Arne Ekstrom, Ph.D.
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A. Education

Jan. 2004, Ph.D. Neuroscience, Brandeis University (advisor: Michael Kahana).
May 2001, M.S. Neuroscience, University of Arizona.
May 1996, B.A. Biology and Psychology, Brandeis University.

B. Professional Appointments

2018	Associate Professor, Psychology, University of Arizona
2014-2018	Associate Professor, Psychology, UC Davis Center for. Neuroscience.
March 2009 - 2014	Assistant Professor, Psychology, UC Davis Center For Neuroscience.
June 2004 - 2009	Postdoctoral Fellow, UCLA Semel Institute for Neuroscience.
August 1996 -1997	Research Assistant, Harvard University.

Honors and Awards

2015 Chancellor's Fellow (UC Davis)
2012 Kavli Fellow – National Academy of Sciences Kavli Frontiers of Science.
2011 Alfred P. Sloan Fellow.
2011 Hellman Young Investigator Award (UC Davis)
2008 The Brain Research Institute Distinguished Postdoctoral Fellow in Neuroscience (UCLA)
1998 Flinn Biomathematics Fellow (University of Arizona)
1996 B.A., Brandeis University, *magna cum laud*e, high honors in neuroscience.

C. Refereed Journal Articles (71 peer-reviewed manuscripts / book chapters total; google H-index: 33; 5,012 citations)

1. Kim K., Schedlbauer A., Rollo M., Karunakaran S., **Ekstrom A.D.**, Tandon N. (in press). Network-based brain stimulation selectively impairs spatial retrieval. Brain Stimulation.
2. **Ekstrom A.D.**, Huffman D., and Starrett M.J. (in press). Interacting networks of brain regions underlie human spatial navigation: A review and novel synthesis of the literature. Journal of Neurophysiology.
3. Kyle C.T., Stokes J.D., Bennett J., Meltzer J. Permenter M.R., Voyt J.A., **Ekstrom A.D.** and Barnes C.A. (in press). Cytoarchitectonically-driven MRI atlas of nonhuman primate hippocampus: preservation of subfield volumes in aging. Hippocampus.
4. Kolarik B.S., Baer T., Shahlaie K., Yonelinas A.P., and **Ekstrom A.D.** (in press). Close but no cigar: Spatial precision deficits following medial temporal lobe lesions provide novel insight into theoretical models of navigation and memory. Hippocampus.
5. Bouffard N., Stokes J.D., Kramer H.J., and **Ekstrom A.D.** (in press). Temporal encoding strategies result in boosts to final free recall comparable to spatial ones. Memory & Cognition.
6. **Ekstrom A.D.** & Isham E.A. (in press). Human spatial navigation: Representations across dimensions and scales. Current Opinion in Behavioral Sciences.
7. **Ekstrom A.D.** & Ranganath C.R. (in press). Space, time and episodic Memory: The hippocampus is all over the cognitive map (commentary). Hippocampus.
8. Bohbot V.D., Copara M.S., Gotman J., and **Ekstrom A.D.** (2017). Low-frequency oscillations in the human hippocampus during real-world and virtual navigation. Nature Communications. 8: 14415. PMID: 28195129.
9. Lieberman J.L., Kyle CT., Schedlbauer A.M., Stokes J.D., and **Ekstrom A.D.** (2017). A tale of two temporal coding strategies: Common and dissociable brain regions involved in recency vs. associative temporal order retrieval strategies. Journal of Cognitive Neuroscience. 29: 739-754. PMID: 27897678.

