

## Hyesang Chang, Ph.D.

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### Education

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Ph.D.	Psychology (Cognition), University of Chicago	2017
M.A.	Social Sciences (Psychology), University of Chicago	2011
B.A.	Psychology, Concentration in Neuroscience, Grinnell College, Grinnell, IA	2009

### Publications

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#### Peer-reviewed Journal Articles (\*Equal contribution)

16. Liu, J.\*, Supekar, K.\*, El-Said, D., de los Angeles, C., Zhang, Y., **Chang, H.**, & Menon, V. (2024). Neuroanatomical, transcriptomic, and molecular correlates of math ability and their prognostic value for predicting learning outcomes. *Science Advances*, *10*, eadk7220.
15. Park, Y., Zhang, Y., **Chang, H.**, & Menon, V. (2024). Short-term number sense training recapitulates long-term neurodevelopmental changes from childhood to adolescence. *Developmental Science*, e13524.
14. Xie, Y.\*, **Chang, H.\***, Zhang, Y., Wang, C., Zhang, Y., Chen, L., Geng, F., Ku, Y., Menon, V., & Chen, F. (2024). Long-term abacus training gains in children are predicted by medial temporal lobe anatomy and circuitry. *Developmental Science*, e13489.
13. Liu, J.\*, **Chang, H.\***, Abrams, D., Kang, J. B., Chen, L., Rosenberg-Lee, M., & Menon, V. (2023). Atypical cognitive training-induced learning and brain plasticity and their relation to insistence on sameness in children with autism. *Elife*, e86035.
12. Liu, J., Chen, L., **Chang, H.**, Rudoler, J., Al-Zughoul, A. B., Kang, J. B., Abrams, D., & Menon, V. (2023). Replicable patterns of memory impairments in children with autism and their links to hyperconnected brain circuits. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *8*, 1113-1123.
11. Chen, L.\*, **Chang, H.\***, Rudoler, J., Arnardottir, E., Zhang, Y., de los Angeles, C., & Menon, V. (2022). Cognitive training enhances growth mindset in children through plasticity of cortico-striatal circuits. *npj Science of Learning*, *7*, 30.
10. **Chang, H.**, Chen, L., Zhang, Y., Xie, Y., de los Angeles, C., Adair, E., Zanitti, G., Wassermann, D., Rosenberg-Lee, M., & Menon, V. (2022). Foundational number sense training gains are predicted by hippocampal – parietal circuits. *Journal of Neuroscience*, *42*, 4000-4015.
9. Schwartz, F.\*, Zhang, Y.\*, **Chang, H.\***, Karraker, S., Kang, J. B., & Menon V. (2021). Neural representational similarity between symbolic and non-symbolic quantities predicts arithmetic skills in childhood but not adolescence. *Developmental Science*, *24*, e13123.
8. Menon, V. & **Chang, H.** (2021). Emerging neurodevelopmental perspectives on mathematical learning. *Developmental Review*, *60*, 100964.
7. Supekar, K.\*, **Chang, H.\***, Mistry, P.\*, Iuculano, T., & Menon, V. (2021). Neurocognitive modeling of latent memory processes reveals hippocampal-cortical circuit reorganization underlying learning and efficient strategies. *Communications Biology*, *4*, 405.
6. **Chang, H.**, Rosenberg-Lee, M., Qin, S., & Menon, V. (2019). Faster learners transfer their knowledge better: behavioral, mnemonic, and neural mechanisms of individual differences in children's learning. *Developmental Cognitive Neuroscience*, *40*, 100719.
5. **Chang, H.\***, Sprute, L.\*, Maloney, E. A., Beilock, S. L., & Berman, M. G. (2017). Simple arithmetic: not so simple for highly math anxious individuals. *Social Cognitive and Affective Neuroscience*, *12*, 1940–1949.
4. **Chang, H.**, & Beilock, S. L. (2016). The math anxiety-math performance link and its relation to individual and environmental factors: a review of current behavioral and psychophysiological research. *Current Opinion in Behavioral Sciences*, *10*, 33-38.

