# Choong-Wan Woo

Center for Neuroscience Imaging Research,
Institute for Basic Science
Department of Biomedical Engineering
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(Last updated: Dec 2022)

## MAJOR RESEARCH GOALS

- Understanding the neural mechanisms of pain and emotions
- Developing integrated brain models of human affective experiences and clinical outcomes
- Translating basic and computational neuroscience findings into clinical applications
- Building life- and neuroscience-inspired artificial general intelligence

## CURRENT ACADEMIC POSITION

**Associate Director** Dec 2022 ~ present
Center for Neuroscience Imaging Research,
**Institute for Basic Science**

**Assistant Professor** March 2017 ~ present
Department of Biomedical Engineering,
**Sungkyunkwan University** (Suwon, South Korea)

## EDUCATION and TRAINING

**Research Associate/Postdoctoral Fellow** Feb 2017
Cognitive and Affective Neuroscience Lab
Institute of Cognitive Sciences,
University of Colorado at Boulder, USA
Advisor: Tor D. Wager, Ph.D.

**Ph.D. (dual)** Psychology*/Cognitive Science** Aug 2016
*Department of Psychology and Neuroscience,
**Institute of Cognitive Sciences,
University of Colorado at Boulder, USA
Advisor: Tor D. Wager, Ph.D.

PhD dissertation (submitted at Aug 2016)
*Brain Representations and Mechanisms of Pain Experience and Regulation: A Multivariate Pattern Approach* (committee: Tor D. Wager, Randall C. O'Reilly, Yuko Munakata, June Gruber, Tamara R. Sumner, Alaa Ahmed)

**Clinical Training** Full time 3-year Residency Training (Clinical Psychology) Feb 2010.
Department of Psychiatry, Seoul National University Hospital
Advisor: Min-Sup Shin, Ph.D.

**M.A.** Clinical Psychology Feb 2007.
Department of Psychology, Seoul National University, South Korea
Advisor: Seok-Man Kwon, Ph.D.

MA Thesis at Seoul National University (Feb 2007)
*The Relationship between Excessive Doubts due to Error Processing Dysfunction and Obsessive Compulsive Symptoms*

**B.S.** (cum laude) Biological Sciences Feb 2005.
Major GPA: 3.75/4.30, Last 2 years' GPA: 3.96/4.30
Seoul National University, South Korea

## RESEARCH GRANTS

Institute for Basic Science, 2017-present
Center for Neuroscience Imaging Research, Participating Investigator
"Affective Neuroscience" Team leader (IBS-R015-D1)

Korea Institute of Science and Technology, KRW 100M/year 2021-2022
Institutional Program, Principal Investigator
"Developing brain-based biomarkers of the aging brain based on the computational models of the network-level homeostatic regulation" (2E30410-20-085)

National Research Foundation of Korea, PI, KRW 500M/4 years 2019-2022
"Development and validation of pain biomarkers based on functional neuroimaging and machine learning in human" (2019R1C1C1004512)

Ministry of Science and ICT, Participating Investigator, KRW 100M/1 years 2020
"BabyMind: Infant-Mimic Neurocognitive Developmental Machine Learning from Interaction Experience with Real World" (2019-0-01367- BabyMind)

Ministry of Science and ICT, Participating Investigator, KRW 120M/2 years 2019-2020
"Hub Construction for Brain Science" (18-BR-03)

## HONORS and AWARDS

**Top 100 R&D achievements** (국가연구개발 우수성과 100선),
Title: *"Developing neuroimaging-based pain biomarkers based on experimental pain"*
Ministry of Science and ICT (Nov 2022)

**Kim Chan Award** (김찬 학술상, 대한통증연구회),
The Korean Pain Research Society (Nov 2022)

**Outstanding Achievement Award** (학술상 본상, 대한뇌기능매핑학회),
Korean Society for Human Brain Mapping (Nov 2021)

**Teaching Award,**
Sungkyunkwan University (Sep 2020)

**Jae-il Kim Young Scholar Award** (김재일 소장학자상, 한국심리학회)**,**
Korean Psychological Association (Aug 2019)

**International Association for the Study of Pain (IASP) Travel Award ($1,450),**
IASP, 16th World Congress on Pain, Yokohama, Japan (Sep 2016)