10. Wisse L.E., Daugherty AM, Olsen RK, Berron D, Carr VA, Stark CE, Amaral RS, Amunts K, Augustinack JC, Bender AR, Bernstein JD, Boccardi M, Bocchetta M, Burggren A, Chakravarty MM, Chupin M, **Ekstrom A.D.**, de Flores R, Insausti R, Kanel P, Kedo O, Kennedy KM, Kerchner GA, LaRocque KF, Liu X, Maass A, Malykhin N, Mueller SG, Ofen N, Palombo DJ, Parekh MB, Pluta JB, Pruessner JC, Raz N, Rodrigue KM, Schoemaker D, Shafer AT, Steve TA, Suthana N, Wang L, Winterburn JL, Yassa MA, Yushkevich PA, la Joie R. (2017). A harmonized segmentation protocol for hippocampal and parahippocampal subregions: Why do we need one and what are the key goals? Hippocampus. 27: 3-11. PMID: 27862600.
11. Arnold AE., Iaria G., and **Ekstrom A.D.** (2016). Mental simulation of routes during navigation involves adaptive temporal compression. Cognition. 157: 14-23. PMID: 27568586.
12. Kim K., **Ekstrom A.D.**, and Tandon N. (2016). A network approach for modulating memory processes via direct stimulation: Toward a causal approach for the neural basis of memory. Neurobiology of Learning and Memory. 134: 162-177. PMID: 27066987.
13. Vass L.K., Copara M.S., Seyal M. Shahlie, K., Tomaszewski-Farias S., Shen P., **Ekstrom A.D.** (2016). Oscillations go the distance: Low frequency human hippocampal oscillations code spatial distance in the absence of sensory cues during teleportation. Neuron. 89: 1-7. PMID: 26924436.
14. Kolarik B.S., Shahlaie K., Hassan B., Borders A.A., Kaufman K., Gurkoff G., Yonelinas A.P., **Ekstrom A.D.** (2016). Impairments in precision, rather than spatial strategy, characterize performance on the virtual Morris Water Maze: A case study. Neuropsychologia, 80: 90-101. PMID: 26593960.
15. Kyle C.T., Stokes J.D., Lieberman J., Hassan A.S., **Ekstrom A.D.** (2015). Successful retrieval of competing spatial environments in humans involves hippocampal pattern separation mechanisms. eLife. 27, e10499. PMID: 26613414.
16. Lee D.J., Gurkoff G.G., Izadi A., Seidl S.E., Echeverri A., Melnik M., Berman R.F., **Ekstrom A.D.**, Muizelaar J.P., Lyeth B.G., Shahlaie K. (2015). Septohippocampal neuromodulation improves cognition after traumatic brain injury. Journal of Neurotrauma. 112: 1822-1832. PMID: 26096267.
17. Suthana N.A., Parikshak N., **Ekstrom A.D.**, Ison M. Knowlton B.J., Bookheimer S.Y., and Fried I. (2015). Specific responses of human hippocampal neurons are associated with better memory. Proceeding of the National Academy of Science. 12(33):10503-8. PMID: 26240357
18. **Ekstrom A.D.** (2015). Why vision is important to how we navigate. Hippocampus. 25(6): 731-5. PMID: 25800632.
19. Yushkevich P.A., Amaral RS, Augustinack JC, Bender AR, Bernstein JD, Boccardi M, Bocchetta M, Burggren AC, Carr VA, Chakravarty MM, Chételat G, Daugherty AM, Davachi L, Ding SL, **Ekstrom A**, Geerlings MI, Hassan A, Huang Y, Iglesias JE, La Joie R, Kerchner GA, LaRocque KF, Libby LA, Malykhin N, Mueller SG, Olsen RK, Palombo DJ, Parekh MB, Pluta JB, Preston AR, Pruessner JC, Ranganath C, Raz N, Schlichting ML, Schoemaker D, Singh S, Stark CE, Suthana N, Tompary A, Turowski MM, Van Leemput K, Wagner AD, Wang L, Winterburn JL, Wisse LE, Yassa MA, Zeineh MM. (2015). Quantitative comparison of 21 protocols for labeling hippocampal subfields and parahippocampal subregions in in vivo MRI: Towards a harmonized segmentation protocol. Neuroimage. 111:526-41. PMID: 25596463
20. Suthana NA, Donix M, Wozny DR, Bazih A, Jones M, Heidemann RM, Trampel R, **Ekstrom AD**, Scharf M, Knowlton B, Turner R, Bookheimer SY. (2015). High-resolution 7-Tesla fMRI of Human Hippocampal Subfields during Associative Learning. Journal of Cognitive Neuroscience. 27(6):1194-206. PMID: 25514656
21. Kyle C.T., Stokes J.D., and **Ekstrom A.D.** (2015). Roles of human hippocampal subfields in retrieval of spatial and temporal context. Behavioural Brain Research. 278:549-545. PMID: 25446813.
22. Watrous A.J., Fell J., **Ekstrom A.D.** and Axmacher N. (2015). More than spikes: common oscillatory mechanisms for content specific neural representations during perception and memory. Current Opinion in Neurobiology. 31:33-39. PMID: 25129044.
23. Stokes J.D., Kyle C. and **Ekstrom A.D.** (2015). Complementary roles of human hippocampal subfields in differentiation and integration of spatial context. Journal of Cognitive Neuroscience. 27(3): 546-59.
24. **Ekstrom A.D.**, Arnold A.E.G.F and Iaria G. (2014). A critical review of the allocentric spatial representation and its neural underpinnings: toward a network-based perspective. Frontiers in

Human Neuroscience, 8(903), 1-15.

