DARPA-EA-24-01-04
Investigating how Neurological Systems Process Information in REality (INSPIRE)

Are there new ways to explore and describe how functional neural systems store and process information that expand beyond the limits of digital representations?

I. ARC Opportunity

The Defense Advanced Research Projects Agency (DARPA) Defense Sciences Office (DSO) is issuing an Advanced Research Concepts (ARC) Opportunity, inviting submissions of Abstracts for innovative exploratory research concepts in the technical domain of Experimental and Computational Neuroscience. This ARC Opportunity, Investigating how Neurological Systems Process Information in REality (INSPIRE), is issued under the master ARC Exploration Announcement (EA), DARPA-EA-24-01.

ARC Opportunities are designed to allow an individual researcher the opportunity and time to focus on nascent, paradigm-shifting ideas for national security applications. While multiple researchers from the same organization may be proposed, the aggregate level of effort for a proposed research concept is expected to be equivalent to one full-time equivalent (FTE) and 12 months, as ARC topics are designed for ideas that nominally would take a full year effort (1 FTE over 1 year) to properly validate. DARPA expects that the individual(s) working on the proposed idea primarily focus on the effort for the entire period of performance to the maximum extent practical. Only minimal variation to this requirement will be accepted. The maximum period of performance is 12 months. Each ARC award's total cost is expected to range from $100,000 to $300,000, including direct and indirect costs and graduate student tuition, if applicable. Proposed costs are limited to $10,000 or less for materials, equipment, and Other Direct Costs (ODC). Under no circumstances will profit be authorized. While resource sharing is not expected, it may be offered in the proposal. DARPA understands that not all ideas and organizations may fit in this parameter range and will work with a proposer to ensure truly innovative ideas can be explored with the required resources. Travel and publication costs may not be proposed. No subawardees are permitted.

To view the latest amendment of the DARPA Exploration Announcement, visit SAM.gov under solicitation number DARPA-EA-24-01: https://sam.gov/opp/179ef7e5199e4e6daea1615631f4a81f/view. It is incumbent upon the proposer to review DARPA-EA-24-01, any resulting amendments to DARPA-EA-24-01, and Frequently Asked Questions (FAQs) before preparing and submitting an Abstract and/or an Oral Proposal Package (OPP) (if invited). All Abstract submissions to this announcement must adhere to the instructions contained in DARPA EA-24-01.

All technical, contractual, and administrative questions regarding this notice must be emailed to INSPIRE@darpa.mil. This ARC Opportunity is soliciting Abstracts only. DARPA will evaluate Abstracts submitted in response to this ARC Opportunity, as detailed in Section 4 of the latest amendment issued against DARPA-EA-24-01. If the Government selects an Abstract for an Oral Presentation, the Government will issue an invitation to submit an OPP. The invitation will include the submission instructions and deadline.

All awards made as a result of the ARC Opportunity will be Research Other Transactions (OTs) awarded under the authority of 10 U.S.C. § 4021.

Abstracts submitted to this ARC Opportunity will be evaluated on a rolling basis in accordance with the latest amendment issued against DARPA-EA-24-01. The end of the submission period is January 31, 2025 at 4:00 p.m. Eastern Time. No Abstracts will be accepted after the end of the submission period. Proposers are encouraged to submit Abstracts as early as possible. Funding for this ARC Opportunity is limited. Should funding be exhausted, the Government may elect to shorten the overall submission period with an amendment to this ARC Opportunity.

II. ARC Opportunity Description

How the brain stores and processes information remains a mystery, despite incredible discoveries and advancements in the field of neuroscience over the last century. The field of neuroscience has operated under the overarching idea that the brain processes information in a digital fashion based on firing rate of neurons. This concept has informed countless experiments, neurotechnology, and computational analysis of experimental data. However, evidence shows that digital-only models are insufficient to explain the brain's computational power and complexity, and that neurological systems store information in other ways that could illuminate how the brain represents reality. For example, grid cells,[1] place cells,[2] and time cells[3] are neurons that possess a representation of where the brain is in time and space. Current experimental frameworks and computational capabilities are inadequate for exploring how the brain processes information in ways beyond a purely digital fashion. Recent advances enable novel opportunities for experimentation, such as brain organoids,[4] which allow experimental neuroscience to precisely manipulate and understand systems in ways previously not possible in animal models. The INSPIRE ARC opportunity is soliciting ideas to explore the question: Are there new ways to explore and describe how functional neural systems store and process information that expand beyond the limits of digital representations?

