

February 20, 2024

MATTHEW HARRISON-TRAINOR

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RESEARCH INTERESTS

Mathematical logic and computability theory. I am interested in understanding and measuring complexity in mathematics from a computability-theoretic viewpoint.

EDUCATION

Ph.D. in Logic and the Methodology of Science. University of California, Berkeley, 2017.
Advisor: Antonio Montalbán. Thesis title: *The Complexity of Countable Structures*.

B.Math in Pure Mathematics. University of Waterloo, 2012.

EMPLOYMENT (POST PHD)

2023–current. **Assistant Professor** at the University of Illinois Chicago.

2021–2023. **Donald J. Lewis Research Assistant Professor** at the University of Michigan.

2018–2021. **Post-doctoral Fellow** at Victoria University of Wellington, New Zealand (with Rod Downey and Noam Greenberg) and Massey University, New Zealand (with Alexander Melnikov).

2017–2018. **Banting Post-doctoral Fellow** at the University of Waterloo, Canada (with Barbara Csima).

GRANTS

NSF Grant 2022-2025. DMS-2153823.

HONORS, AWARDS, AND FELLOWSHIPS

Alfred P. Sloan Research Fellowship 2024. Awarded to early-career researchers whose creativity, innovation, and research accomplishments make them stand out as the next generation of leaders.

Sacks Prize 2017. Awarded by the Association for Symbolic Logic for the most outstanding thesis in mathematical logic worldwide.

Herb Alexander Prize 2017. Awarded for an outstanding dissertation in pure mathematics at the University of California, Berkeley.

Banting Post-doctoral Fellowship 2017. Canada's most prestigious post-doctoral fellowship. Awarded to the top seventy applicants in all areas of research across Canada.

Outstanding Graduate Student Instructor Award 2016. University of California, Berkeley.

NSERC Postgraduate Scholarship (Doctoral) 2014. Awarded to the top Canadian Ph.D. students in the natural sciences and engineering.

NSERC Julie Payette Research Scholarship 2012. The most prestigious NSERC scholarship at the Master's level; awarded to twenty-four Masters and Ph.D. students across Canada in the natural sciences and engineering.

Berkeley Fellowship 2012. Awarded to the top 4% of applicants to doctoral programs in all fields.

Alumni Gold Medal (Faculty of Mathematics) 2012. Awarded to one graduating student in each faculty at the University of Waterloo in recognition of their academic achievements.

Jessie W.H. Zou Memorial Award for Excellence in Undergraduate Research 2012. Awarded to one undergraduate student for excellence in research at the University of Waterloo.

Mike Vangoch Memorial Scholarship 2012. Awarded annually to an outstanding fourth-year undergraduate student in Pure Mathematics.

Edwin Anderson National Scholarship 2008. One of sixteen national scholarships awarded to entering students in the Faculty of Mathematics at the University of Waterloo.

PUBLICATIONS

1. *Two results on complexities of decision problems of groups* (with Uri Andrews and Meng-Che Ho).
Submitted for publication.
2. *An effective classification of Borel Wadge classes* (with Adam Day, Noam Greenberg, and Dan Turetsky).
Submitted for publication.
3. *The logic of cardinality comparison without the axiom of choice* (with Dhruv Kulshreshtha).
Submitted for publication.
4. *There is no simple characterization of the relatively decidable theories*.
Submitted for publication.
5. *Describing finitely presented algebraic structures*.
Submitted for publication.
6. *A representation theorem for possibility models*.
Submitted for publication.
7. *Coding information into all infinite subsets of a dense set* (with Lu Liu and Patrick Lutz).
Israel Journal of Mathematics, to appear.
8. *Iterated priority arguments in descriptive set theory* (with Adam Day, Noam Greenberg, and Dan Turetsky).
Bulletin of Symbolic Logic, to appear.
9. *An arithmetic analysis of closed surfaces* (with Alexander Melnikov).
Transactions of the AMS, to appear.
10. *Infinitary logic has no expressive efficiency over finitary logic* (with Miles Kretschmer).
Journal of Symbolic Logic, to appear.
11. *Enumerations of families closed under finite differences* (with Noam Greenberg, Joe Miller, and Dan Turetsky).
Computability, to appear.
12. *Computable Stone spaces* (with Nikolay Bazhenov and Alexander Melnikov).
Annals of Pure and Applied Logic, 174 (2023), no. 9, 103304, 25 pp.
13. *Which classes of structures are both pseudo-elementary and $\mathcal{L}_{\omega_1\omega}$ -elementary?* (with Will Boney, Barbara Csima and Nancy Day).
Bulletin of Symbolic Logic, 29 (2022), no. 1, 1–18.
14. *The tree of tuples of a structure* (with Antonio Montalbán).
Journal of Symbolic Logic, 87 (2022), no. 1, 21–46.
15. *An analysis of random elections with large numbers of voters*.
Mathematical Social Sciences 116 (2022), 68–84.
16. *A minimal set low for speed* (with Rod Downey).
Journal of Symbolic Logic, 87 (2022), no. 4, 1693–1728.
17. *An introduction to the Scott complexity of countable structures and a survey of recent results*.
Bulletin of Symbolic Logic, 28 (2022), no. 1, 71–103.
18. *Some questions of uniformity in algorithmic randomness* (with Laurent Bienvenu and Barbara Csima).
Journal of Symbolic Logic, 86 (2021), no. 4, 1612–1631.
19. *Relationships between computability-theoretic properties of problems* (with Rod Downey, Noam Greenberg, Ludovic Patey, and Dan Turetsky).
Journal of Symbolic Logic, 87 (2022), no. 1, 47–71.