3. Ramirez, G., **Chang, H.**, Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology*, *141*, 83-100.
2. **Chang, H.** & Gibson, J. M. (2011). The odd-even effect in Sudoku puzzles: Effects of working memory, aging, and experience. *American Journal of Psychology*, *124*, 313-324.
1. Brooks, J. O., **Chang, H.**, & Krasnykh, O. (2009). Metabolic risks in older adults receiving second-generation antipsychotic medication. *Current Psychiatry Reports*, *11*, 33-40.

### Book Chapters

Menon, V. & **Chang, H.** (2022). Theories of dyscalculia. In *The Cambridge Handbook of Dyslexia and Dyscalculia* (Cambridge Handbooks in Psychology, pp. 25-44). M. A. Skeide (Ed.). Cambridge: Cambridge University Press.

### Presentations

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#### Invited Talk

- Math anxiety and math performance: Exploring the intersection of emotion and cognitive control.* (2017, May). Department of Psychology Cognitive Brown Bag, University of Chicago.
- Understanding the relationship between math anxiety and performance.* (2014, March). Department of Psychology, Elmhurst College, Elmhurst, IL.
- The role of math anxiety in learning arithmetic facts.* (2013, November). Department of Psychology Cognitive Brown Bag, University of Chicago.

#### Conference Presentations

18. Raza, Z., Liu, J., **Chang, H.**, & Menon, V. (2024, April). *Changes in neural response variability in response to cognitive training and its relation to restricted repetitive behavior in children with autism.* Poster presented at the 2024 CNS Annual Meeting in Toronto, Canada.
17. Raza, Z., Tragoudas, G., Venkatesh, H., El-Said, D., Park, Y., **Chang, H.**, Liu, J., & Menon, V. (2024, March). *Executive function deficits and learning outcomes with cognitive training in children with autism spectrum disorder.* Poster presented at the 2024 Bay Area Autism Consortium in San Francisco, CA.
16. Zhang, Y., Liu, R., **Chang, H.**, & Menon, V. (2023, March). *Dynamic causal interactions in brain circuits underlying numerical processing from childhood to adolescence.* Poster presented at the 2023 CNS Annual Meeting in San Francisco, CA.
15. Liu, R., **Chang, H.**, El-Said, D., Zhang, Y., Wassermann, D., & Menon, V. (2023, March). *Category-specific representation of numbers and letters is distributed across neural systems.* Poster presented at the 2023 CNS Annual Meeting in San Francisco, CA.
14. Park, Y., Zhang, Y., Schwartz, F., Iuculano, T., **Chang, H.**, & Menon, V. (2023, March). *Integrated number sense tutoring induces distinct patterns of changes in neural representations in children with and without mathematical difficulties.* Poster presented at the 2023 CNS Annual Meeting in San Francisco, CA.
13. **Chang, H.**, Chen, L., Zhang, Y., Xie, Y., Adair, E., de Los Angeles, C., Zanitti, G., Wassermann, D., Rosenberg-Lee, M., & Menon, V. (2021, Sept). *Foundational number sense training gains are predicted by hippocampal – parietal circuits.* Flash Talk and Poster presented at the 9<sup>th</sup> Annual Meeting of Flux Congress (virtual meeting).
12. Xie, Y., Wang, C., Weng, J., Supekar, K., **Chang, H.**, & Chen, F. (2019, June). *AMC Training-induced structural plasticity in hippocampus predicts long-term gains in math ability.* Poster presented at the 25<sup>th</sup> Annual Meeting of the Organization for Human Brain Mapping. Rome, Italy.