A. ARC Opportunity Technical Objective

The INSPIRE ARC urges performers to go back to fundamentals and consider novel, paradigm-shifting questions about how the brain and neurological systems construct reality. For a century, the field has relied on firing rate to explain how the brain stores and processes information. This has led to numerous neurotechnologies focused on precise spike recording tools, yet we know these models are overly simplistic to explain the variety and complexity of perception and cognition[5]. INSPIRE aims to explore new fundamental theories of how neurological systems may store and process information, which could inform the next generation of neurotechnologies and

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[1] Moser, Edvard I., et al. "Grid cells and cortical representation." *Nature Reviews Neuroscience* 15.7 (2014): 466-481.
[2] O'Keefe, John. "Place units in the hippocampus of the freely moving rat." Experimental neurology 51.1 (1976): 78-109.
[3] Eichenbaum, Howard. "Time cells in the hippocampus: a new dimension for mapping memories." Nature Reviews Neuroscience 15.11 (2014): 732-744.
[4] Lancaster, Madeline A., et al. "Cerebral organoids model human brain development and microcephaly." Nature 501.7467 (2013): 373-379.
[5] Queenan BN, Ryan TJ, Gazzaniga MS, Gallistel CR. On the research of time past: the hunt for the substrate of memory. Ann N Y Acad Sci. 2017 May;1396(1):108-125. doi: 10.1111/nyas.13348. PMID: 28548457; PMCID: PMC5448307.

tools for accurately and precisely measuring neural function. All performers should address the overarching goal of discovering new fundamental theories in neuroscience with the potential for further foundational insights or development of novel technologies.

INSPIRE performers may conduct experiments on neurological systems (e.g., brain organoids, invertebrates, or other models) including, but not limited to:

- Precise measurement of functional neural units beyond firing rate
- Teaching brain organoids novel tasks to explore how neurological systems learn
- Studying the effects of disease and trauma on information processing
- Developing novel computational or mathematical models to interpret either new or existing data

Experimental, computational, and theoretical efforts will be considered in-scope for the ARC topic. In all cases, performers will justify how their methods or insights go beyond the current state of the art. Approaches providing insight for a single neuron and new vertebrate experiments are out of scope.

B. ARC Abstracts

INSPIRE ARC abstract submitters should clearly articulate the question or theory they are testing, the reasoning behind their hypothesis, and the neurological system they are using. Abstracts must include how a novel insight or concept into the neurological system of interest can be generalized or used for future understanding of the brain.

Abstracts should quantitatively validate their experiments and/or computational models against reasonable controls. Discovering new theories requires clear methodology and validation of the materials, experiments, and data analysis, so specific details should be provided for each step rather than a general topic overview.

This ARC Opportunity is intended to be as inclusive as possible; however, proposed ideas should address the appropriate scope, have a clear deliverable at the end of the effort, and include specific practical applications of the research.

Abstracts should describe a research plan including (1) detailed intermediate technical objectives with evaluation measures and (2) a schedule segmented monthly or quarterly outlining corresponding deliverables.

DARPA will evaluate Abstracts submitted in response to this ARC Opportunity, as detailed in Section 4 of the latest amendment issued against DARPA-EA-24-01. If the Government selects an Abstract for an Oral Presentation, the Government will issue an invitation to submit an OPP. The invitation will include the submission instructions and deadline.

C. Schedule of Milestones

The specific milestones and due dates listed below are common to all Abstracts and OPPs (see above for technical details and Section III.A. below for additional information on milestones). Abstracts selected to submit an OPP will be required to propose milestones associated with the program plan as part of the oral proposal.

