

PSYC E-1620: Brain & Behavior in the Extremes

Course Overview and Contact Information

Semester and Year: Fall 2019; 2 hours once per week

Day/Times: Thursdays, 20:00h-22:00h

Location: 1 Story Street, Rm 302, Cambridge, MA

Course Format: On-campus or on-line.

Instructor: Vladimir Ivkovic, PhD; Instructor, Department of Psychiatry, Harvard Medical School; Director, Laboratory for Neuroimaging and Integrative Physiology, Neural Systems Group, Department of Psychiatry, Massachusetts General Hospital.

Office Location/Contact Information: Massachusetts General Hospital—East, Charlestown Navy Yard, 149 13th Street, Charlestown, MA 02129; Phone: 617-724-5550; Email: vivkovic@mgh.harvard.edu

Office Hours: Mondays 11:00am-12:00pm US-EST by appointment. Students are welcome to visit Dr. Ivkovic in his office at MGH-CNY 149, or chat via Skype.

Course Description and Learning Objectives

Prerequisites: No prerequisites. However, prospective students would benefit from completing introductory-level courses in psychology and human physiology prior to taking this course.

Intellectual Basis: Human neurophysiologic, cognitive, and behavioral performance continuously adapt to environmental pressures with the aim of improving fitness. Shaped by evolutionary forces, human neurobehavioral performance is capable of rapid (re)adaptation to extreme novel environmental pressures such as those experienced by individuals exposed to isolated, confined, and extreme (ICE) environments. Of all the human physiologic systems, the Central Nervous System (CNS) is the most adaptive to environmental pressures, and thus most prone to change during exposure to extreme environments, and upon return to baseline environments. Yet, the CNS is central to regulation of human performance and dynamically interacts with other physiologic systems adapting to the varying modalities of challenging extreme environmental conditions.

Course Description: What happens to the human brain and behavior when we are exposed to isolated, confined, and extreme environments? Examples include spaceflight, high altitude flights / mountaineering, submersed / underwater activities, polar / desert / jungle exploration, etc. This course covers the effects of extreme environmental exposures on major physiologic systems and the resulting effects on neurophysiologic and neurobehavioral performance and (re)adaptation. These topics are augmented by contemporary findings from research studies conducted in operational environments and are discussed in the context of history, systems, experimental methods, and research paradigms used in extreme environmental physiology / translational neuroscience. Theoretical concepts and research findings are evaluated relative to their utility in developing functional countermeasures for extreme human habitation as well as methods for clinical treatment of related medical conditions in the general population. As such, this course may be particularly interesting to students pursuing careers in translational neuroscience, psychology, extreme physiology/medicine, and human performance in extreme environments. This class will feature expert guest lecturers (e.g. NASA researchers, Antarctic physicians, etc.) and demonstrations of unique experimental methodologies and equipment used in isolated, confined, and extreme environments. In this class, I hope to provide the students with the theoretical and practical knowledge that will be relevant to their professional experiences and interests, and would support their future career development.

Learning Outcomes: Upon successful completion of this course, the students will have:

- 1) Understanding of the physiologic and behavioral challenges posed by exposure to extreme environments (e.g. spaceflight, high altitude flights/mountaineering, submersed/underwater activities, polar/desert/jungle exploration, etc.);
- 2) Understanding of the neurophysiologic mechanisms governing functional (re)adaptation to extreme environments;
- 3) Understanding of the mechanistic relationship between neurobehavioral (re)adaptation to extreme environments and the associated medical conditions;
- 4) Understanding of the process of design, development, and application of countermeasures for neurobehavioral (re)adaptation to extreme environments;
- 5) Practical exposure to research tools, methodologies, and operational strategies used for monitoring of human brain and neurobehavioral performance in extreme environments, clinical practices and countermeasures for mitigation of associated medical conditions;
- 6) Discussed experimental research findings on neurophysiologic and behavioral (re)adaptation to extreme environmental pressures;
- 7) Presented their work in a public forum to scientists and non-scientists alike, and written a structured term paper following rigorous scientific writing standards.

The first class will consist of syllabus presentation, introduction to the course format and expectations, and a brief introduction to study of neurophysiologic and neurobehavioral adaptations to extreme environments. The next four classes will consist of 90-minute lectures by the instructor followed by a 30-minute in-class/online discussion. Each consecutive class will include a 60-minute lecture on the scheduled topic by the instructor, followed by a 10-minute in-class/online discussion. The remaining class time will be dedicated to (i) two 15-minute student presentations on specific aspects of the scheduled class topic, (ii) two follow-up 5-minute in-class/online discussion sessions, and (iii) one 10-minute weekly literature review/update.

