Request for Information (RFI)
DARPA-SN-16-70
Forensic Social Science Supercolliders (FS3)[i] - Amendment 1

Responses Accepted: Until 4:00 PM (Eastern) on October 18, 2016
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The Defense Advanced Research Projects Agency (DARPA) Defense Sciences Office (DSO) is requesting information on new ideas, approaches, and capabilities for developing interactive simulations that can be used to calibrate the validity of different social science research methods and tools in drawing "strong inference" about causal mechanisms that can lead to emergent complex behaviors in human social systems.

Background

The Department of Defense often relies upon methods, tools, and frameworks from the social sciences to help planners and decision-makers understand a wide variety of complex human social behaviors and systems. In part, this is because a major goal of any social science is to be able to draw "strong inference" that advances understanding: that is, by using necessarily limited empirical observations, one may draw reliable conclusions about the causes and patterns of the social behaviors and systems being observed. In their pursuit of strong inference, social scientists have developed a wide range of research methods and tools, often applied under different conditions and in different combinations, ranging from the highly qualitative to highly quantitative, and often involving various kinds of observational, experimental, confirmatory, and exploratory approaches at different scales.

A persistent challenge for all of these methods is that social scientists rarely, if ever, have ground truth regarding the actual causes of observed behaviors in the "real world," and therefore they struggle to accurately calibrate the inferential validity of their different methods. This hampers our understanding of different research methods' limitations in being able to correctly identify and characterize the causes of emergent behaviors, particularly in stochastic, dynamic, often non-linear social processes and systems.

Today, social scientists are increasingly incorporating simulation as a research method, particularly agent-based models (ABMs) and system-level simulations (which may include large-scale distributed online games). Where simulation is used currently, however, it generally appears as part of a larger collection of social science research methods, usually as an early exploratory mechanism to help identify or refine hypotheses that can then guide further data collection and observation in the "real world." Hence simulations currently also suffer from the above limitations due to a lack of ground truth.

Rather than simply being another research method, simulations – if advanced to a sufficient level of sophistication – might provide new capabilities for calibrating the inferential validity of social science research methods in the first place. Indeed, DARPA hypothesizes that ABMs, system

simulations, and games – rather than being complementary research tools – might provide initial capabilities as a kind of "social supercollider" in which other methods and tools can themselves be tested[ii]. If successful, such simulations could provide testbeds in which social science research methods can be forensically evaluated for their capabilities and their limitations to correctly identify and characterize different causal mechanisms and dynamics that give rise to observed complex behaviors and systems. Simulations might also engender new opportunities to test, calibrate, and explore a wide range of combinations of existing methods and tools, and potentially enable the discovery of novel hybrid social science research methods with unique capabilities for correctly inferring causality.

DARPA is referring to this potential capability as "forensic" for two reasons. First, if successful, the "supercollider" could support simulations that, while artificial, allow for complex social behavior to emerge from relatively simple first principles, where these first principles are known because they were coded into the simulation from the beginning. Provided these simulations are sufficiently sophisticated, they will enable the testing and evaluation of inferences derived from different social science research methods against ground truth with precision and certainty almost never available in the "real world". Second, this kind of social science supercollider could allow simulations of sudden, disruptive changes in key parameters or system behaviors (phase transitions, tipping points, etc.) in order to further calibrate the accuracy of different methods to correctly infer "what really happened" to cause the observed simulated behaviors.

If feasible, DARPA anticipates that successful forensic social science supercolliders would enable a number of key advances for the social sciences and for national security, including:

- understanding and quantifying capabilities, limitations, uncertainty, and error associated with social science research methods, under different conditions, given different kinds of questions, data, and observations;
- providing scalable ways to explore and exploit mixed research methods for maximum inferential validity, through potentially novel combinations of qualitative and quantitative research methods;
- determining the advantages and disadvantages of methods and combinations of methods for inferring causal relationships between "micro" and "macro" scales in systems of growing complexity (e.g., from small-world networks to megacities to global incentive structures);
- enabling ethical and tractable ways to study potentially rare but high impact systemic disruptions, such as conflicts or economic collapse, further deepening our understanding of different methods' abilities to make strong inferences about key principles and causes that can lead to such events.

Goal

Accordingly, DARPA is seeking responses to this RFI to assess the feasibility of sufficiently advancing simulation and/or experimental platforms to enable forensic social science by addressing the three Technical Areas (TAs) detailed below.