- Kick-off meeting: Should define the technical approach and steps going forward.
- Milestone status meeting: Briefing to include detailed progress towards all research

objectives, progress to plan, and discussion of the next milestone's objectives.
- Final Milestone: Outbrief to summarize all work completed on the project.

D. Reporting Requirements

Performers will be expected to provide at a minimum the following reports:

- Monthly technical updates and financial reports. These reports should include progress to plan and a high-level financial summary.
- Milestone technical report. Each report should detail progress towards all research objectives and should include a master document that refers to associated explanatory presentation slides, design document, algorithms, models, modeling data and results, and model validation data, publications, and software source code with full documentation, as needed.
- Final technical report. The final report should include the final master document from the quarterly technical reports and detail results of all milestones associated with the program plan for the entire period of performance. This must include work that was successful towards reaching milestones as well as work that was not successful.

III. ARC Opportunity Submission Format, Instructions and Selection

A. Abstract Content and Format

All Abstracts submitted in response to this notice must comply with the content and format instructions in Section 3.1 of the latest amendment issued against DARPA-EA-24-01. The submission must use the template provided as attachment to DARPA-EA-24-01. Abstracts submitted in response to this ARC Opportunity must be unclassified.

B. Abstract and OPP Submission Instructions

Abstracts submitted in response to this ARC Opportunity and OPPs submitted in response to an invitation shall be submitted electronically via the DARPA Submission website at https://baa.darpa.mil. See Section 3.3 of the latest amendment issued against DARPA-EA-24-01 for Abstract and OPP submission instructions.

Technical support for the DARPA Submission website is available during regular business hours, Monday – Friday, 9:00 a.m. – 5:00 p.m. Eastern Time. Requests for technical support must be emailed to BAAT_Support@darpa.mil with a copy to INSPIRE@darpa.mil. Questions regarding submission contents, format, deadlines, etc. should be emailed to INSPIRE@darpa.mil. Questions/requests for support sent to any other email address may result in delayed/no response.

DARPA will acknowledge receipt of complete submissions via email and assign identifying numbers that should be used in all further correspondence regarding those submissions. If no confirmation is received within two (2) business days, please contact INSPIRE@darpa.mil to verify receipt.

No Abstracts will be accepted after the end of the overall submission period listed in Section I above. Abstracts must be submitted per the instructions outlined in this ARC Opportunity *and received by DARPA* no later than this time and date. Proposers are advised that the Abstract submission deadline outlined herein is in Eastern Time.

Abstracts will be evaluated and selected in accordance with Section 4 of the latest amendment issued against DARPA-EA-24-01.

IV. Award Information

Selected OPPs will result in a potential award of a Research OT agreement subject to the proposer's acceptance of the terms and conditions. Proposers must review the model Research OT agreement provided as Attachment E to DARPA-EA-24-01.

The completed Task Description Document, Schedule of Milestones and Payments (templates included in Attachment E), and data rights will be included in the Research OT agreement upon award.

Given the limited funding available for each ARC Opportunity, not all proposals considered selectable may be selected for a potential award.

V. Eligibility

See Section 6 of the latest amendment issued against DARPA-EA-24-01 for information on who may be eligible to respond to this notice.

VI. Human Subject Research

Abstracts to this ARC Opportunity proposing human subjects research will be considered out of scope and may be disregarded.

VII. Administrative Requirements

Section 7.2 of the latest amendment issued against DARPA-EA-24-01 provides information on administrative requirements that may be applicable for proposal submission as well as performance under an award.

VIII. Frequently Asked Questions (FAQs)

All technical, contractual, and administrative questions regarding this notice must be emailed to INSPIRE@darpa.mil. Emails sent directly to the Program Manager or any other address may result in delayed or no response.

All questions must be in English and must include the name, email address, and telephone number of a point of contact. DARPA will attempt to answer questions publicly in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered.

DARPA may post an FAQ list under the ARC Opportunity on the DARPA/DSO Opportunities page at (http://www.darpa.mil/work-with-us/opportunities). The list will be updated on an ongoing basis until one (1) week prior to the abstract due date. DARPA will also maintain https://www.darpa.mil/ARC as a resource page with links to all relevant ARC Opportunities and FAQs.