25. Schedlbauer A., Copara M.S., Watrous A.J. and **Ekstrom A.D.** (2014). Multiple interacting brain areas underlie successful spatiotemporal memory retrieval in humans. Scientific Reports, 4, 6431. PMID: 25234342.
26. Copara M.S., Hassan A., Kyle C., Libby L., Ranganath C., and **Ekstrom A.D.** (2014). Complementary roles of human hippocampal subregions during retrieval of spatiotemporal context. Journal of Neuroscience. 34(20): 6834-42. PMID: 24828637.
27. Zhang H., Zherdeva K. and **Ekstrom A.D.** (2014). Different "routes" to a cognitive map: Dissociable forms of spatial knowledge derived from route and cartographic map learning. Memory & Cognition. 42(7): 1106-1117. PMID: 24845757.
28. Lee J.K., **Ekstrom A.D.**, and Ghetti S. (2014). Volume of hippocampal subfields and episodic memory in childhood and adolescence. Neuroimage. 94:162-171. PMID: 24642282.
29. Watrous A.J. and **Ekstrom A.D.** (2014). The Spectro-Contextual Encoding and Retrieval Theory of Episodic Memory. Frontiers in Human Neuroscience. 8(75): 1-14. PMID: 24600373.
30. **Ekstrom A.D.** and Watrous A.J. (2014). Multifaceted roles for low-frequency oscillations in bottom-up and top-down processing during navigation and memory. Neuroimage. 85:667-77. PMID: 23792985.
31. **Ekstrom A.D.** (2014). Cognitive neuroscience: Navigating human verbal memory. Current Biology, 24(2): 167-168. PMID: 24556442.
32. Watrous A.J., Lee D.J., Izadi A., Gurkoff G.G., Shahlie K., and **Ekstrom A.D.** (2013). A comparative study of human and rat hippocampal low frequency oscillations during spatial navigation. Hippocampus. 23(8):656-61. PMID: 23520039.
33. Watrous A.J., Tandon N., Connor C., Pieters T., and **Ekstrom A.D.** (2013). Frequency specific increases in network connectivity underlie successful spatiotemporal memory retrieval. Nature Neuroscience. 16(3): 349-356. PMID: 23354333.
34. Gruber M.J., Watrous A.J., **Ekstrom A.D.**, Ranganath C., Otten L.J. (2013). Expected reward modulated encoding-related theta activity before an event. Neuroimage. 64: 68-74. PMID: 22917987.
35. Zhang H. and **Ekstrom, A.D.** (2013). Human Neural Systems Underlying Rigid and Flexible Forms of Allocentric Spatial Representation. Human Brainmapping. 34(5):1070-87. PMID: 22786703.
36. Zhang H., Copara M., and **Ekstrom A.D. (**2012). Differential Recruitment of Brain Networks Following Route and Cartographic Map Learning of Spatial Environments. PLoS ONE. 7(9):e44886. PMID: 23028661.
37. Libby L.A., **Ekstrom A.D.**, Ragland, J.D., & Ranganath, C**.** (2012). Differential connectivity of perirhinal and parahippocampal cortices within human hippocampal subregions revealed by high-resolution functional imaging, Journal of Neuroscience. 32: 6550-60. PMID: 22573677.
38. Kern K., **Ekstrom A.D.**, Suthana N.A., Giesse, B.S., Montag M.S., Arshanapalli A., Bookheimer S., Sicotte N. (2012). Fornix Damage Limits Verbal Memory Functional Compensation in Multiple Sclerosis. Neuroimage. 59(3):2932-40. PMID: 22001266.
39. Staba R.J., **Ekstrom, A.D.**, Suthana N.A., Burggren A., Fried I., Engel J. Jr, Bookheimer S.Y. (2012). Gray matter loss correlates with mesial temporal lobe neuronal hyper-excitability inside the human seizure-onset zone. Epilepsia. 53(1):25-34. PMID: 22126325.
40. Lee D.J., Gurkoff G.G., Izadi A., Berman R.F., **Ekstrom A.D.**, Mulzelaar P., Lyeth B., Shahlie K. (2012). Medial septal nucleus theta frequency deep brain stimulation improves spatial working memory following traumatic brain injury. Journal of Neurotrauma. Epub. PMID: 23016534.
41. Watrous A., Fried I., & **Ekstrom A.D.** (2011). Behavioral correlates of human hippocampal delta and theta oscillations during navigation. Journal of Neurophysiology. 105:1747-55. PMID: 21289136.
42. **Ekstrom A.D.**, Copara M.S., Isham E.A., Wang W., and Yonelinas A.P. (2011). Dissociable networks involved in spatial and temporal order source retrieval. Neuroimage. 56: 1803-1813. PMID: 21334445.
43. Mukamel R., **Ekstrom A.D.**, Kaplan J., Iacoboni M., Fried I. (2011). Single-neuron responses in humans during execution and observation of actions. Current Biology. 2010:7. PMID: 20381353.
44. Suthana N., **Ekstrom A.D.,** Moshirvaziri S., Knowlton B., & Bookheimer S. (2011). Dissociations within human hippocampal subregions during encoding and retrieval of episodic spatial