TA1: Formalizing candidate first principles and rules for supercolliders

The purpose of TA1 is to explore identifying and formalizing minimal but appropriate sets of relatively simple first principles from which complex behaviors may emerge. Forensic social science simulations/supercolliders are likely to require formal specification of a minimal but appropriate set of first principles in order to enable conditions for the emergence of different kinds of simulated complex behaviors and systems. DARPA anticipates that these first principles will need to describe both inherent properties of agents and their environment, as well as rules describing agents' interactions and system dynamics. Accordingly, DARPA is requesting input regarding candidate first principles and formal instantiations thereof, potentially drawn from a variety of disciplines, including (but not limited to) psychology, sociology, economics, network science, biology, linguistics, physics, game theory, ecology, and anthropology.

Ultimately, any simulation will reflect its particular set of system properties and dynamics, which may also shape the subset of research methods that can be evaluated in that environment. DARPA therefore anticipates that initial forensic social science supercolliders may adopt more focused topics at specific levels of analyses than entire social systems, e.g., looking to first build simulated economies, political structures, or identities engaging in competition for resources or facing internal and external threats, within a simulated Dense Urban Area. Importantly for the purposes of calibrating social science research methods against known ground truth, these environments need not explicitly resemble the "real world", but DARPA expects that they may be built using different combinations of reasonably well-established first principles from across the social, behavioral, and physical sciences and might be comparable at a high level to actual historical conditions and events.

TA2: Building sufficiently rich, interactive social supercolliders

TA2 is focused on ideas for developing simulation platforms (aka supercolliders) that have sufficiently interactive agents, behaviors, and systems to enable the testing of the inferential validity of both qualitative and quantitative social science research methods for determining causality in complex social behaviors and systems, including potentially disruptive events. While causal ground truth of the first principles and rules that give rise to the simulated complex behaviors will be known to modelers (i.e., the rules that were coded into the simulation), researchers will only be able to use their best methods to forensically infer what those rules and principles are. Therefore successful simulations should allow for engagement and interaction among agents, their simulated behaviors and data, and social science researchers and their particular methods and tools. Accordingly, DARPA anticipates that forensic social science supercolliders will have to enable at least minimally responsive, interactive environments and agents that can accommodate different kinds of etic and emic research approaches in ways that afford researchers an opportunity to explore what the anthropologist Clifford Geertz called the "native's point of view."[iii] For example, researchers should be able to measure agents both qualitatively and quantitatively at the micro- and macro-levels to try and capture observable behaviors as they emerge. They should also be able to query agents for information, e.g., to ask agents why they think they are doing what they are

doing, insofar as agents may understand their own, or other agents', rules or dispositions. Such interactivity might be instantiated via system simulations, agent-based models, or volunteer participants using game platforms (or combinations thereof) but should presumably provide richness in time, space, and behavioral domains to allow for complex interactions among agents, in support of learning, communication, group formation, and response to different perceived conditions such as resource scarcity or threats.

DARPA anticipates that responses may describe solutions involving multiple ensemble simulations with varying parameters (e.g., time, homogeneity of agents, environmental effects) to better operationalize degrees of variability for any given set of first principles and dynamics, as well as the dependence of global, emergent outcomes on microscale parameters. Potential ensemble approaches might also enable evaluation of the sensitivity and robustness of different combinations of social science research methods for identifying changes in individual system properties at multiple scales.

TA3: Scoring inferential validity and reliability of research methods and tools

TA3 is looking at ways of providing credible metrics and evaluation frameworks with which to score the inferential validity and reliability of different social science research methods (and combinations thereof), thus helping to calibrate our understanding of the methods' limitations in inferring causality under different conditions and at different scales. A primary aim of this RFI is to assess the feasibility of creating simulations that enable quantitative and qualitative analyses of limitations of social science methods (and their combinations) for inferring causality in complex social behaviors and systems. Therefore, the utility of any forensic social science supercollider will necessarily require the development of methods and metrics for evaluating the accuracy and generalizability of the causal inferences derived from different social science research methods. DARPA is therefore interested in new approaches or appropriate adoption of existing methods for scoring the ability of any given research method or combination of methods to determine first principles, causal mechanisms, and interaction dynamics giving rise to observable complex social behaviors under various conditions and at various scales (aka draw "strong inference"). Of particular interest are ways to quantitatively calibrate how well social science research methods may do at recovering first principles and causes that may give rise to different emergent behaviors under different conditions. Note that while ground truth will be known in terms of which principles and rules were used to generate the behaviors seen in any given supercollider, it is an open question whether recovering those known principles and rules can offer a complete description of complex interaction dynamics observed in the simulation, including emergence of potentially new or unanticipated behaviors or properties. Accordingly, evaluation frameworks may need to include novel probabilistic metrics for accuracy and error in the context of emergence and non-determinism in a dynamic environment. In the case of ensemble simulations, the use of cross-validation on simulations with varying parameters may be appropriate for evaluating an approach's efficacy across different simulated multi-dimensional parameter spaces.

