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*CORRESPONDENCE
Thomas Hartung
THartung@jhu.edu

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The Baltimore declaration toward the exploration of organoid intelligence

Thomas Hartung[1,2*], Lena Smirnova[1], Itzy E. Morales Pantoja[1], Akwasi Akwaboah[3], Dowlette-Mary Alam El Din[1], Cynthia A. Berlinicke[4], J. Lomax Boyd[5], Brian S. Caffo[6], Ben Cappiello[7], Tzahi Cohen-Karni[8,9], J. Lowry Curley[7], Ralph Etienne-Cummings[3], Raha Dastgheyb[10], David H. Gracias[11,12,13,14,15,16], Frederic Gilbert[17], Christa Whelan Habela[10], Fang Han[18], Timothy D. Harris[19,20], Kathrin Herrmann[1], Eric J. Hill[21], Qi Huang[11], Rabih E. Jabbour[22], Erik C. Johnson[20], Brett J. Kagan[23], Caroline Krall[1], Andre Levchenko[24], Paul Locke[1], Alexandra Maertens[1], Monica Metea[25], Alysson R. Muotri[26,27], Rheinallt Parri[28], Barton L. Paulhamus[20], Jesse D. Plotkin[1], Paul Roach[29], July Carolina Romero[1], Jens C. Schwamborn[30], Fenna Sillé[1], Alexander S. Szalay[31,32,33], Katya Tsaioun[1], Daniel Tornero[34,35], Joshua T. Vogelstein[36], Karl J. Wahlin[37] and Donald J. Zack[38,39,40,41]

[1]Center for Alternatives to Animal Testing (CAAT), Department of Environmental Health and Engineering, Bloomberg School of Public Health and Whiting School of Engineering, Johns Hopkins University, Baltimore, MD, United States, [2]Center for Alternatives to Animal Testing (CAAT)-Europe, University of Konstanz, Konstanz, Germany, [3]Department of Electrical and Computer Engineering, Johns Hopkins University, Baltimore, MD, United States, [4]Wilmer Eye Institute, Johns Hopkins University School of Medicine, Baltimore, MD, United States, [5]Berman Institute of Bioethics, Johns Hopkins University, Baltimore, MD, United States, [6]Department of Biostatistics, Johns Hopkins Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, United States, [7]AxoSim Inc., New Orleans, LA, United States, [8]Department of Biomedical Engineering in Carnegie Mellon University, Pittsburgh, PA, United States, [9]Department of Materials Science and Engineering in Carnegie Mellon University, Pittsburgh, PA, United States, [10]Department of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD, United States, [11]Department of Chemical and Biomolecular Engineering, Johns Hopkins University, Baltimore, MD, United States, [12]Department of Chemistry, Johns Hopkins University, Baltimore, MD, United States, [13]Department of Materials Science and Engineering, Johns Hopkins University, Baltimore, MD, United States, [14]Laboratory for Computational Sensing and Robotics (LCSR), Johns Hopkins University, Baltimore, MD, United States, [15]Center for Microphysiological Systems (MPS), Johns Hopkins University School of Medicine, Baltimore, MD, United States, [16]Oncology and Sidney Kimmel Comprehensive Cancer Center, Johns Hopkins University School of Medicine, Baltimore, MD, United States, [17]Philosophy Program, School of Humanities, University of Tasmania, Hobart, TAS, Australia, [18]Department of Statistics and Economics, University of Washington, Seattle, WA, United States, [19]Janelia Research Campus, Howard Hughes Medical Institute, Ashburn, VA, United States, [20]Research and Exploratory Development Department, Johns Hopkins University Applied Physics Laboratory, Laurel, MD, United States, [21]School of Biosciences, College of Health and Life Sciences, Aston University, Birmingham, United Kingdom, [22]Bioscience and Biotechnology Department, University of Maryland, Rockville, MD, United States, [23]Cortical Labs, Melbourne, VIC, Australia, [24]Biomedical Engineering Department, Yale Systems Biology Institute, Yale University, New Haven, CT, United States, [25]Preclinical Electrophysiology Consulting, LLC, Mattapoisett, MA, United States, [26]Departments of Pediatrics and Cellular & Molecular Medicine, School of Medicine, University of California, San Diego, La Jolla, CA, United States, [27]Center for Academic Research and Training in Anthropogeny (CARTA), Kavli Institute for Brain and Mind, Archealization Center (ArchC), University of California, San Diego, La Jolla, CA, United States, [28]Aston Pharmacy School, College of Health and Life Sciences, Aston University, Birmingham, United Kingdom, [29]Department of Chemistry, School of Science,