**Organization for Human Brain Mapping (OHBM) Abstract Travel Award ($1,000),**
OHBM 2016 Annual meeting, Geneva, Switzerland (June 2016)

**Heyer Award,**
Dept. of Psychology and Neuroscience, University of Colorado at Boulder (May 2015)

**Carol B. Lynch Graduate Fellowship,**
University of Colorado at Boulder (May 2015)

**Institute of Cognitive Science (ICS) Travel Award,**
University of Colorado at Boulder (July 2014; Feb 2015)

**Invited scholar,**
European Pain School, Siena, Italy (June 2013)

**American Psychosomatic Society (APS) Travel Award for MacLean Scholars,**
American Psychosomatic Society (Jan 2013)

**United Government of Graduate Students Travel Award,**
University of Colorado at Boulder (Oct 2012)

**Fulbright Graduate Study Award,**
Bureau of Educational and Cultural Affairs,
United States Department of State, (2011 ~ 2013)

**High Academic Achievement Award,**
College of Natural Sciences, Seoul National University (2005)

**Undergraduate Student Research Award,**
Title: "*The Role of Contrast and Exposure Duration in Pattern Motion Perception*"
Institute of Psychological Science, Seoul National University (2004)

**Scholarship for the Research Participating Program for Undergraduate Students,**
Title: "*Brain Imaging Method: Focusing on Functional Magnetic Resonance Imaging*"
Center for Teaching and Learning, Seoul National University (2004)

## PROFESSIONAL AFFILIATIONS

Society for Neuroscience; Organization for Human Brain Mapping; Social and Affective Neuroscience Society; Korean Society for Human Brain Mapping (2019-2020 국제간사, 2021-2022 국제이사, 2023-2024 학술이사); The Korean Society for Brain and Neural Sciences (2020 학술부위원장, 2022-3 학술위원); Korean Society for Cognitive & Biological Psychology; Korean Clinical Psychology Association (2022-2023 59대 학술이사)

## PROFESSIONAL ACTIVITIES

| | |
|---|---|
| Associate Editor | *Pain* |
| Consulting Editor | *Cognition & Emotion* |
| Ad-Hoc Reviewer | *Nature Neuroscience, Science Translational Medicine; Nature Communications; eLife; Pain; Pain Reports; Cognitive, Affective, and Behavioral Neuroscience; Human Brain Mapping; NeuroImage; NeuroImage Clinical; Journal of the American Academy of Child and Adolescent Psychiatry; Brain and Language; Journal of American Neuroradiology; Magnetic Resonance in Medicine; Neuroinformatics* |

## LICENSURE

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|---|---|
| 2010 ~ Present | Professional Clinical Psychologist (Korean Psychological Association) |
| 2010 ~ Present | Mental Health Clinical Psychologist (Ministry of Health and Welfare, Republic of Korea) |

## RESEARCH

### Publications (Journal Articles):

★indicates Cocoan lab trainee; ☆indicates Cocoan lab undergrad trainee

*2023*

★Kim, J., Andrews-Hanna, J. R., Eisenbarth, H. ★Lux, B. K., ★Kim, H. J., ★Lee, E., Lindquist, M. A., Losin, E. A. R., Wager, T. D., **Woo, C.-W.** (2023) A Dorsomedial Prefrontal Cortex-based Dynamic Functional Connectivity Model of Rumination, *Nature Communications*, **14**, 3540 (1-14), https://doi.org/10.1038/s41467-023-39142-9

*2022*

★Kohoutová, L., Atlas, L. Y., Büchel, C., Buhle, J. T., Geuter, S., Jepma, M., Koban, L., Krishnan, A., ★Lee, D. H., ★Lee, S., Roy, M., Schafer, S. M., Schmidt, L., Wager, T. D., **Woo, C.-W.** (2022) Individual Variability in Brain Representations of Pain, *Nature Neuroscience*, **25**, 749-759, doi: 10.1038/s41593-022-01081-x