11. Rudoler, J., Chen, L., **Chang, H.**, Rosenberg-Lee, M., Adair, E., & Menon, V. (2019, March). *Learning to believe: Behavioral and neurobiological evidence on cognitive training supporting growth mindset in children*. Poster presented at the 2019 CNS Annual Meeting in San Francisco, CA.
10. Karraker, S., Schwartz, F., **Chang, H.**, Iuculano, T., Adair, E., Rosenberg-Lee, M., Chen, L., & Menon, V. (2018, September). *Number training remediates math difficulties in children: behavioral and neural correlates*. Poster presented at the 6th Biennial Meeting of the International Mind, Brain, and Education Society, Los Angeles, CA.
9. Kang, J., **Chang, H.**, Chen, L., & Menon, V. (2018, September). *Neurocognitive mechanisms underlying affective and motivational factors in math problem solving*. Poster presented at the 6th Biennial Meeting of the International Mind, Brain, and Education Society, Los Angeles, CA.
8. Herts, J. B., **Chang, H.**, Beilock, S. & Levine, S. (2018, May). *Expressing emotion through art improves test performance*. Poster presented at the 30th Annual Meeting of the Association for Psychological Science, San Francisco, CA.
7. **Chang, H.**, Sprute, L., Maloney, E. A., Beilock, S. L., & Berman, M. G. (2017, March). *Simple arithmetic: Not so simple for highly math anxious individuals*. Poster presented at the 2017 CNS Annual Meeting in San Francisco, CA.
6. **Chang, H.**, Van Hedger, K., Henry, A., Norman, G. J., & Beilock, S. L. (2014, November). *The role of anticipation in the relation between math anxiety and math performance*. Poster presented at the 55<sup>th</sup> Annual Meeting of the Psychonomic Society, Long Beach, CA. **Selected as one of eleven finalists for the APA Division 3 Early Career Poster Award**
5. **Chang, H.**, Lyons, I. M., & Beilock, S. L. (2013, November). *Symbolic processing mediates the relationship between math anxiety and mental arithmetic performance*. Poster presented at the 54<sup>th</sup> Annual Meeting of the Psychonomic Society, Toronto, Ontario, Canada. **Selected as one of nine finalists for the APA Division 3 Early Career Poster Award**
4. **Chang, H.**, Lyons, I. M., & Beilock, S. L. (2013, May). *Symbolic processing mediates the relationship between math-anxiety and mental-arithmetic*. Oral presentation at the 85<sup>th</sup> Annual Meeting of the Midwestern Psychological Association, Chicago, IL.
3. Brooks, J. O., **Chang, H.**, Bearden, C. E., & Glahn, D. C. (2011, June). *Prefrontal and limbic dysregulation during emotional processing in bipolar disorder: a functional magnetic resonance imaging meta-analyses*. Poster presented at the 9<sup>th</sup> International Conference on Bipolar Disorder, Pittsburgh, PA.
2. Brooks, J. O., **Chang, H.**, Bearden, C. E., & Glahn, D. C. (2010, May). *Dysregulated activation of prefrontal and limbic regions in emotional processing in bipolar disorder: A meta-analysis*. Poster presented at the 65<sup>th</sup> Annual Meeting of the Society of Biological Psychiatry, New Orleans, LA.
1. Gibson, J. M. & **Chang, H.** (2009, May). *Working memory modulates the odd-even effect in Sudoku puzzles and math problems*. Poster presented at the 21<sup>st</sup> Annual Meeting of the Association for Psychological Science, San Francisco, CA.

## **Funding/Awards**

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Postdoctoral Support Award	2019 – 2021
Maternal & Child Health Research Institute, Stanford University	
Undergraduate Preceptorship, University of Chicago	2016 – 2017
Chicago Center for Teaching Fellowship, University of Chicago	2016 – 2017
Research Grant, Hymen Milgrom Supporting Organization, University of Chicago	2015 – 2017
Division of the Social Sciences Summer Grant, University of Chicago	2015
Norman Henry Anderson Research and Travel Fund, University of Chicago	2013 – 2017
Mentored Advanced Project Fund, Grinnell College	2008

## Research Experience

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**Research Scientist, Postdoctoral Scholar, Stanford University** 2017 – 2024

*Stanford Cognitive and Systems Neuroscience Lab, Department of Psychiatry and Behavioral Sciences*

Projects: Cognitive and brain mechanisms of mathematical learning in children (Mentor: Vinod Menon, Ph.D.)