20. *Computing sets from all infinite subsets* (with Noam Greenberg, Ludovic Patey, and Dan Turetsky). **Transactions of the AMS**, 374 (2021), 8131–8160.
21. *Scott complexity of countable structures* (with Rachael Alvir, Noam Greenberg, and Dan Turetsky). **Journal of Symbolic Logic**, 86 (2021), no. 4, 1706–1720.
22. *Non-density in punctual computability* (with Noam Greenberg, Alexander Melnikov, and Dan Turetsky). **Annals of Pure and Applied Logic**, 172 (2021), no. 9, 102985, 17 pp.
23. *Relativizing computable categoricity* (with Rod Downey and Alexander Melnikov). **Proceedings of the AMS**, 149 (2021), no. 9, 3999–4013.
24. *The property “arithmetic-is-recursive” on a cone* (with Uri Andrews and Noah Schweber). **Journal of Mathematical Logic**, 21 (2021), no. 3, 2150021.
25. *Finitely generated groups are universal among finitely generated structures* (with Meng-Che Ho). **Annals of Pure and Applied Logic**, 172 (2021), no. 1, 102855, 21 pp.
26. *Computability up to homeomorphism* (with Alexander Melnikov and Keng Meng Ng). **Journal of Symbolic Logic**, 85 (2020), no. 4, 1664–1686.
27. *The logic of comparative cardinality* (with Yifeng Deng and Wesley Holliday). **Journal of Symbolic Logic**, 85 (2020), no. 3, 972–1005.
28. *Graphs are not universal for online computability* (with Rod Downey, Iskander Kalimullin, Alexander Melnikov, and Daniel Turetsky). **Journal of Computing and System Sciences**, 112 (2020), 1–12.
29. *Degrees of categoricity above limit ordinals* (with Barbara Csima, Michael Deveau, and Mohammad Hamdy). **Computability**, 9 (2020), no. 2, 127–137.
30. *Optimal bounds for single-source Kolmogorov extractors* (with Laurent Bienvenu and Barbara Csima). **Transactions of the AMS**, 373 (2020), no. 3, 1983–2006.
31. *First-order possibility models and finitary completeness proofs*. **Review of Symbolic Logic**, 12 (2019), no. 4, 637–662.
32. *Automatic and polynomial-time algebraic structures* (with Nikolay Bazhenov, Iskander Kalimullin, Alexander Melnikov, and Keng Meng Ng). **Journal of Symbolic Logic**, 84 (2019), no. 4, 1630–1669.
33. *Constructing decidable graphs from decidable structures* (with Nikolay Bazhenov). **Algebra and Logic**, 58 (2019), no. 5, 369–382.
34. *Characterizations of cancellable groups* (with Meng-che Ho). **Proceedings of the AMS**, 147 (2019), no. 8, 3533–3545.
35. *Effective aspects of algorithmically random structures* (with Bakh Khossainov and Daniel Turetsky). **Computability**, 8 (2019), no. 3-4, 359–375.
36. *A first-order theory of Ulm type*. **Computability**, 8 (2019), no. 3-4, 347–358.
37. *There is no classification of the decidable presentable structures*. **Journal of Mathematical Logic**, 18 (2018), no. 2.
38. *Borel functors and infinitary interpretations* (with Russell Miller and Antonio Montalbán). **Journal of Symbolic Logic**, 83 (2018), no. 4, 1434–1456.
39. *On optimal Scott sentences of finitely generated algebraic structures* (with Meng-Che Ho). **Proceedings of the AMS**, 146 (2018), no. 10, 4473–4485.
40. *Degree spectra of relations on a cone*. **Memoirs of the AMS**, 253 (2018), no. 1208.
41. *Computable valued fields*. **Archive for Mathematical Logic**, 57 (2018), no. 5–6, 473–495.
42. *Some new computable structures of high rank* (with Gregory Igusa and Julia Knight). **Proceedings of the AMS**, 146 (2018), no. 7, 3097–3109.