Course Materials

Course Materials: Lectures, sample presentation/term paper topics, assignments, video/audio recordings, and course readings (see sample below) will be available to students on the course web page. The course will include online assignments. Students attending the course online will need to have fast internet access, noise-cancelling headphones, video/audio streaming technology (to follow and deliver live on-line presentations to the class) and should be able to log into class website to attend and participate in the course in real time.

Readings: Course readings will be assigned for each class, and will include book chapters, review papers, and original peer-review manuscripts. The list of reading is not exhaustive—new reading assignments will be posted on-line at least one week prior to class they are required for. The instructor will post new reading assignment updates on-line and notify the students by email. Prior to each class meeting, students are expected to complete the designated readings. Completing course readings is necessary to fully participate in class activities, benefit from the subject matter information on each topic, and prepare for the scheduled quizzes and exams.

Grading

The final grade for the class will be calculated from the following student contributions:

- Skills Check (0%): A 30-question multiple choice online quiz will be available during one week prior to the first class, and due by 11:59pm on Wednesday, September 4, 2019. The

content of the skills check quiz will cover basic concepts in neurophysiology, psychology, extreme physiology.

- Participation (20%): Class participation (Q&As, discussions, literature update contributions) are mandatory, and will be evaluated by the instructor.
- 5 Online quizzes (25%): Non-cumulative review quizzes will be given online after completing each 20% topic increments. Each quiz will consist of 20 multiple choice questions. One attempt for each quiz will be allowed, and they will be available for one week. No make-up quizzes or extensions will be given. The content of quizzes for graduate students will be more advanced compared to quizzes for undergraduate students.
- 1 Presentation (25%): A 15-minute presentation on a student-selected aspect of a course topic/unit will be given to class by each student. The presentation will be developed using verified literature resources, with topic approved by the instructor, and can be delivered in-class or online. At least one week prior to the class at which they will present, each student will upload one comprehensive review article and one original research paper on their topic of choice. Each student's task, when presenting, will be to give the class an overview of their topic and describe several research reports in this area (including the uploaded original research paper). The presentation will be evaluated on content, relevance of cited literature, scientific rigor, and delivery. Once scheduled, no presentation extensions will be given.
- 1 Term Paper (30%): Original paper on a student-selected aspect of a course topic/unit will be written by each student. Term paper outline and preliminary list of bibliographic references must be uploaded via course website by 11:59pm on Thursday, October 31, 2019. The final version of the term paper must be submitted via course website by 11:59pm on the last day of class, Thursday, December 19, 2019. The paper should not exceed 5,000 words for undergraduate and 7000 words for graduate students, excluding references, and be written using verified literature resources, with topic approved by the instructor. The paper will be evaluated on content quality, relevance of cited literature, and scientific / methodological rigor. No deadline extensions for Term Paper will be given.

Note: Students will select the presentation and term paper topics and upload them via course website no later than 11:59pm on September 26, 2019. These will be reviewed by the instructor to verify viability of selected topics. Presentation and term paper topics cannot be the same, but subject matter overlap is allowed. Students are encouraged to select presentation and term paper topics relevant to their professional experience, activities, and interests.

Course assignment and final grades will be determined according to the scales below. The grading standards will be different for undergraduate and graduate students.

Letter Grade	Undergraduate % Range	Graduate % Range
A	90-100	93-100
A-	87-89	90-92
B+	84-86	87-89
B	80-83	83-86
B-	77-79	80-82
C+	73-76	77-79
C	70-72	73-76
C-	67-69	70-72
D+	63-66	67-69
D	60-62	63-66
D-	57-59	60-62
F	<57	<60

Expectations and Policies

Attendance: Attendance (in-class or online) is mandatory and will be evaluated directly by the instructor based on attendance records. One absence from class will be allowed if appropriate justification is provided. Unless special approval is provided ahead of time, additional absences will incur a 5% deduction from the cumulative course grade. You cannot arrive late or leave early. If you are traveling from afar or connecting on-line, please plan accordingly giving yourself plenty of time to arrive/log in by the start of class. No exceptions can be granted.