Loughborough University, Leicestershire, United Kingdom, [30]Luxembourg Centre for Systems Biomedicine (LCSB), University of Luxembourg, Belvaux, Luxembourg, [31]Department of Computer Science, Whiting School of Engineering, Johns Hopkins University, Baltimore, MD, United States, [32]Department of Physics and Astronomy, Krieger School of Arts and Sciences, Johns Hopkins University, Baltimore, MD, United States, [33]Mark Foundation Center for Advanced Genomics and Imaging, Johns Hopkins University, Baltimore, MD, United States, [34]Department of Biomedical Sciences, Institute of Neuroscience, University of Barcelona, Barcelona, Spain, [35]Clinic Hospital, August Pi i Sunyer Biomedical Research Institute (IDIBAPS), Barcelona, Spain, [36]Department of Biomedical Engineering, Johns Hopkins University, Baltimore, MD, United States, [37]Viterbi Family Department of Ophthalmology & the Shiley Eye Institute, University of California, San Diego, La Jolla, CA, United States, [38]Department of Ophthalmology, Johns Hopkins University School of Medicine, Baltimore, MD, United States, [39]Department of Molecular Biology and Genetics, Johns Hopkins University School of Medicine, Baltimore, MD, United States, [40]Department of Genetic Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, United States, [41]Department of Neuroscience, Johns Hopkins University School of Medicine, Baltimore, MD, United States

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An Editorial on the Frontiers in Science Lead Article

Organoid intelligence (OI): the new frontier in biocomputing and intelligence-in-a-dish

We, the participants of the First Organoid Intelligence Workshop – "Forming an OI Community" (22–24 February 2022), call on the international scientific community to explore the potential of human brain-based organoid cell cultures to advance our understanding of the brain and unleash new forms of biocomputing while recognizing and addressing the associated ethical implications.

The term "organoid intelligence" (OI) has been coined to describe this research and development approach (1) in a manner consistent with the term "artificial intelligence" (AI) – used to describe the enablement of computers to perform tasks normally requiring human intelligence.

OI has the potential for diverse and far-reaching applications that could benefit humankind and our planet, and which urge the strategic development of OI as a collaborative scientific discipline. OI holds promise to elucidate the physiology of human cognitive functions such as memory and learning. It presents game-changing opportunities in biological and hybrid computing that could overcome significant limitations in silicon-based computing. It offers the prospect of unparalleled advances in interfaces between brains and machines. Finally, OI could allow breakthroughs in modeling and treating dementias and other neurogenerative disorders that cause an immense and growing disease burden globally.

Realizing the world-changing potential of OI will require scientific breakthroughs (1). We need advances in human stem cell technology and bioengineering to recreate brain architectures and to model their potential for pseudo-cognitive capabilities. We need interface breakthroughs to allow us to deliver input signals to organoids, measure output signals, and employ feedback mechanisms to model learning processes. We also need novel machine learning, big data, and AI technologies to allow us to understand brain organoids.

In addition to confronting these scientific and technical challenges, we also need to anticipate (as far as possible) and address the significant and largely unexplored ethical challenges associated with this research. We must be alert to any possibility that organoids could develop forms or aspects of consciousness and mitigate and safeguard against this. The cell donor's personal rights and interests are among other important considerations. These issues warrant stringent, ongoing discussions throughout the development of OI toward an accepted ethical framework. Such discussions should include all relevant stakeholders and take due account of public values.

We are only just beginning this multidisciplinary and multistakeholder endeavor. The potential benefits are world-changing, but the challenges are daunting. We call on the scientific community to join us on this journey. Only by collaborating will we be able to realize the full potential of OI to advance science, technology, and medicine.

Author contributions

TH, LS, and IMP drafted the Declaration. All authors reviewed and approved the final version.

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Conflict of interest

TH is employed by, and inventor on a patent by Johns Hopkins University on the production of brain organoids, which is licensed to AxoSim, New Orleans, LA, USA, and receives royalty shares. TH also consults for AxoSim. LS is employed by Johns Hopkins University and consults for AxoSim, New Orleans, LA, USA. BC and JLC are employed by AxoSim. JS is employed by, and inventor on a patent by the University of Luxembourg on the production of midbrain organoids, which is licensed to OrganoTherapeutics SARL, Esch-sur-Alzette, Luxembourg. JS is also co-founder and shareholder of OrganoTherapeutics SARL.

ARM is employed by the University of California, San Diego and is co-founder and has equity interest in TISMOO, a company dedicated to genetic analysis and human brain organogenesis, focusing on therapeutic applications customized for autism spectrum disorders and other neurological disorders origin genetics. The terms of this arrangement have been reviewed and approved by the University of California, San Diego, in accordance with its conflict of interest policies. BK is employed by Cortical Labs Pty Ltd, Melbourne, Australia, and is an inventor on patents for technology related to this article, and holds shares in Cortical Labs Pty Ltd, Melbourne, Australia. MM is employed by and owner of Preclinical Electrophysiology Consulting, LLC. Preclinical Electrophysiology Consulting, LLC does not have any commercial or financial relationships that could be construed as a potential conflict of interest.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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