information. Hippocampus. 21. 694-701. PMID: 20882543.

45. Isham E.A., **Ekstrom A.D.**, & Banks W.P. Effects of youth authorship on the appraisal of paintings. (2011). Psychology of Aesthetics, Creativity, and the Arts.
46. Isham EA, Banks WP, **Ekstrom AD**, Stern JA. (2011). Deceived and distorted: game outcome retrospectively determines the reported time of action. Journal of Experimental Psychology: Human Perception and Performance. 37: 1458-69.
47. Hsieh L.T., **Ekstrom A.D.**, and Ranganath C. (2011). Neural oscillations associated with item and temporal order maintenance in working memory. Journal of Neuroscience. 31: 10803-10. PMID: 21795532.
48. Addante R., Watrous A.J., Yonelinas A.P., **Ekstrom A.D.**, and Ranganath C. (2011). Pre-stimulus theta activity predicts correct source memory retrieval. Proceedings of the National Academy of Sciences. 108: 10702-7. PMID: 21670287.
49. Jacobs J., Kahana M.J., **Ekstrom A.D.,** Mollison M.V., & Fried I. (2011). A sense of direction in human entorhinal Cortex. Proceedings of the National Academy of Sciences. 107, 6487-6492. PMID: 20308554.
50. **Ekstrom A.D. (2010)**. How and when the fMRI BOLD signal relates to underlying neural activity: The danger in dissociation. Brain Research Reviews, 62(2):233-44. PMID: 20026191.
51. Jacobs J., Korolev I., Caplan J.B., **Ekstrom A.D**., Litt B., Baltuch G., Fried I., Schulze-Bonhage A., Madsen J., & Kahana M.J. (2010). Right-lateralized brain oscillations in human spatial navigation. Journal of Cognitive Neuroscience. 22, 824-836. PMID: 19400683.
52. Suthana N.A., Krupa A., Donix M., Burggren A., **Ekstrom A.D.**, Jones M., Ercoli L.M, Miller K.J., Siddart P., Small G.W., & Bookheimer S.Y. (2010). Reduced Hippocampal CA2, CA3 and Dentate Gyrus Activity in Asymptotic People at Genetic Risk For Alzheimer's Disease. Neuroimage. 53, 1077-1084. PMID:20005961.
53. Donix M, Burggren AC, Suthana NA, Siddarth P, **Ekstrom AD**, Krupa AK, Jones M, Martin-Harris L, Ercoli LM, Miller KJ, Small GW, Bookheimer SY. (2010). Family history of Alzheimer's disease and hippocampal structure in healthy people. The American Journal of Psychiatry, 167, 1399-1406. PMID: 20686185.
54. Donix M, Burggren AC, Suthana NA, Siddarth P, **Ekstrom AD**, Krupa AK, Jones M, Rao A, Martin-Harris L, Ercoli LM, Miller KJ, Small GW, Bookheimer SY. (2010). Longitudinal changes in medial temporal cortical thickness in normal subjects with the APOE-4 polymorphism. Neuroimage, 53, 37-43. PMID: 20541611.
55. **Ekstrom A.D.,** Bazih A.J., Suthana N.A., Al-Hakim R., Ogura K., Zeineh M., & Bookheimer S.Y. (2009). Advances in high-resolution imaging and computational unfolding of the human hippocampus. Neuroimage. 47, 42-49. PMID: 19303448.
56. Suthana N.A., **Ekstrom A.D.**, Moshirvaziri S., Knowlton B., & Bookheimer S.Y. (2009). Human Hippocampal CA1 involvement during allocentric encoding of spatial information. Journal of Neuroscience, 26, 10512-10519. PMID: 19710304.
57. **Ekstrom A.D.**, Suthana N.A., Millet D., Fried I., & Bookheimer S.Y. (2009). Correlation Between BOLD fMRI and Theta-band Local Field Potentials In the Human Hippocampal Area. Journal of Neurophysiology, 101, 2668-2678. PMID: 19244353.
58. **Ekstrom A.D.**, Suthana N.A., Behnke E., Salamon N., Bookheimer S.Y., & Fried I. (2008). High-Resolution depth electrode localization and imaging in patients with pharmacologically intractable epilepsy. Technical Note. Journal of Neurosurgery, 108, 812-5. PMID: 18377264.
59. **Ekstrom A.D.**, Suthana N.A., Millet D., Fried I., & Bookheimer S.Y. (2009). Correlation Between BOLD fMRI and Theta-band Local Field Potentials In the Human Hippocampal Area. Journal of Neurophysiology, 101, 2668-2678. PMID: 19244353.
60. Burggren A.C., Zeineh M.M., **Ekstrom A.D.**, Braskie M.N., Thompson P.M., Small G.W., & Bookheimer S.Y. (2008). Reduced cortical thickness in hippocampal subregions among cognitively normal apolipoprotein E e4 carriers. Neuroimage, 41, 1177-83. PMID: 18486492.
61. **Ekstrom A.D.,** Viskontas I., Kahana M.J., Jacobs J., Upchurch K., Bookheimer S.Y., & Fried I. (2007). Contrasting roles of neural firing rate and local field potentials in human memory. Hippocampus, 17, 606-617. PMID: 17546683
62. **Ekstrom A.D.,** & Bookheimer S.Y. (2007). Spatial and temporal episodic memory retrieval recruit dissociable functional networks in the human brain. Learning and Memory, 14, 645-654. PMID: 17893237.