43. *Scott ranks of models of a theory.*
Advances in Mathematics, 330 (2018), 109–147.
44. *Left-orderable computable groups.*
Journal of Symbolic Logic, 83 (2018), no. 1, 237–255.
45. *Inferring probability comparisons* (with Wesley Holliday and Thomas Icard).
Mathematical Social Sciences, 91 (2018), 62–70.
46. *On computable field embeddings and difference closed fields* (with Alexander Melnikov and Russell Miller).
Canadian Journal of Mathematics, 69 (2017), no. 6, 1338–1363.
47. *The Gamma question for many-one degrees.*
Annals of Pure and Applied Logic, 168 (2017), no. 7, 1396–1405.
48. *Preferential structures for comparative probabilistic reasoning* (with Wesley Holliday and Thomas Icard).
AAAI, (2017), 1135–1141.
49. *Computable functors and effective interpretability* (with Alexander Melnikov, Russell Miller, and Antonio Montalbán).
Journal of Symbolic Logic, 82 (2017), no. 1, 77–97.
50. *Degrees of categoricity on a cone via η -systems* (with Barbara Csima).
Journal of Symbolic Logic, 82 (2017), no. 1, 325–346.
51. *A note on cancellation axioms for comparative probability* (with Wesley Holliday and Thomas Icard).
Theory and Decision, 80 (2016), no. 1, 159–166.
52. *Independence in computable algebra* (with Alexander Melnikov and Antonio Montalbán).
Journal of Algebra, 443 (2015), 441–468.
53. *Differential-algebraic jet spaces preserve internality to the constants* (with Zoé Chatzidakis and Rahim Moosa).
Journal of Symbolic Logic, 80 (2015), no. 3, 1022–1034.
54. *Nonstandard methods for bounds in differential polynomial rings* (with Jack Klys and Rahim Moosa).
Journal of Algebra, 360 (2012), 71–86.

INVITED TALKS

1. **Computability in Europe.** Amsterdam, Netherlands. July 2024 (upcoming). (**Tutorial.**)
2. **Logic Colloquium.** Gothenburg, Sweden. June 2024 (upcoming).
3. **AMS Spring Eastern Sectional Meeting.** Washington, DC. April 2024 (upcoming).
4. **Joint Math Meetings.** San Francisco, CA. January 2024. (**ASL Invited Lecture.**)
The Complexity of Classifying Topological Spaces.
5. **Ohio State University Logic Seminar,**
The Beginnings of a Scott Analysis of Topological Spaces.
6. **Midwest Computability Seminar.** Chicago, IL. May 2023.
True stages and descriptive set theory.
7. **Notre Dame Logic Seminar.** South Bend, IN. April 2023.
The complexity of homeomorphism classes.
8. **Southeastern Logic Symposium.** Gainesville, FL. March 2023. (**Plenary talk.**)
Properties expressible simultaneously in two different logical forms.
9. **CMU Mathematical Logic Seminar.** Pittsburgh, PA. October 2022 (online).
Computable approximations and true stages.
10. **Models and Computability: The Mathematics of Julie Knight.** South Bend, IN. October 2022.
Describing algebraic structures.
11. **XIX Simposio Latinoamericano de Lógica Matemática.** Costa Rica. July 2022.
To what extent do structural properties and computational properties coincide?

