

potential models, we would have to imagine living and navigating in them. Which, it seems to me, we do, but only in our dreams.

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Response

THE ANALOGY BETWEEN MACHINE AND human cognition may suggest that reported bizarre, random dreams may not be entirely random. The robot we described did not just replay its experiences to build consistent internal self-models and then “dream up” an action based on those models. Instead, it synthesized new brief actions that deliberately caused its competing internal models to disagree in their predictions, thus challenging them to falsify less plausible theories and, as a result, improving its overall knowledge of self. It is possible that the mangled experiences that people report as bizarre dreams correspond to this unconscious search for actions able to clarify their self-perceptions. Many of the intermediate candidate models and actions developed by the robot (as seen in Movie S1 in our Supporting Online Material) were indeed very contorted, but were optimized nonetheless to elucidate uncertainties. Edelman (1), Calvin (2), and others have suggested the existence of competitive processes in the brain. Perhaps the fact that human dreams appear mangled and brief is exactly because they are—as in the robot—“optimized” to challenge and improve these competing internal models?

Indeed, analogies between machines learning from past experiences and human dreaming are potentially very fruitful and may be applicable in both directions. Although robots and their onboard algorithms are clearly simpler and may bear little or no direct relation to humans and their minds, it may be much easier to test hypotheses about humans in robots. Conversely, ideas from human cognition research may help direct robotic research beyond merely serving as inspiration. Specifically, it is likely that as robots become more complex and their internal models are formed indirectly rather than being explicitly engineered and represented, indirect probing techniques developed for studying humans may become essential for analyzing machines too.

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References

1. G. Edelman, *Neural Darwinism: The Theory of Neuronal Group Selection* (Basic Books, New York, 1988).
2. W. H. Calvin, *A Brief History of the Mind: From Apes to Intellect and Beyond* (Oxford Univ. Press, Oxford, 2004).

Online Versus Hardcopy Textbooks

SEVEN YEARS (2000–2006) OF ANALYSIS OF 1751 introductory lab science students in 10 separate semesters at Arizona State University reveals no statistically significant differences in class performance between online (81.2 ± 11.0) and hardcopy (80.8 ± 10.8) textbook users. In a required physical geography lab science class, students were given the option of using either an online ($n = 760$) or a hardcopy ($n = 991$) text to reinforce learning such topics as Wien's law, invading species, dissolution of minerals, Chezy-Manning equation, and glacial processes. By any measure, the hardcopy texts were more sophisticated than the online alternative, even though the basic information remained similar. Yet, even after disaggregating data into different semesters, texts, disciplines, class, GPA, age, ethnicity, and whether the student is a first-generation college student, no statistically significant differences emerged. Given the importance of required lab courses in shaping opinions of college-educated citizens about the importance of science, and given the growing resentment expressed by students over increasingly high-priced textbooks, similar studies in other general education lab science disciplines would seem justified.

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Is the EC Afraid of Its Own Visions?

IN A VISIONARY PHASE OF POLITICAL decision-making, the European Commission (EC) initiated new instruments of research funding within its 6th Framework Programme (FP 6), including the Integrated Projects (IPs), large-scale interdisciplinary programs. The first ones started in early 2004 with several tens of partner organizations and funding beyond 10 million Euro. In FP 7, launched on 22 December 2006, this instrument was scaled down and—at least for the first funding cycle—nearly abandoned.

Why has this change been made? Will most of these IPs, which have at least two more years to go, be failures?

Since February 2004, we have coordinated the IP ALARM (1), which is made up of 67 partner organizations and 250 scientists from 35 countries and receives EC funding of nearly 13 million Euro. ALARM focuses on some of the main drivers of biodiversity change [climate and land use change, environmental chemicals, invasive species, and loss of pollinators (2)] and combines ecological, environmental, and economic research. The consortium includes many leading scientists, who increasingly appreciate the opportunities offered through a project of such size and scope, e.g., by forming new teams conducting inter- and transdisciplinary research.

This is exactly what is urgently needed in science, as expressed by Carpenter *et al.* (3): “Meeting the research needs described will require new coalitions among disciplines that traditionally have been isolated....The [Millennium Ecosystem Assessment] has provided a road map; now, we need to start the journey.” We think that large integrated projects have the clear potential to fulfil these requirements.

By initiating the IP instrument, the European Commission created considerable support to get the journey started. Do they now intend to stop halfway?

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References

1. J. Settele *et al.*, *GAIA* **14**, 69 (2005) (see www.alarmproject.net).
2. J. C. Biesmeijer *et al.*, *Science* **313**, 351 (2006).
3. S. R. Carpenter *et al.*, *Science* **314**, 257 (2006).

CORRECTIONS AND CLARIFICATIONS

News of the Week: “New Swiss influenza database to test promises of access” by M. Enserink (16 Feb., p. 923). Amos Bairoch is not the director of the Swiss Institute of Bioinformatics (SIB), as the article stated, but director of the Swiss-Prot group at SIB, as well as director of the Structural Biology and Bioinformatics department of the University of Geneva. The SIB's director is Ernest Feytmans.

Special Section: Sustainability and Energy: News: “Catalyzing the emergence of a practical biorefinery” by A. Cho (9 Feb., p. 795). The Pacific Northwest National Laboratory is in Richland, Washington, not Hanford.

News Focus: “Judging Jerusalem” by A. Lawler (2 Feb., p. 588). Dr. Eilat Mazar is a senior fellow at the Shalem Center, an academic research institute in Jerusalem. She heads its archaeology institute, which sponsored the dig in the City of David.

Reports: “Highly siderophile element constraints on accretion and differentiation of the Earth-Moon system” by J. M. D. Day *et al.* (12 Jan., p. 217). In the first sentence of the second full paragraph on page 218, LaPaz, Bolivia, was incorrectly named as the location of meteoritic samples. The corrected sentence should read, “We report precise