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Course Outline and Schedule

Class 1: Thursday, September 5

- Introduction to the syllabus, course expectations and requirements;
- *Introduction to Extreme Environments* [Isolated, confined, and extreme environments (ICE) defined; Deep underwater; Deserts; Mountains; Space (orbital, gravitational bodies); Isolation and confinement; Environmental and atmospheric extremes; Relevance to studies of human physiology, neuroscience, and medicine].

Assigned Reading: Syllabus.

Thursday, September 9, 2019: Course change period ends.

Class 2: Thursday, September 12

- *Exploring Beyond the Horizon—History of Human Exploration* [Homo sapiens—evolutionary benefits of exploration; The Age of Discovery; Exploration: oceanographic, geographic, atmospheric, space; The great explorers];
- *Expeditionary and Occupational Extreme Environments* [Exploration as component of military activities and operational deployments; Firefighting—continuing exposure to environmental extremes in urban and wildland settings; Astronautics and human space exploration; Underwater activities; Mountaineering].

Assigned Reading: McPhee J.C. & Charles J.B. “Human Health and Performance Risks of Space Exploration Missions”. NASA, Houston, 2010.

Class 3: Thursday, September 19

- *Extreme Environmental Physiology* [Operational extreme/integrative physiology; Integration of systems physiology in extreme environments (central/peripheral nervous, cardiovascular/pulmonary, musculoskeletal, endocrine); physiologic processes and metabolism (energy sources, storage and expenditure, physical activity and oxygen supply; Nutrition; Homeostasis, evolutionary adaptations, and human variability];

Assigned Reading: Gunga, H-C. “Human Physiology in Extreme Environments”. Elsevier Academic Press, London, 2015, selected text from various chapters; Castellini M (2012) Life under water: physiological adaptations to diving and living at sea. *Compr. Physiol.* 2(3): 1889-1919. doi: 10.1002/cphy.c110013; Zuccarelli L, Galasso L, Turner R, Coffey EJB, Bessone L, Strapazon G (2019) Human Physiology During Exposure to the Cave Environment: A Systematic Review With Implications for Aerospace Medicine. *Front Physiol.* 10:442. doi: 10.3389/fphys.2019.00442. eCollection 2019.

Thursday, September 19, 2019, 11:59pm: Online quiz #1 due.

Class 4: Thursday, September 26

- *Translational Neuroscience in Extreme Environmental Contexts* [From clinical needs to extreme environmental challenges and back; Brain plasticity and functional adaptations; Perception; Sensorimotor function; Cognition; Orientation; Locomotion; Cerebral auto-regulation; Sleep deprivation; Disorders of the nervous system in extreme environments].

Assigned Reading: Strangman G.E., Sipes W., Beven G. (2014) Human Cognitive performance in spaceflight and analogue environments. *Aviat Space Environ Med.* 85(10): 1033-1048; Barkazsi I., et al. (2016) Extreme environmental effects on cognitive functions: A longitudinal study in high altitude in Antarctica. *Front Humn Neurosci.* 10: 331-342.

Thursday, September 26, 2019, 11:59pm: Presentation and Term Paper topics must be uploaded via course website.

Class 5: Thursday, October 3

- *Research Paradigms and Methodologies* [Research analogs; Technological advances; Wearable technologies—promise and limitations; Monitoring systemic and psychophysiology, brain function, and behavior in extreme vs. clinical environments; Where extreme environmental and clinical research methodologies converge];

- *Tools, Vehicles, and Habitats* [Physiologic boundaries; Technological and engineering constraints; Exploration vehicles—from canoes to spaceships; Exploration habitats—polar outposts, submersibles, analogs, space stations; Environmental control and life support systems (ECLSS)];
- *State of the Art Technologies for Monitoring Brain and Psychophysiologic Functions in Extreme Environments* [Ambulatory brain imaging and physiologic monitoring for assessment of neurobehavioral health and operational performance in extreme environments].

Assigned Reading: Lowe M., et al. (2007) Neuropsychological assessment in extreme environments. *ArchClin Neuropsych*, 22S, S89-S99; Hu G, Zhang Q, Ivkovic V, Strangman G Ambulatory diffuse optical tomography and multi-modality physiological monitoring system for muscle and exercise applications. *Journal of Biomedical Optics* 2016 21(9): 091314. doi: 10.1117/1.JBO.21.9.091314; Strangman GE, Ivkovic V, Zhang Q Wearable brain imaging and multi-modal physiological monitoring system. *Journal of Applied Physiology* (1985). 2018 124(3): 564-572; Cosic K, Sarlija M, Ivkovic V, Zhang Q, Strangman GE, Popovic S (2019) Stress resilience assessment based on physiological features in selection of air traffic controllers. *IEEE Access*. e-ISSN: 2169-3536, 7: 41989-42005.