12. **ASL North American Annual Meeting.** Ithaca, NY. April 2022.
How hard is it to find an atlas for a surface?
13. **ASL North American Annual Meeting.** Ithaca, NY. April 2022.
Lowness notions in computer science.
14. **New directions in computability theory.** CIRM. March 2022.
Coding in structures.
15. **Southeastern Logic Symposium.** Gainesville, FL. March 2022 (hybrid).
How hard is it to find an atlas for a surface?
16. **Midwest Computability Seminar.** February 2022 (online).
Kolmogorov extractors and evenly-distributed hypergraphs.
17. **Logical Foundations of Computer Science.** January 2022 (online).
Extracting randomness and evenly distributed hypergraphs.
18. **The Great Mathematical Workshop.** Novosibirsk, Russia. August 2021 (online).
Coding into metric spaces is difficult.
19. **Joint Mathematics Meeting Special Session on Computability Theory and Effective Mathematics.** January 2021 (online).
Computing sets from all infinite subsets.
20. **Berkeley Logic Colloquium.** Berkeley, CA. October 2020 (online).
Scott complexity of countable structures.
21. **The First Workshop at the Mathematical Center in Akademgorodok.** July 2020 (online).
Analysing the Complexity of Characterization and Classification Problems.
22. **Computability Theory and Applications Online Seminar.** May 2020 (online).
The tree of tuples of a structure.
23. **UC Berkeley Computability Seminar.** Berkeley, California. October 2019.
Introreducibility.
24. **University of Waterloo Computability Seminar.** Waterloo, Canada. October 2019.
Introreducibility.
25. **Logic Colloquium.** Prague, Czech Republic. August 2019. **(Plenary talk.)**
Describing Countable Structures.
26. **Malcev Meeting.** Novosibirsk, Russia. August 2019. **(Plenary talk.)**
The Complexity of Classifications and Descriptions.
27. **University of Wisconsin–Madison Logic Seminar.** Madison, WI. March 2018.
There is no natural construction of a structure of Scott rank ω_1^{CK} .
28. **Oberwolfach Workshop on Computability Theory.** Oberwolfach, Germany. January 2018.
When is a property expressed in infinitary logic also pseudo-elementary?
29. **Notre Dame Logic Seminar.** South Bend, IN. November 2017.
When is a property expressed in infinitary logic also pseudo-elementary?
30. **New England Recursion and Definability Seminar.** Wellesley, MA. October 2017.
Scott ranks of computable structures.
31. **Mid-Atlantic Mathematical Logic Seminar.** New York, NY. October 2017.
Some computable structure theory of finitely generated structures.
32. **Cornell Logic Seminar.** Ithaca, NY. October 2017.
*Some computable structure theory of finitely generated structures.
Scott ranks of computable structures.*
33. **Aspects of Computation.** Singapore. September 2017.
Some computable structure theory of finitely generated structures.
34. **UCLA Logic Seminar.** Los Angeles, CA. May 2017.
Describing finitely generated structures.

35. **AMS Spring Central Sectional Meeting.** Bloomington, IN. April 2017.
Optimal Scott sentences for finitely generated groups.
36. **University of Wisconsin–Madison Logic Seminar.** Madison, WI. March 2017.
There is no classification of the decidably presentable structures.
37. **ASL North American Annual Meeting.** Boise, ID. March 2017.
Some results on characterizing structures using infinitary formulas.
38. **AMS Spring Southeastern Sectional Meeting.** Charleston, SC. March 2017.
Extending automorphisms of normal algebraic fields.
39. **Southeastern Logic Symposium.** Gainesville, FL. March 2017.
Optimal Scott sentences for finitely generated groups.
40. **Workshop on Computability.** Ghent, Belgium. July 2016.
Computable structures of high Scott rank.
41. **CUNY Model Theory Seminar.** New York, NY. December 2015.
Scott ranks of models of a theory.
42. **Kolchin Seminar in Differential Algebra.** New York, NY. December 2015.
Differential-Algebraic Jet Spaces and Internality.
43. **Notre Dame Logic Seminar.** South Bend, IN. September 2015.
Scott ranks of models of a theory.
44. **CSLI Workshop on Logic, Rationality, and Intelligent Interaction.** Stanford, CA. May 2015.
First-order possibility models and worldizations.
45. **Sets and Computations.** Singapore. April 2015.
Computable structures on a cone.
46. **AMS Spring Eastern Sectional Meeting.** Washington D.C. March 2015.
Computable functors and effective interpretability.
47. **CMS Winter Meeting.** Hamilton, Canada. December 2014.
Independence in computable algebra.
48. **McMaster Model Theory Seminar.** Hamilton, Canada. November 2011.
Jet spaces are C -Moishezon.
49. **Kolchin Seminar in Differential Algebra.** New York, NY. October 2011
Non-standard methods for bounds in differential polynomial rings.