- Assist in leading research projects aimed to understand neurocognitive mechanisms underlying mathematical learning; design and conduct intervention and neuroimaging study protocols in children, perform analysis of behavioral and brain imaging data, mentor individuals, and prepare manuscripts and grant applications.

**Graduate Student Researcher, University of Chicago** 2010 – 2011, 2012 – 2017

*Human Performance Lab, Department of Psychology*

Projects: Basic numerical processing; training-related changes in arithmetic strategy selection and efficiency; neural and physiological correlates of math anxiety and math performance (Mentor: Sian L. Beilock, Ph.D.)

Dissertation (2017): *The role of anticipation in the relation between math anxiety and math performance*

Master's Thesis (2014): *Training effects on arithmetic performance and strategy selection: the role of math anxiety*

Master's Thesis (2011): *Numerical-ordering ability mediates the relationship between math-anxiety and math-ability*

- Developed research protocols to understand the mechanisms of math anxiety and math performance; prepared study materials, recruited young adults and high school students, conducted experiments, trained individuals, performed analysis of behavioral, brain imaging, and physiological data, prepared manuscripts, and communicated findings to scientific and broader communities.

**Research Assistant, University of Chicago** 2011 – 2012

*Human Performance Lab, Department of Psychology*

Project: Learning Math & Spatial Skills (PI: Sian L. Beilock, Ph.D.)

- Recruited first and second grade teachers and their students, prepared and administered behavioral and neuropsychological assessments, trained individuals, coded qualitative data, and built and managed data sets to facilitate a research project aimed at illuminating cognitive, affective, and motivational factors associated with math achievement in children.

**Staff Research Associate I, University of California, Los Angeles** 2010

*Cousins Center for Psychoneuroimmunology*

Project: Sleep and Healthy Aging Research Study (PI: Michael R. Irwin, M.D.)

- Recruited older adults and administered telephone surveys to study the relation among subjective social isolation, sleep, and general health in older adults.

**Research Assistant, University of California, Los Angeles** 2009 – 2010

*Semel Institute for Neuroscience and Human Behavior*

Project: Meta-analysis of fMRI studies of affective processing (Supervisor: John Brooks, Ph.D., M.D.)

- Performed meta-analyses on functional magnetic resonance imaging studies of affective processing in healthy individuals and patients with bipolar disorder.

**Undergraduate Student Researcher, Grinnell College** 2008 – 2009

*Department of Psychology*

Project: The odd/even effect and working memory (Mentor: Janet M. Gibson, Ph.D.)

- Developed a research protocol to investigate the role of working memory in processing odd and even numbers; recruited younger and older adults, conducted experiments, analyzed data, and presented findings at a national conference.

**Research Assistant, Stanford University** 2008

*VA Palo Alto Health Care System*

Project: Neurocognitive function in older adults with bipolar disorder (PI: John Brooks, Ph.D., M.D.)

- Assisted with data entries and analyses, literature search, and manuscript preparation.

## **Teaching and Mentoring Experience**

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**Research Mentor, University of Chicago, Stanford University** 2012 – 2017, 2017 – 2024

- Mentor and collaborate on research activities, including study design, participant recruitment, study measure and protocol development, behavioral, psychophysiological, and brain imaging data acquisition and analysis, and preparation of conference presentations, manuscripts, and grant applications, of postdoctoral scholars, graduate, undergraduate, and pre-collegiate students, and staff research assistants.
- Advised master's thesis, senior honor's thesis, and independent study.

**Chicago Center for Teaching Fellow, University of Chicago** 2016 – 2017

- Developed and co-led workshop series covering topics on undergraduate teaching in Psychology.
- Provided resources on effective teaching and discussed pedagogical topics across disciplines in the University.

