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March 2012

# Reproducibility: Gold or Fool's Gold in Digital Social Research?

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# Reproducibility: Gold or Fool's Gold in Digital Social Research?

*Christine L. Borgman, UCLA*

Keynote Presentation

Oxford Internet Institute

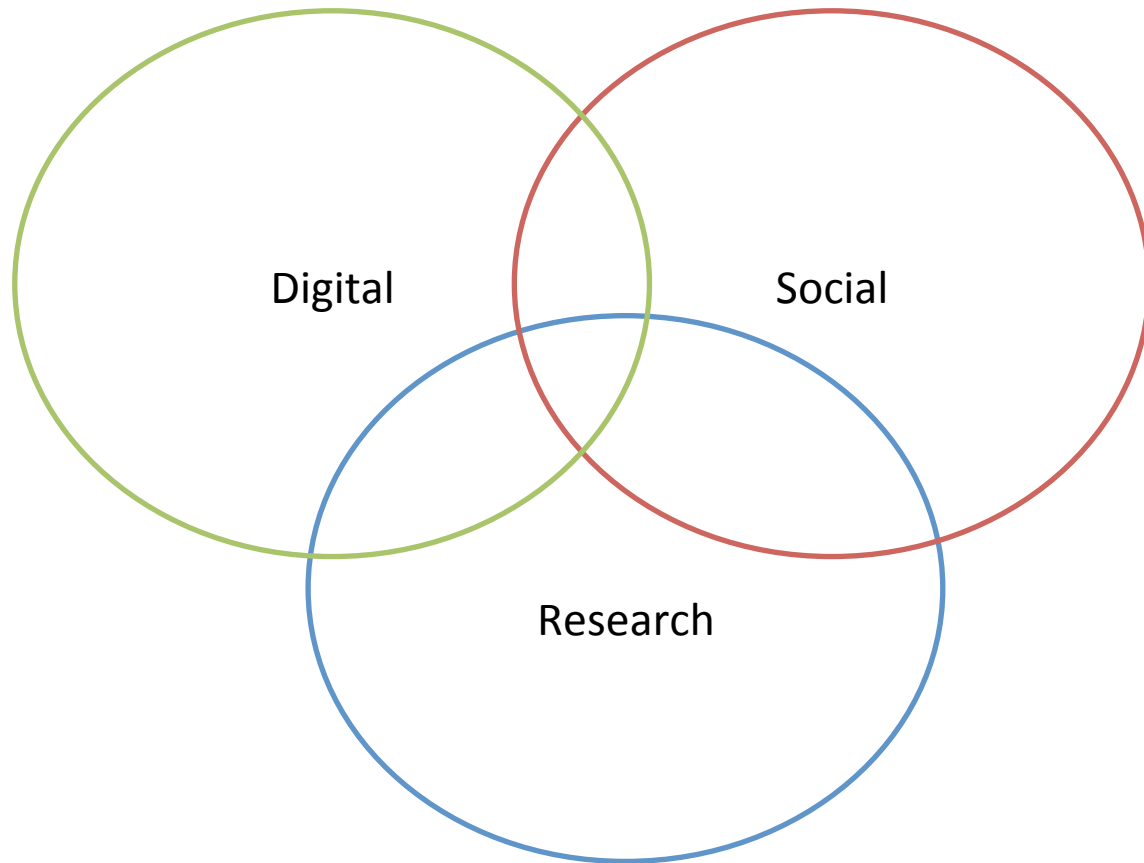
Symposia on Social Science and

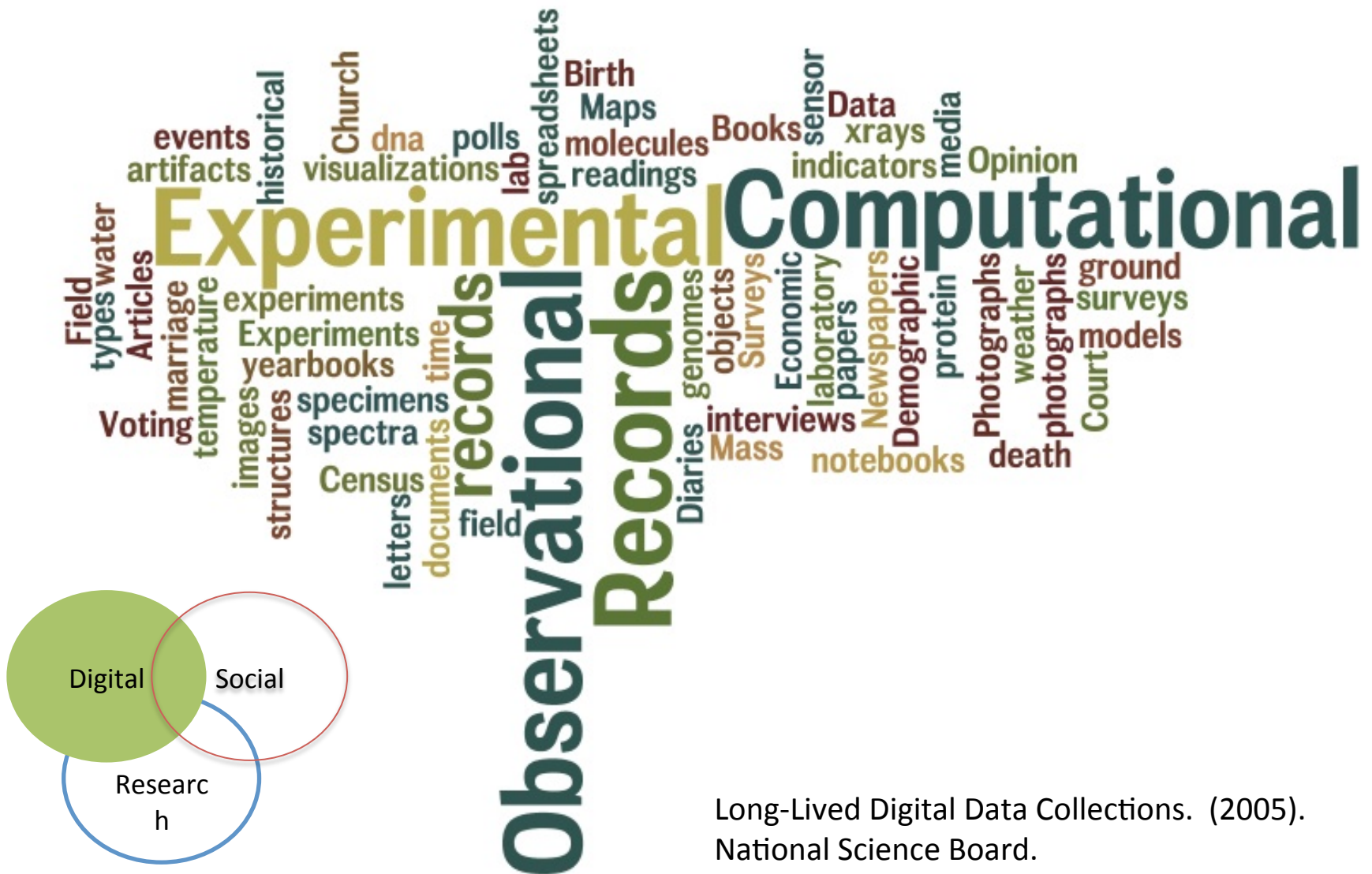
Digital Research

12 March 2012