OTHER CONFERENCE TALKS

1. **Computability in Europe.** Paris, France. June 2016.
Borel functors and interpretations.
2. **ASL North American Annual Meeting.** Storrs, CT. May 2016.
Scott ranks of models of a theory.
3. **ASL North American Annual Meeting.** Urbana-Champaign, IL. March 2015.
Computable structures relative to a cone.
4. **Logic Colloquium.** Vienna, Austria. July 2014.
Degree spectra of relations on a cone.
5. **ASL North American Annual Meeting.** Boulder, CO. May 2014.
Degree spectra of relations on a cone.
6. **Graduate Student Conference in Logic.** Madison, WI. April 2014.
Degree spectra of relations on a cone.

MEETINGS, SEMINARS, OR SPECIAL SESSIONS ORGANIZED OR CO-ORGANIZED

1. **Special Session on Computability Theory**, AMS Spring Central Sectional Meeting, Milwaukee, 2024.
2. **Midwest Computability Seminar**, Chicago, 2023-2024.
3. **Department Colloquium**, University of Illinois Chicago, 2023-2024.
4. **Logic Seminar**, University of Illinois Chicago, 2023-2024.
5. **Special Session in Computability Theory**, ASL North American Annual Meeting, UC Irvine, 2023.
6. **Logic Seminar**, University of Michigan, 2021-2023.
7. **Special Session in Computability Theory**, Logic Colloquium, Poland, 2021.
8. **Workshop on Digitalization and Computable Models**, Program Committee, Novosibirsk, 2021.
9. **Workshop on Digitalization and Computable Models**, Program Committee, Novosibirsk, 2019.
10. **Workshop on Computability Theory and its Applications**, Waterloo, 2018.

STUDENTS MENTORED

Graduate student thesis chapters mentored:

1. Michael Deveau, University of Waterloo. 2017-2018. (Advisor: Barbara Csima.)
2. Mohammad Hamdy, University of Waterloo. 2017-2018. (Advisor: Barbara Csima.)

REU students:

1. Jad Damaj, at University of Michigan, 2023.
Degree spectra of natural relations on $(\mathbb{N}, <)$, in preparation.
2. Syed Akbari, at University of Michigan, 2023.
Computable learning of natural hypothesis classes, in preparation.
3. Eissa Haydar, at University of Michigan, 2023.
The complexity of characterizing $[0, 1]$ up to homeomorphism, in preparation.
4. Miles Kretschmer, at University of Michigan, 2022.
Infinitary logic has no expressive efficiency over finitary logic, Journal of Symbolic Logic.
5. Dhruv Kulshreshtha, at University of Michigan, 2022.
The logic of cardinality comparison without the axiom of choice, submitted for publication.
6. Songqi Guo, at Massey University, 2021. (Co-supervised with Alexander Melnikov.)

Supervised reading and reading courses:

1. Taeyoung Em (graduate), University of Michigan, 2022.
2. Terry Guan (undergraduate), University of Michigan, 2022.
3. Wentao Yang (undergraduate), University of Waterloo. 2018. (Co-supervised with Barbara Csima.)

TEACHING

As **Instructor**, University of Illinois Chicago:

- Math 320 – Linear Algebra I, Spring 2024.
- Math 210 – Calculus III, Fall 2023 (two sections).

As **Instructor**, University of Michigan:

- Math 681 – Mathematical Logic, Winter 2023.
- Math 684 – Recursion Theory, Fall 2022.
- Math 681 – Mathematical Logic, Winter 2022.
- Math 451 – Advanced Calculus I, Fall 2021.

As **Instructor**, Massey University:

- Math 302 – Modern Algebra, second half on rings and fields, Trimester 2 2020.

As **Instructor**, Victoria University of Wellington:

- Math 434 – Honours Set Theory, Trimester 1 2019
- Math 324 – Coding Theory and Cryptography, first half on coding theory, Trimester 2 2018.

As **Graduate Student Instructor (GSI)**, UC Berkeley:

- Math 53 – Multivariable Calculus, Spring 2017;
- Math 54 – Linear Algebra and Differential Equations, Fall 2016;
- Math 53 – Multivariable Calculus, Fall 2015.