

Brandon T. Shapiro

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Research Interests

Combinatorial approaches to topology, geometry, K -theory, higher categories, and applied 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*.

Papers

2024 **A combinatorial construction of homology via ACGW categories**. *Submitted for publication*. With Maru Sarazola and Inna Zakharevich. [\[arXiv:2410.00276\]](https://arxiv.org/abs/2410.00276)

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

2024 **A Polynomial Construction of Nerves for Higher Categories**. *Submitted for publication*. 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. [\[arXiv:2301.01445\]](https://arxiv.org/abs/2301.01445)

2022 **Duoidal Structures for Compositional Dependence**. *Submitted for publication*. With David Spivak. [\[arXiv:2210.01962\]](https://arxiv.org/abs/2210.01962)

2022 **Dynamic Operads, Dynamic Categories: From Deep Learning to Prediction Markets**. *Electronic Proceedings in Theoretical Computer Science*, 2022. With David Spivak. [\[arXiv:2205.03906\]](https://arxiv.org/abs/2205.03906)

2022 **A Gillet-Waldhausen Theorem for Chain Complexes of Sets**. *Submitted for publication*. With Maru Sarazola. [\[arXiv:2107.07701\]](https://arxiv.org/abs/2107.07701)

2022 **Enrichment of Algebraic Higher Categories**. *Preprint*. [\[arXiv:2205.12235\]](https://arxiv.org/abs/2205.12235)

2021 **Familial Monads as Higher Category Theories**. *Preprint*. [\[arXiv:2111.14796\]](https://arxiv.org/abs/2111.14796)

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. [\[arXiv:2105.04775\]](https://arxiv.org/abs/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](#)]

Teaching

- 2024 **Algebraic Topology II**, *University of Virginia*, Math 7810
- 2024 **Linear Algebra**, *University of Virginia*, Math 3351, 2 sections
- 2023 **Differential Geometry (undergraduate)**, *University of Virginia*, Math 4720
- 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, Tutor)**, *Brandeis University*, COSI 12b

Mentorship

- 2024 **Peer Mentoring Initiative**, *University of Virginia*, Organizer and mentor
Students at different career stages are paired with more experienced students or postdocs for meetups and mentorship.
- 2024 **REU Mentor**, *University of Virginia*, Categorical tiling theory
Lead a group of undergraduates pursuing original research over the summer on a categorical approach to combinatorial geometry.
- 2023-Present **Geometry Lab Mentor**, *University of Virginia*, Zome geometry group
Leading a group of beginning undergraduates in semester-long exploratory projects.
- 2023 **Workshop on $(\infty, 2)$ -Categories**, *Online*
Mentored a student in preparation for an expository talk based on a research paper.
- 2020-2022 **Directed Reading Program**, *Cornell University*
Mentored three undergraduates in projects on constructive type theory, categorical algebra, and combinatorial topology.
- 2020 **Julia Robinson Math Festival Volunteer**, *Cornell University*

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.

--- 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 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 $\mathbb{C}at^\#$** . 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.

--- Workshop Participation

2024 **Polynomial Functors at Work**, *Topos Institute*
 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 ∞ -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 **∞ -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*