★Lee, J.-J., ★Lee, S., ★Lee, D. H., **Woo, C.-W.** (2022). Functional Brain Reconfiguration During Sustained Pain. *eLife*, *11*, e74463 (1-39), doi: 10.7554/eLife.74463

★Kim, B., Andrews-Hanna, J. R., ★Han, J., ★Lee, E., & **Woo, C.-W.** (2022). When self comes to a wandering mind: Brain representations and dynamics of self-generated concepts in spontaneous thought, *Science Advances*, *8(35)*, eabn8616, doi: 10.1126/sciadv.abn8616

Andrews-Hanna, J. R.*, **Woo, C.-W.***, Wilcox, R., Eisenbarth, H., ★Kim, B., ★Han, J., Losin, E. A. R., Wager, T. D. (2022) The Conceptual Building Blocks of Everyday Thought: Tracking the Emergence and Dynamics of Ruminative and Non-Ruminative Thinking, *Journal of Experimental Psychology: General*, *151(3)*, 628-642, doi:10.1037/xge0001096
*co-first author

Kim, D., **Woo, C.-W.***, Kim S.-G. (2022) Neural mechanisms of pain relief through paying attention to painful stimuli, *Pain*, 163(6), 1130-1138, doi:10.1097/j.pain.0000000000002464
*corresponding author

Čeko, M., Kragel, P. A., **Woo, C.-W.**, López-Solà, M., Wager, T. D. (2022) Common and stimulus type-specific brain representations of negative affect, *Nature Neuroscience*, doi: 10.1038/s41593-022-01082-w

Coll, M.-P., Slimani, H., **Woo, C.-W.**, Wager, T. D., Rainville, P., Vachon-Presseau, E., Roy, M. (2022). The neural signature of the decision value of future pain, *Proceedings of the National Academy of Sciences (PNAS)*, *119(23)*, e2119931119, doi: 10.1073/pnas.2119931119

Kim, K. I., Jung, W. H., **Woo, C.-W.**, Kim, H. (2022). Neural signatures of individual variability in context-dependent perception of ambiguous facial expression, *NeuroImage*, *258*, 1053-811, doi: 10.1016/j.neuroimage.2022.119355

Lee, S.-H., Chey, J. Ahn, W.-Y., **Woo, C.-W.**, Youm, Y., Kim, H., Oh, N., Park, H., ★Gim, S., ★Lee, E., Choi, I. (2022). Psychological well-being and salivary markers of inflammation: The moderating effect of age, *Applied Psychology: Health and Well-being*, doi: 10.1111/aphw.12389

Jiang, R., **Woo, C.-W.**, Qi, S., Wu, J., Sui, J. (2022). Challenges and Solutions for Interpreting Brain Biomarkers in Machine Learning-Based Predictive Neuroimaging. *IEEE SPM (Signal Processing Magazine)*, *39(4)*, 107-118, doi: 10.1109/MSP.2022.3155951

Lee, J.-Y., You, T., Lee, C.-H., Im, G. H., Seo, H., **Woo, C.-W.**, Kim, S.-G. (2022) Role of Anterior Cingulate Cortex Inputs to Periaqueductal Gray for Pain Avoidance. *Current Biology*, *32*, 1-14; doi:10.1016/j.cub.2022.04.090

Petre, B., Kragel, P., Atlas, L. Y., Geuter, S., Jepma, M., Koban, L., Krishnan, A., Lopez-Sola, M., Losin, E. A. R., Roy, M., **Woo, C.-W.**, Wager, T. D. (2022) A multistudy analysis reveals that evoked pain intensity representation is distributed across brain systems. *PLoS Biology*, 20(5), e3001620; doi:10.1371/journal.pbio.3001620

Han, X., Ashar, Y. K., Kragel, P., Petre, B., Schelkun, V., Atlas, Lauren Y., Chang, L. J., Jepma,

