Cubical Sets Seminar, Online.

2020 **Constructing Cubes from Semicubes.** MSRI Cubical Sets Seminar, Online.

Teaching

2023 **Differential Geometry**, *University of Virginia*, Math 1110

2023 **Geometry Lab Mentor**, *University of Virginia*, Zome geometry group

2020-2022 **Directed Reading Program Mentor**, *Cornell University*

2021 **Calculus I**, *Cornell University*, Math 1110

2019 **Applied Linear Algebra (Teaching Assistant)**, *Cornell University*, Math 2310

2018 **Geometric Group Theory (Teaching Assistant)**, *Cornell University*, Math 4560

2016 **Discrete Math (Teaching Assistant)**, *Brandeis University*, COSI 29a

2015 **Java Programming (Teaching Assistant)**, *Brandeis University*, COSI 12b

2015 **Java Programming (Tutor)**, *Brandeis University*, COSI 12b

Workshop Participation

2023 **Workshop on $(\infty, 2)$-Categories**, *Online*, Mentor

2023 **Math and Metaphysics Symposium**, *Austin, TX*, Presenter

2023 **Finding the Right Abstractions for Healthy Systems**, *Bodega Bay, CA*

2021 **Equivariant Algebra Seminar**, *eCHT*, Presenter

2019 **Applied Category Theory Adjoint School & Workshop**, *University of Oxford*

2019 **School & Workshop on Univalent Foundations**, *University of Birmingham*

2018 **Homotopy Theory Summer**, *Berlin Mathematical School*

2018 **Talbot Workshop**, *Govt. Camp, OR*, Model Independent ∞-Category Theory

2016 **SMALL REU**, *Williams College*, Hyperbolic Knot Theory Group

2015 **Internship Project**, *Draper Laboratories*, Formal Methods Group

2014 **Computational Astrophysics REU**, *North Carolina State University*

Local Seminars

2023 **Topology Seminar**, *University of Virginia*, Presenter

2022-2023 **Berkeley Seminar**, *Topos Institute*, Organizer, Presenter

2018-2022 **Homotopy Group**, *Cornell University*, Organizer, Presenter

2017-2022 **Topology Seminar**, *Cornell University*, Presenter

2020 **Logic Seminar**, *Cornell University*, Presenter

2019 **"What is...?" Seminar**, *Cornell University*, Organizer

2018 **∞-Category Theory Reading Group**, *Cornell University*, Presenter
2018 **Homotopy Type Theory Group**, *Cornell University*, Organizer, Presenter
2017-2022 **Olivetti Club**, *Cornell University*, Presenter
2016-2017 **Floer Homology Group**, *Brandeis University*
2015 **Haskell and Type Theory Group**, *Brandeis University*

Extracurricular

2020 **Julia Robinson Math Festival Volunteer**, *Cornell University*
2018-2022 **Incoming Graduate Student Mentor**, *Cornell University*
2018-2022 **Class Representative**, *Cornell University*
2018 **Math Department Spring Concert Organizer**, *Cornell University*
2018 **Guest Speaker on College Math**, *Walt Whitman High School*
2016-2017 **Math Club Founder and President**, *Brandeis University*
2015-2017 **Undergraduate Mathematics Department Representative**, *Brandeis University*