Class 6: Thursday, October 10

- *Integrative Physiologic Effects of Extreme Environments on Brain Function* [Pressure extremes in diving, climbing, and flying (hypobaric, hyperbaric); Environmental extremes (desert, tropical, and polar environments, thermoregulation, adaptation / acclimatization / acclimation / habituation); Spaceflight (microgravity, radiation, circadian disruption and sleep deprivation); Alterations in sensorimotor function and perception];
- Student presentations

Assigned Reading: Rai B, Foing BH, Kaur J (2012) Working hours, sleep, salivary cortisol, fatigue and neuro-behavior during Mars analog mission: five crews study. *Neurosci. Lett.* 516(2):177-81. doi: 10.1016/j.neulet.2012.03.067; Gunga, H-C. "Human Physiology in Extreme Environments". Elsevier Academic Press, London, 2015; selected text from various chapters; Ponganis PJ (2019) State of the art review: from the seaside to the bedside: insights from comparative diving physiology into respiratory, sleep and critical care. *Thorax*. 74(5):512-518. doi: 10.1136/thoraxjnl-2018-212136.

<i>Thursday, October 10, 2019, 11:59pm: Online quiz #2 due.</i>

Class 7: Thursday, October 17

- *Neurobehavioral Adaptations to Extreme Environments* [Effects of isolation, confinement, disruptive scheduling, circadian disruption, fatigue; Habitability; Sleep, immune function, and neurocognitive performance];
- Student presentations.

Assigned Reading: Mallis MM, DeRoshia CW (2005) Circadian rhythms, sleep, and performance in space. *Aviat. Space. Environ. Med.* 76(6 Suppl):B94-107; Basner M, Rao H, Goel N, Dinges DF (2013) Sleep deprivation and neurobehavioral dynamics. *Curr. Op. Neurobio.*, 23: 854-863; Mairesse O, MacDonald-Nethercott E, Neu D, Tellez HF, Dessy E, Neyt X, Meeusen R, Pattyn N. (2019) Preparing for Mars: human sleep and performance during a 13 month stay in Antarctica. *Sleep* 1;42(1). doi: 10.1093/sleep/zsy206.

Class 8: Thursday, October 24

- *Neurobehavioral Health as a Limiting Factor of Human Performance in Extreme Environments* [Operational performance; Social interactions; Management of psychological stress; Psychiatric disorders; Contemporary countermeasures for neurobehavioral disorders];
- Student presentations.

Assigned Reading: Harrison AA (2005) Behavioral health: integrating research and application in support of exploration missions. *Aviat. Space. Environ. Med.* 76(6 Suppl): B3-12; Flynn BW, Speier AH (2014) Disaster behavioral health: legal and ethical considerations in a rapidly changing field. *Curr Psychiatry Rep.* 16(8):457. doi: 10.1007/s11920-014-0457-9; Nindl BC, Billing DC, Drain JR, Beckner ME, Greeves J, Groeller H, Teien HK, Marcora S, Moffitt A, Reilly T, Taylor NAS, Young AJ, Friedl KE. (2018) Perspectives on resilience for military readiness and preparedness: Report of an international military physiology roundtable. *J Sci Med Sport.* 21(11): 1116-1124. doi: 10.1016/j.jsams.2018.05.005.

Class 9: Thursday, October 31

- *Psychological Challenges to Human Neurobehavioral Performance in Extreme Environments* [Isolation and confinement; Limited control of mission outcomes; High-risk conditions and potential for loss of life; Mission complexity; Hostile environments; Alterations in sensory stimuli; Sleep disruption; Limited habitability (e.g. hygiene)];
- *Countermeasures* [Defining countermeasure; Countermeasures for behavioral and (operational) performance; Countermeasures for neurocognitive decline; Countermeasures for psychophysiological stress management and resilience];
- Student presentations.

Assigned Reading: Palinkas LA and Suedfeld P (2008) Psychological effects of polar expeditions. *Lancet.* 371(9607):153-63; Leach J (2016) Psychological factors in exceptional, extreme, and torturous environments; Leach J. (2018) *Extrem Physiol Med*, 5:7; 'Give-up-itis' revisited: Neuropathology of extremis. *Med Hypotheses.* 120:14-21. doi: 10.1016/j.mehy.2018.08.009.