M., Koban, L., Losin, E. A. R., Roy, M., **Woo, C.-W.**, & Wager, T. D. (2022) Effect sizes and test-retest reliability of the fMRI-based Neurologic Pain Signature. *NeuroImage*, *247*, 118844.; https://doi.org/10.1016/j.neuroimage.2021.118844

*2021*

★Lee, J.-J., ★Kim, H. J., Čeko, M. Park, B., ★Lee, S. A., Park, H., Roy, M., Kim, S.-G., Wager, T. D., & **Woo, C.-W.** (2021) A Neuroimaging Biomarker for Sustained Experimental and Clinical Pain, *Nature Medicine*, *27*, 174-182; https://doi.org/10.1038/s41591-020-1142-7

Lim, J.-S.*#, ★Lee, J.-J.*, **Woo, C.-W.**# (2021) Post-stroke cognitive impairment: Pathophysiological insights into brain disconnectome from advanced neuroimaging analysis techniques, *Journal of Stroke*, *23(3)*, 297-311; doi:10.5853/jos.2021.02376
*co-first author, #co-corresponding author

*2020*

★Kohoutová, L., Heo, J., Cha, S., ★Lee, S. Moon, T., Wager, T. D., & **Woo, C. -W.** (2020) Interpreting machine learning models in neuroimaging: Towards a unified framework, *Nature Protocols*, *15*, 1399-1435; https://doi.org/ 10.1038/s41596-019-0289-5

Losin, E. A. R., **Woo, C. -W.**, Medina, N. A., Andrews-Hanna, J., Eisenbarth, H., Wager, T. D. (2020) Neural and Sociocultural Mediators of Ethnic Differences in Pain, *Nature Human Behaviour*. https://doi.org/10.1038/s41562-020-0819-8

Lee. T. Y., Hwang, W. J., Kim, N. S., Park, I., Lho, S. K., Moon, S.-Y., Oh, S., Lee. J., Kim. M., **Woo, C.-W.**, Kwon, J. S. (2020) Prediction of psychosis: model development and internal validation of a personalized risk calculator, *Psychological Medicine*, 1-9; https://doi.org/10.1017/S0033291720004675

Shin, W.-G., **Woo, C.-W.**, Jung, W. H., Kim, H., Lee, T. Y., Decety, J., Kwon, J. S. (2020) The neurobehavioral mechanisms underlying attitudes toward people with mental or physical illness, *Frontiers in Behavioral Neuroscience*, *14*, 571225; https://doi.org/10.3389/fnbeh.2020.571225

Park, B., ★Lee, J.-J., ★Kim, H. J., **Woo, C.-W.**, Park, H. (2020) A neuroimaging marker for predicting longitudinal changes in pain intensity of subacute back pain based on large-scale brain network interactions, *Scientific Reports*, *10*, 17392; https://doi.org/10.1038/s41598-020-74217-3

Silvestrini, N., Chen, J., Piché, M., Roy, M., Vachon-Presseau, E., **Woo, C.-W.**, Wager, T. D., & Rainville, P. (2020) Distinct fMRI patterns colocalized in the cingulate cortex underlie the after-effects of cognitive control on pain, *NeuroImage*, *217*, 116898;

https://doi.org/10.1016/j.neuroimage.2020.116898

Lim, J. S.*, ★Lee, J. -J.* , **Woo, C. -W.**, Song, J., Oh, M. -S., Yu, K. -H., Lee, B. -C. (2020) Individual-level lesion-network mapping to visualize stroke lesion effects on the brain network, *Journal of Clinical Neurology*, *16(1)*, 116-123
*co-first authors

Zheng, W., **Woo, C. -W**, Yao, Z., Goldstein, P., Atlas, L. Y., Roy, M., Schmidt, L., Krishnan, A., Jepma, M., Hu, B. and Wager, T. D. (2020) Pain-Evoked Reorganization in Functional Brain Networks, *Cerebral Cortex*, *30(5)*, 2804-2822