63. Jacobs J., Kahana M., **Ekstrom A.D.**, & Fried, I. (2007). Brain oscillations control timing of single-neuron activity in humans. Journal of Neuroscience, 27, 3839-3844. PMID: 17409248
64. Viskontas I., **Ekstrom A.D.,** Wilson C.L., & Fried I. (2007). Characterizing interneuron and pyramidal cells in the human medial temporal lobe *in vivo* using extracellular recordings. Hippocampus,17:49:57. PMID: 17143903
65. **Ekstrom A.D.,** Caplan J.B., Ho E., Shattuck K., Fried I., & Kahana M.J. (2005). Human hippocampal theta activity during virtual navigation. Hippocampus, 15, 881-889. PMID: 16114040.
66. **Ekstrom A.D.,** Kahana M.J., Caplan J.B., Fields T.A., Isham E.A., Newman E., & Fried I. (2003). Cellular networks underlying human spatial navigation. Nature, 425, 184-188. PMID: 12968182.
67. **Ekstrom A.D.,** Meltzer J., McNaughton B.L., & Barnes C.A. (2001). NMDA receptor antagonism blocks experience-dependent expansion of hippocampal "place fields." Neuron, 31, 631-638. PMID: 11545721.
68. Redish A.D., Battaglia F.P., Chawla M.K., **Ekstrom A.D.**, Gerrard J.L., Lipa P., Rosenzweig E.S., Worley P.F., Guzowski J.F., McNaughton B.L., & Barnes C.A. (2001). Independence of firing correlates of anatomically proximate hippocampal pyramidal cells. Journal of Neuroscience, 21, 1-6. PMID:11222672.