# e-Social Science → Digital Social Research

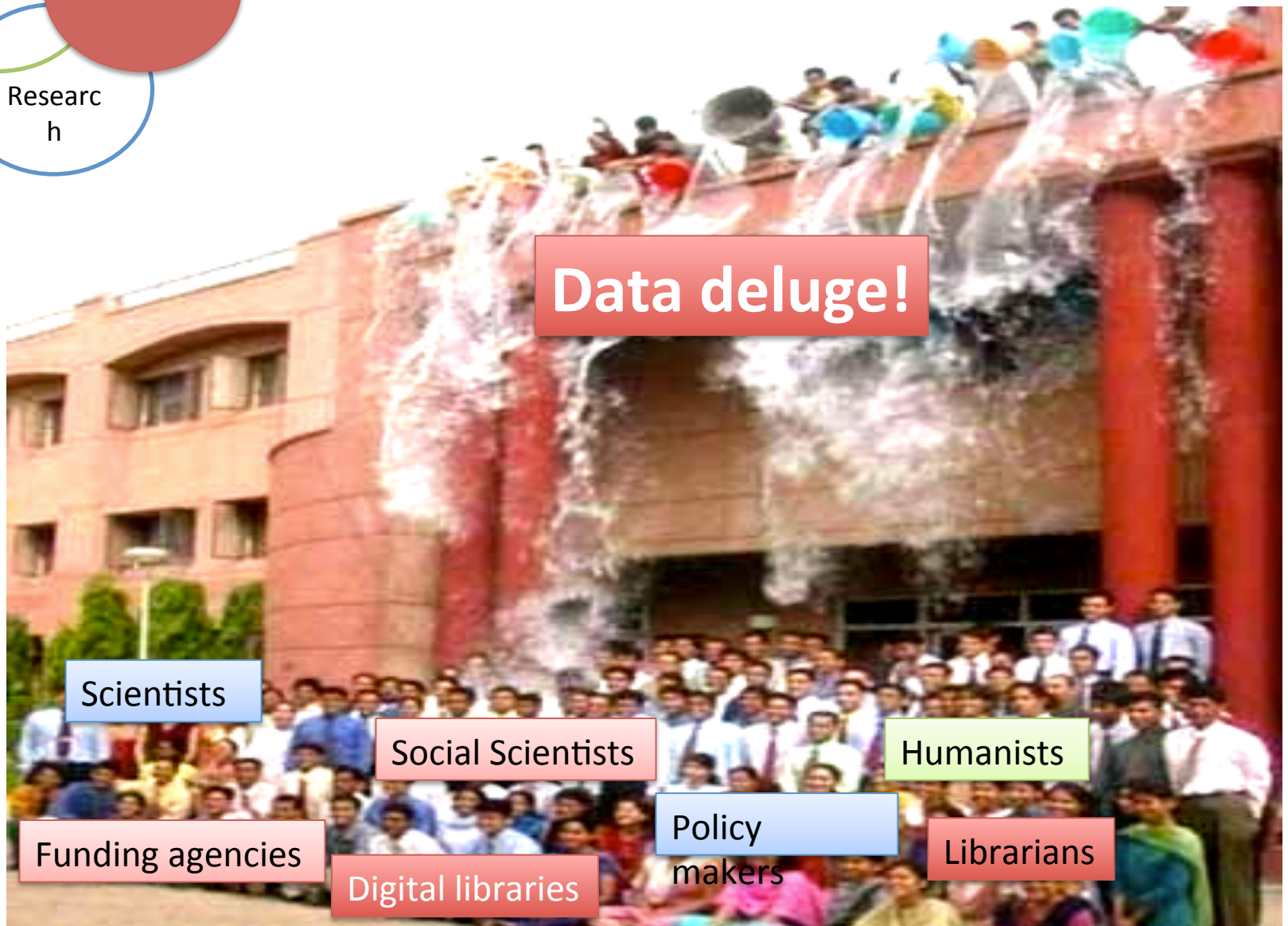
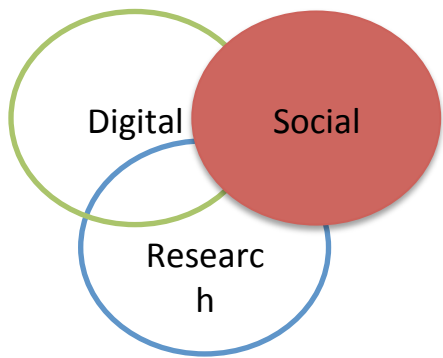




Long-Lived Digital Data Collections. (2005).  
National Science Board.

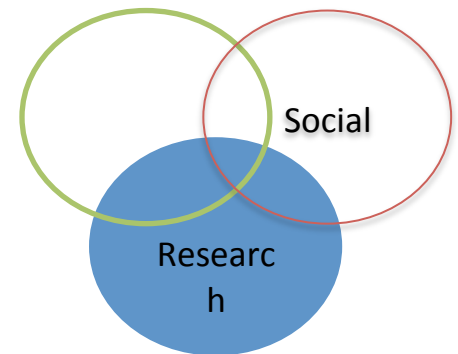
<http://www.nsf.gov/pubs/2005/nsb0540/>





# Data sharing policies

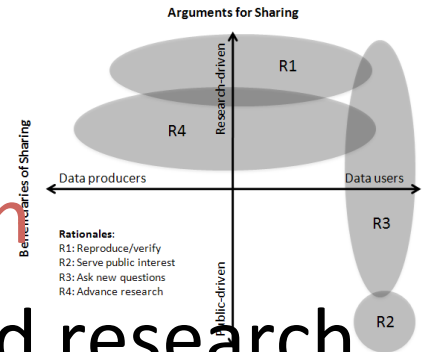
- Wellcome Trust
  - Data sharing requirements
  - Data management plans
- Economic and Social Research Council
  - Data sharing requirements
  - Data reuse
  - Data deposit
- National Science Foundation
  - Data sharing requirements
  - Data management plans



# Why share research data?

## Rationales

1. To reproduce or to verify research
2. To make results of publicly funded research available to the public
3. To enable others to ask new questions of extant data
4. To advance the state of research and innovation



# Scientific Gold Standard



REPLICATION—THE CONFIRMATION OF RESULTS AND CONCLUSIONS FROM ONE STUDY obtained independently in another—is considered the scientific gold standard.

