

# 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  $(\infty, n)$ -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 University*, Advisor: Inna Zakharevich.  
Thesis: Shape Independent Category Theory.

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

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

2024 **All Concepts are  $\mathbb{C}at^\#$** . *Preprint*. With Owen Lynch and David Spivak. [[arXiv:2305.02571](https://arxiv.org/abs/2305.02571)]

2024 **A Polynomial Construction of Nerves for Higher Categories**. *Preprint*. With David Spivak. [[arXiv:2405.13157](https://arxiv.org/abs/2405.13157)]

2023 **Structures in Categories of Polynomials**. *Submitted for publication*. With David Spivak. [[arXiv:2305.00167](https://arxiv.org/abs/2305.00167)]

- 2023 **A Compositional Account of Motifs, Mechanisms, and Dynamics in Biochemical Regulatory Networks.** *Compositionality* 6, 2, 2024. 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 **Enrichment of Algebraic Higher Categories.** *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](#)]
- 2020 **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](#)]
- 2016 **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](#)]
- 2016 **specgen: A Tool for Modeling Statecharts in CSP.** *Nasa Formal Methods* 282, 2017. With Chris Casinghino.
- 2015 **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

- 2024 **Homotopy Theory of Double Categories for Algebraic  $K$ -Theory.** AMS Spring Southeastern Sectional Meeting, Tallahassee.
- 2024 **CGW Categories.** Workshop on Higher Segal Spaces and their Applications to Algebraic  $K$ -Theory, Hall Algebras, and Combinatorics, BIRS.
- 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  $\omega$ -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  $\text{Cat}^\#$ .** 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  $\omega$ -Categories and Cubical  $\Theta$ .** 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

- 2024 **Polynomial Functors at Work,** *Topos Institute*
- 2023 **Workshop on  $(\infty, 2)$ -Categories,** *Online*, Mentor
- 2023 **Talbot Workshop,** *Online*, Scissors Congruence  $K$ -Theory
- 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  $\infty$ -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
- 2024 **Spectra Reading Group**, *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  **$\infty$ -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*