**Undergraduate Preceptor in Psychology, University of Chicago** 2016 – 2017

- Co-led a Lab Night event for research lab members across campus to introduce research opportunities to undergraduate students interested in gaining research experience.
- Assisted in holding workshops and panels for undergraduate students' academic and career development.

**Instructor, University of Chicago**

*Cognitive Psychology* Summer 2016

- Designed a syllabus to teach a class of undergraduate and pre-collegiate University of Chicago summer program students on various topics in cognitive psychology.
- Used teaching methods and assessments that facilitate student-centered learning, including *think-pair-share*, *minute paper*, online discussion, and student-led presentations to critically review research articles.

**Teaching Assistant, University of Chicago**

*Psychological Research Methods* Winter 2015, Winter 2016

- Led a weekly lab section to advise undergraduate students on designing and conducting a research project, writing research proposal and report, and presenting a scientific poster.
- Delivered guest lectures on *Experimental Design* in a class of undergraduate students.

*Psychological Statistics* Fall 2015

- Co-led weekly lab section of undergraduate students and held office hours to review statistical concepts.
- Graded weekly assignments and identified topics to review during the lab section.

*Cognitive Psychology* Spring 2015

- Led a weekly discussion section of undergraduate students to facilitate discussion on topics related to cognition and assisted in developing questions for weekly quizzes and short-answer assignments.

**Pedagogical Training, Chicago Center for Teaching, University of Chicago** 2015 – 2016

- Completed pedagogical training courses, including *Workshop on Teaching in the College*, *College Teaching Course*, *Teaching by Discussion*, *How to Design an Award Winning Course*, and *Teaching Portfolios*.

## **Outreach**

*How does the mind work* (virtual meeting). Fremont High School, Sunnyvale, CA 2022

*Brain Day Event*. 7<sup>th</sup> grade classroom, Jordan Middle School, Palo Alto, CA 2018

*Q&A sessions to review current research*. Multiple 9-12<sup>th</sup> grade classrooms in the Midwest 2016 – 2017

*What do I study?* 5<sup>th</sup> grade classroom, Francis W. Parker School, Chicago, IL 2015

*How to look at brain data: A tutorial*. 12<sup>th</sup> grade advanced biology classroom, Francis W. Parker School 2015

## Training Courses Completed

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- Grant Writing Proposal Bootcamp*. Grant Writing Academy, Stanford University. 2018
- fMRI Image Acquisition and Analyses Course*. The Mind Research Network (MRN). 2015

## University Service

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**Professional Development Committee Member, University of Chicago** 2015 – 2016

*Psychology Graduate Student Organization, Department of Psychology*

- Assisted in planning and organizing career development events for graduate students.

**Student Coordinator, University of Chicago** 2013 – 2015

*Cognitive Brown Bag Series, Department of Psychology*

- Invited guest speakers and coordinated department-wide workshop series.

## Skills

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<b>Clinical</b>	Neuropsychological assessments
<b>Experimental</b>	Computerized task design, quantitative and qualitative data analyses, animal behavioral neuroscience, behavioral task design and coding
<b>Languages</b>	English, Korean
<b>Psychophysiological</b>	Electrocardiogram, functional and structural MRI data acquisition and analysis
<b>Software</b>	Microsoft Office, E-Prime, PsychoPy, R, SPSS, Stata, Matlab, MindWare Heart Rate Variability and Impedance Cardiography Analysis Software, Statistical Parametric Mapping, BrainVoyager, FMRIB Software Library, BrainMap Software
<b>Survey</b>	Computer-assisted telephone interviewing, survey design and administration

## Professional Affiliations

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American Psychological Association: Division 3  
Association for Psychological Science  
Cognitive Neuroscience Society  
Midwestern Psychological Association  
Psychonomic Society

## Ad-hoc Reviewer

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American Educational Research Association  
Brain Research  
Cognitive, Affective, and Behavioral Neuroscience  
Journal of Experimental Child Psychology  
Journal of Experimental Psychology: General  
Learning Disability Quarterly  
Memory & Cognition  
NeuroImage  
PLOS ONE