Thursday, October 31, 2019, 11:59pm: Term paper outline and preliminary list of bibliographic references must be uploaded via course website; Online quiz #3 due.

Class 10: Thursday, November 7

- *Psychosocial Challenges to Human Neurobehavioral Performance in Extreme Environments* [Interpersonal communication; Team/crew coordination demands; Family life disruption; Enforced interpersonal contacts; Team/Crew factors (gender, size, personality, etc.); Multicultural issues; Host-Guest phenomenon; Social conflict];
- Student presentations.

Assigned Reading: Palinkas LA (1992) Going to extremes: the cultural context of stress, illness and coping in Antarctica. *Soc. Sci. Med.* 35(5):651-64; Vanhove A.J. et al. (2014) Examining psychosocial well-being and performance in isolated, confined, and extreme environments. NASA;

Class 11: Thursday, November 14

- *Human Factors Affecting Neurobehavioral Performance in Extreme Environments* [High and low workload; None/limited ability to communicate with “outside” world; Limited equipment, facilities, and supplies; Risks from mission and equipment failure; Adaptation to artificial habitat/environment; Food restrictions/limitations; Technology interface challenges];
- Student presentations.

Assigned Reading: Johnston JH, Phillips HL, Milham LM, Riddle DL, Townsend LN, DeCostanza AH, Patton DJ, Cox KR, Fitzhugh SM (2019) A Team Training Field Research Study: Extending a Theory of Team. Development..Front. Psychol. 10:1480. doi: 10.3389/fpsyg.2019.01480.

Class 12: Thursday, November 21

- *Guest Lecture – Maintaining Physical and Mental Health at the Edge of the World: Antarctica;*
- Student presentations.

Assigned Reading: Sandal GM, van deVijver FJR, Smith N. Psychological Hibernation in Antarctica. Front. Psychol. 9: 2235. doi: 10.3389/fpsyg.2018.02235; Moiseyenko YV, Sukhorukov VI, Pyshnov GY, Mankovska IM, Rozova KV, Miroshnychenko OA, Kovalevska OE, Madjar SA, Bubnov RV, Gorbach AO, Danylenko KM, Moiseyenko OI (2016) Antarctica challenges the new horizons in predictive, preventive, personalized medicine: preliminary results and attractive hypotheses for multi-disciplinary prospective studies in the Ukrainian "Akademik Vernadsky" station. EPMA J. 7:11. doi: 10.1186/s13167-016-0060-8

Thursday, November 21, 2019, 11:59pm: Online quiz #4 due.

Friday, November 22, 2019: Last day to withdraw from a class.

NO CLASS: Thursday, November 28

Wednesday, November 27, 2019 – Sunday, December 1, 2019: Thanksgiving vacation

Class 13: Thursday, December 5

- *Habitability Challenges to Human Neurobehavioral Performance in Extreme Environments* [Limited hygiene; Chronic exposure to vibration, noise, etc.; Limited sleep facilities; Artificial lighting/illumination; Lack of privacy; Isolation from environmental and psychosocial support systems];
- Student presentations.

Assigned Reading: Whitmore M, McQuilkin ML, Woolford BJ. (1998) Habitability and performance issues for long duration space flights. Hum Perf Extrem Environ. 3(1): 64-74; Whitmore M, Adolf JA, Woolford BJ (2000) Habitability research priorities for the International Space Station and beyond. Aviat. Space Environ. Med. 71(9 Suppl): A122-5.

Class 14: Thursday, December 12

- *Current Research on Neurobehavioral Performance in Extreme Environments* [Spaceflight and analog environments (International Space Station (ISS), Human Exploration Research Analog (HERA), NASA Extreme Environment Mission Operations

(NEEMO); Oceanographic vessels and Antarctic polar outposts (McMurdo, Concordia, etc.); United States Army Research Institute of Environmental Medicine (USARIEM); Boston Fire Department Training Academy (BFDTA);

- *Synergy and Future Applications* [Analog studies and applications in clinical sciences/medicine];
- Student presentations.

Class 15: Thursday, December 19

- Course review, questions and answers, future directions and professional opportunities.
- Student presentations

Friday, December 13, 2019 – Thursday, December 19, 2019: Final exams and final class meetings.

Thursday, December 19, 2019, 11:59pm: Final version of the Term Paper must be uploaded via course website; Online quiz #5 due.

Thursday, January 2, 2020: Grades due online.