*2019*

Jeong, S. -J., Lee, I. Y., Jun, B. O. , Ryu, Y. -J., Sohn, J. -W., Kim, S. -P., **Woo, C. -W.**, Koo, J. W. , Cho, I. -J., Oh, U., Kim, K., and Suh, P. -G. (2019) Korea Brain Initiative: Emerging Issues and Institutionalization of Neuroethics, *Neuron*, *101 (3)*, 390-393

★Hong, Y, ☆Yoo, Y, ☆Han, J., Wager, T. D. & **Woo, C. -W.** (2019) False-positive neuroimaging: Undisclosed flexibility in testing spatial hypotheses allows presenting anything as a replicated finding, *NeuroImage*, *195*, 384-395

Matthewson, G.*, **Woo, C. -W.***, Reddan, M. C., & Wager, T. D. (2019) Cognitive self-regulation influences pain-related physiology, *PAIN (Editor's choice)*, *160*, 2338-2349
*co-first authors

*2018*

Kragel, P. A., Kano, M., Van Oudenhove, L., Ly, H. G., Dupont, P., Rubio, A., Delon-Martin, C., Bonaz, B. L. Manuck, S. B., Gianaros, P. J., Ceko, M., Losin, E. A. R., **Woo, C. -W.,** Nichols, T. E. & Wager, T. D. (2018) Generalizable representations of pain, cognitive control, and negative emotion in medial frontal cortex. *Nature Neuroscience*, *21*, 283-289

*2017*

**Woo, C. -W.**, Chang, L. J. Lindquist, M. A., & Wager, T. D. (2017) Building better biomarkers: Brain models in translational neuroimaging. *Nature Neuroscience*, *20*, 365–377

**Woo, C. -W.**, Schmidt, L., Krishnan, A., Jepma, M., Roy, M., Lindquist, M. A., Atlas, L. Y., & Wager, T. D. (2017) Quantifying cerebral contributions to pain beyond nociception. *Nature Communications*, *8*, 14211

Wager, T. D. & **Woo, C. -W.** (2017) Imaging biomarkers and biotypes for depression. *Nature Medicine*. *23*, 16–17. doi:10.1038/nm.4264

Koban, L., Kross, E., **Woo, C. -W.**, Luka Ruzic, L. &, Wager, T. D. (2017) Frontal-brainstem pathways mediating placebo effects on social rejection. *Journal of Neuroscience*, *37 (13)*

3621-3631

López-Solà, M., **Woo, C. -W.**, Pujol, J., Deus, J., Harrison, B. J., Monfort, J. & Wager, T. D. (2017). Towards a neurophysiological signature for fibromyalgia. *PAIN*. 158(1):34-47

Lindquist, M. A., Krishnan, A., Lopez-Sola, M., Jepma, M., **Woo, C. -W.**, Koban, L., Roy, M. Atlas, L. Y., Chang, L. J., Losin, E. A. R., Eisenbarth, H., Ashar, Y. K., Delk, Z., & Wager, T. D. (2017). Group-regularized individual prediction: Theory and application to pain. *NeuroImage*. 145, 274-287. doi: 10.1016/j.neuroimage.2015.10.074

*2016*

Krishnan, A., **Woo, C. -W.**, Chang, L. J., Ruzic, L., Gu, X., López-Solà, M., Jackson, P. L., Pujol, J., Fan, J., & Wager, T. D. (2016). Somatic and vicarious pain are represented by dissociable multivariate brain patterns. *eLife*. *5*:e15166. doi:10.7554/eLife.15166.001

Vachon-Presseau, E. Roy, M., **Woo, C. -W.**, Kunz, M. Martel, M., Sullivan, M. J., Jackson, P. L., Wager, T. D., & Rainville, P. (2016). Multiple faces of pain: Effects of chronic pain on the brain regulation of facial expression. *PAIN*. doi:10.1097/j.pain.0000000000000587

Wager, T. D. & **Woo, C. -W.** (2016). Issues in assessing reliability in pain neuroimaging. *PAIN*. *157*, 1574–1578

**Woo, C. -W.,** & Wager, T. D. (2016). What reliability can and cannot tell us about pain report and pain neuroimaging. *PAIN*. *157*(3):511-3.