Development of methods to score strong inference will likely need to include ways to also evaluate any given simulation's computational efficiency and efficacy in formalizing different

principles, as well as metrics to quantify a given simulation's complexity. Responses should describe measures that help DARPA better understand the limitations of any combination of social science research methods for drawing strong inference from a given set of observations, e.g., Kolmogorov complexity. Responses to TA3 might also address any information-theoretic requirements for a minimum size, span, scale, and number of agents (if simulation) or subject populations (if games) to enable an envisioned forensic social science supercollider.

DARPA is also interested in receiving relevant responses that may demonstrate or identify fundamental theoretical or practical limits to one or more Technical Areas, although responses should provide strong evidence for asserting those limits. Respondents may also suggest additional ideas they believe are under-investigated and under-invested but that could enable the desired transformative research capabilities envisioned in this RFI. Speculative concepts with insight into practical application are encouraged, especially where they represent a potential revolutionary advance over current capabilities; however, responses that build upon speculative knowledge should explicitly state assumptions and presumed technological or methodological developments.

Submission Format

Responses may address one or more of the Technical Areas outlined in this RFI. DARPA encourages responses that describe integrated solutions addressing all three TAs collectively as appropriate. Respondents are encouraged to be as succinct as possible, while also providing actionable insight. Page limits for each section are indicated below.

Format specifications for responses include 12-point font, single-spaced, single-sided, 8.5 by 11 inches paper, with 1-inch margins in .doc, .docx, or PDF format (and, as applicable, .ppt or .pptx). Respondents are responsible for clearly identifying proprietary information. Responses containing proprietary information must have each page containing such information clearly marked with a label such as "Proprietary" or "Company Proprietary." DO NOT INCLUDE ANY CLASSIFIED INFORMATION IN THE RFI RESPONSE.

A. Cover Sheet (1 page): Provide the following information.
   1. Response Title
   2. Technical point of contact name, organization, telephone number, and email address
   3. Indicate the RFI challenge(s) addressed by the response

B. Technical Description (5 pages)

C. Bibliography/References (1 page)

D. Graphic Overview Slide (Optional): If desired, include a single PowerPoint slide that graphically depicts the main ideas of the response.

Submission Instructions

All responses to this RFI must be emailed to FS3_RFI@darpa.mil. Responses will be accepted any

time from the publication of this RFI until 4:00 PM (Eastern) on October 18, 2016. Early responses are encouraged.

Contact Information

All technical and administrative correspondence regarding this RFI should be sent to FS3_RFI@darpa.mil. Emails sent directly to the Program Manager may result in delayed/no response.

Disclaimers and Important Notes

This is an RFI issued solely for information and new program planning purposes; it does not constitute a formal solicitation for proposals. In accordance with FAR 15.201(e), responses to this RFI are not offers and cannot be accepted by the Government as such. In addition, responses do not bind DARPA to any further actions related to this topic including requesting follow-on proposals from respondents to this RFI. Submission is voluntary and is not required to propose to a subsequent Broad Agency Announcement (BAA) (if any) or other research solicitation (if any) on this topic. DARPA will not provide reimbursement for costs incurred in responding to this RFI.

Respondents are advised that DARPA is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI.

DARPA will disclose submission contents only for the purpose of review. Submissions may be reviewed by the Government (DARPA and partners); Federally Funded Research and Development Centers (FFRDCs); and Scientific, Engineering and Technical Assistance (SETA) support contractors.

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[i] Title adapted from "Sociology in the Era of Big Data: The Ascent of Forensic Social Science" (McFarland, DA, Lewis, K, Goldberg, A,, *Am Soc*, 2015: DOI 10.1007/s12108-015-9291-8) in which the term forensic social science is used to describe approaches that are both inductive and theory-oriented, and which merge "applied and theory-driven perspectives…in a sense, deductive and inductive approaches are combined as mutually informing…forensic social science tools need to identify patterns in the data and then trace them back to meaningful analytical constructs."

[ii] "Social supercollider": a facility that combines multiple streams of data, creating richer and more realistic portraits of individual behavior and identity, while retaining the benefits of massive scale." Taken from the article "Computational Social Science: Exciting Progress and Future Directions" by Duncan Watts in *Frontiers of Engineering.* Winter 2013, pp 5-11.

[iii] Geertz, C. (1985) Local Knowledge: Further Essays in Interpretive Anthropology. Basic Books. Also see https://en.wikipedia.org/wiki/Emic_and_etic