Book Chapters

1. **Ekstrom A.D.** (2010). Navigation in virtual space: Psychological and neural Aspects. In Encyclopedia of Behavioral Neuroscience (eds. Koob, Thompson, and Le Moal).
2. Redish AD and **Ekstrom AD.** (2014). Hippocampus and related areas: What the place cell literature tells us about cognitive maps in rats and humans. In Handbook of Spatial Cognition. (eds. Waller & Nadel).
3. Kolark and **Ekstrom** (in press). The Neural Underpinnings of Spatial Memory and Navigation. In: Brain Mapping: An Encyclopedia. (eds: Toga & Poldrack).
4. Schedlbauer, A.M. and **Ekstrom A.D.** (in press). Memory & networks: Network-based approaches to understanding the neural basis of human episodic memory, in *Learning and Memory: A Comprehensive Reference*, J.H. Byrne, Editor., Elsevier.

D. Research Support (active)

BCS-1630296 Ekstrom (PI) 9/1/2016-8/31/2020
NSF
The neural basis of human spatial navigation in large-scale virtual spaces with vestibular input
A major gap in our knowledge about human spatial navigation regards the importance of vestibular and other proprioceptive cues (termed "body-based" cues). We propose to cross this barrier in our knowledge by developing a novel set-up in which participants freely ambulate on a 2-D treadmill with a head-mounted display, allowing for full range of motion during navigation. The expected outcomes from this project are a better understanding of how we represent large-scale spaces during free ambulation and the neural basis of direction and distance codes during enriched vs. impoverished body-based cues.
Role: PI

3R01NS076856 Ekstrom (PI) 7/01/12 – 6/30/17
NIH/NINDS amount: $250,000 / year
Representation and binding of spatiotemporal episodic memories in the human hippocampus
The hippocampus is critical for episodic memory, particularly in coding where and when events occurred. Neurodegenerative diseases such as stroke, epilepsy, and schizophrenia often impact hippocampal function and result in impairments to spatiotemporal episodic memory. Determining how and in what manner the human hippocampus represents space and time will advance our understanding of how damage to this area affects episodic memory.

2R21NS087527 Ekstrom (PI) no cost extension
NIH/NINDS amount: $195,000 / year
Mapping Human Memory with Electrocorticography & Chronometric Stimulation

A critical and unresolved issue regards how multiple brain regions interact as part of their roles in memory. Addressing this issue is important because the neural mechanisms necessary for episodic memory are not currently known. We will address this issue in humans by mapping the brain networks underlying episodic memory using graph theory, multilobular electrocorticographical recordings, and chronometric cortical stimulation.

1R03NS093052 Ekstrom (PI) 7/1/2015-6/31/2017
NIH/NINDS amount: $50,000 / year
Testing a Novel Theoretical Framework for the Human Medial Temporal Lobes in Perception and Memory During Spatial Navigation
Memory and navigation are two important yet poorly linked cognitive functions frequently affected by medial temporal lobe damage. Here, we propose a novel theoretical framework that helps to unify memory and navigation functions of the human medial temporal lobe. Because stroke frequently impacts medial temporal lobe function, one expected outcome is a better understanding of how stroke can impact multiple aspects of cognitive function. This in turn could inspire novel cognitive therapies focusing on both perceptual and mnemonic functions of the medial temporal lobes.
Role: PI

1R01NS08402 Gurkoff (PI) 2/01/2014 – 1/31/2019
NIH/NINDS $250,000/year
Restoring Connectivity Following Traumatic Brain Injury.
The goal of this grant is to assess how traumatic brain injury alters oscillations, particularly phase coherence across distal neural networks, during performance of cognitive tasks and to determine whether deep brain stimulation can be utilized to improve coherence and restore function.
Role: Co-Investigator

R01 AG003376 Barnes (PI) 10/1/15 – 09/31/20
NIH/NIA (Univ Arizona subcontract) $20,872 / year
Neurobehavioral Relations in Senescent Hippocampus
The objective of this research program is to understand the basis of memory impairments that result from normal aging in rhesus macaques.
Role: Co-Investigator

UC-Davis Alzheimer Disease Center Ekstrom (PI) 7/1/16-6/30/17
NIH/NIA $25,000
This grant provides pilot funding to study elderly participants and patients with mild cognitive impairments (MCI) during spatial navigation.
Role: Principal Investigator