*2015*

**Woo, C. -W.,** & Wager, T. D. (2015). The predictive mapping approach in neuroimaging. *Science (supplement*), *Advances in Computational Psychophysiology*, 18-21 (invited contribution)

**Woo, C. -W.,** & Wager, T. D. (2015). Neuroimaging-based biomarker discovery and validation. *PAIN*. *156*(8):1379-81.

**Woo, C. -W.,** Roy, M., Buhle, J. T. & Wager, T. D. (2015). Distinct brain systems mediate the effects of nociceptive input and self-regulation on pain. *PLoS Biology*. *13*(1): e1002036. doi:10.1371/journal.pbio.1002036

Commentary on this publication

Bray, N. (2015). Reappraising pain. *Nature Review Neuroscience*. 16, 124-125

Ploner, M., Bingel, U., & Wiech, K. (2015). Towards a taxonomy of pain modulations. *Trends in Cognitive Sciences*. 19, 180-182

Mano, H. & Seymour, B. (2015). Pain: A Distributed Brain Information Network? *PLoS Biology*. 13(1): e1002037

Wager, T. D. & **Woo, C, -W.** (2015). fMRI in analgesic drug discovery. *Science Translational Medicine*. 7, 274fs6, doi:10.1126/scitranslmed.3010342

Losin, E. A. R., **Woo, C. -W.**, Krishnan, A., Wager, T. D., Iacoboni, M. & Dapretto, M. (2015). Brain and psychological mediators of imitation: Sociocultural versus physical traits. *Culture and Brain.* doi:10.1007/s40167-015-0029-9

Yamamoto, D. J., **Woo, C. -W.,** Wager T. D., Regner, M. & Tanabe, J. (2015) Influence of dorsolateral prefrontal cortex and ventral striatum on risk avoidance in addiction: a mediation analysis. *Drug and Alcohol Dependence*, 149, 10-17. doi: 10.1016/j.drugalcdep.2014.12.026

*2014*

**Woo, C. -W.**, Koban, L., Kross, E., Lindquist, M. A., Banich, M. T., Ruzic, L., Andrews-Hanna, J. R. & Wager, T. D. (2014). Separate neural representations for physical pain and social rejection. *Nature Communications*, *5*, 5380. doi: 10.1038/ncomms6380

Commentary on this publication

Rogachov, A., Cheng, J. C., & DeSouza, D. D. (2015). Discriminating neural representations of physical and social pains: how multivariate statistics challenge the 'shared representation' theory of pain. *Journal of Neurophysiology*

**Woo, C. -W.**, Krishnan, A., Wager, T. D. (2014) Cluster-extent based thresholding in fMRI analyses: Pitfalls and recommendations. *NeuroImage*, *91*, 412-419

*2013*

Wager, T. D., Atlas, L. Y., Lindquist, M. A., Roy, M., **Woo, C. -W.** & Kross, E. (2013). An fMRI-based Neurologic Signature of Physical Pain. *New England Journal of Medicine*, *368 (15)*, 1388-1397.

*2010-2012*

**Woo, C. -W.**, Kwon, S. -M., Lim, Y. -J., & Shin, M. -S. (2010). The obsessive-compulsive inventory-revised (OCI-R): psychometric properties of the Korean version and the order, gender, and cultural effects. *Journal of Behavior Therapy and Experimental Psychiatry*, *41*, 220-227.

**Woo, C. -W.** & Shin, M. -S. (2010). Cognitive impairments in schizophrenia and psychotic bipolar disorder and their relation to psychotic symptoms. *Korean Journal of Clinical Psychology*, *29*, 471-489.

**Woo, C. -W.**, Shin, M. -S, & Kwon, S. -M. (2010). Are obsessive beliefs specific to obsessive-compulsive symptoms? *Korean Journal of Clinical Psychology*, *29*, 35-52.