Jasny, B. R., Chin, G., Chong, L. & Vignieri, S. (2011). Again, and again, and again. *Science*, 334(6060): 1225.







Victoria Stodden,  
Columbia University

- Deductive sciences
  - Check the proof
- Experimental sciences
  - Redo the field work
- Computational sciences
  - Start with the dataset
  - Reconstruct workflow

# Reproducibility?

## Analytic validity

Do different labs, techniques, and platforms measure the same thing?

## Repeatability

Can other scientists access the data and protocols, repeat the analyses, and get the same results?

## Replication

Do many different data sets and their combination (meta-analysis) get consistent results?

## External validation

Do different data sets by different teams, preferably prospectively and with large-scale evidence, get consistent results?

## Clinical validity

Does the discovered information predict clinical outcomes?

## Clinical utility

Does the use of the discovered information improve clinical outcomes?

# What data are replicable?

- Field observations?
  - Plants, animals, soil, air, water
  - Places and times
- Digital records of
  - Observations
  - Experiments
  - Models
  - Workflows?
- Materials?
- Software, code, algorithms?



# Data, Replication, and Interpretation

- Unit of replication
  - One paper
  - One dataset
  - One program of research
- Provenance
  - Chain of custody
  - Transformations from original state
- Tacit knowledge
  - Domain knowledge
  - Research methods
  - Research skills



[http://chicagoist.com/2008/10/09/a\\_gourmet\\_oasis\\_provenance\\_food\\_and.php](http://chicagoist.com/2008/10/09/a_gourmet_oasis_provenance_food_and.php)

# Reproducibility rationales

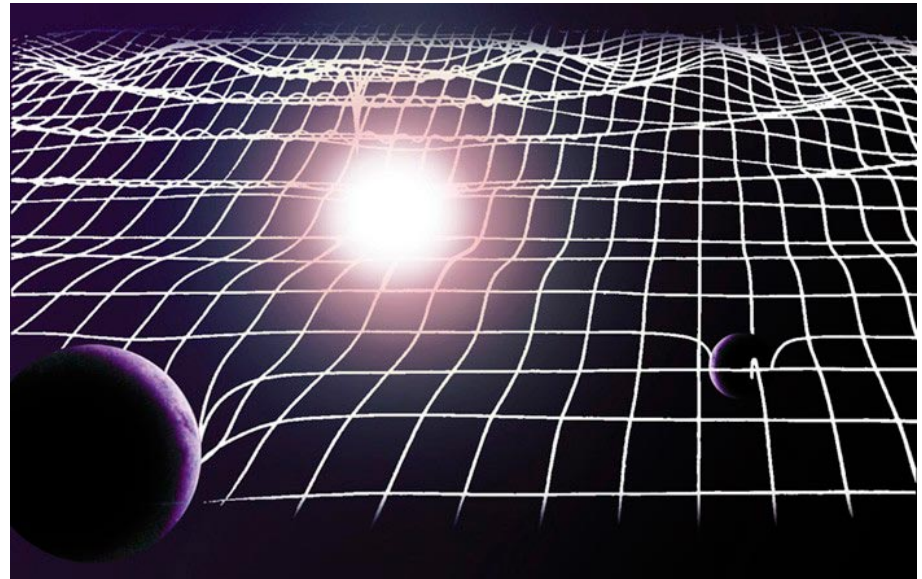
- Resolve disputes
- Confirm scientific claims
- Protect public interest





# Resolve disputes?

- Gravitational waves
- Valid experiments were those that
  - Detected waves
  - Failed to detect waves



Collins, H. M. (1975). The seven sexes: A study in the sociology of a phenomenon, or the replication of experiments in physics. *Sociology*, 9: 205-24.

Collins, H. M. (1998). The meaning of data: Open and closed evidential cultures in the search for gravitational waves. *American Journal of Sociology*, 104(2): 293-338.

# Gravitational waves, 2011

Black hole twins spew gravitational waves: Physics World, April 2011

Astronomers could be on the cusp of detecting gravitational waves after four decades of trying, according to a team of Polish astrophysicists. They say that if current gravitational-wave detectors are upgraded to search for binary black-hole systems, gravitational waves would be expected "within the first year of operation". If correct, it would open up a new window to the cosmos, allowing astronomers to see the universe with fresh eyes. ...

However, a team of researchers, led by Chris Belczynski of the Los Alamos National Laboratory, report that these projects have taken the wrong option, saying that double black hole systems may be far more common than previously thought. The reason is related to stars' metallicity, which is the fraction of elements that are heavier than helium. The lower the metallicity the less mass is lost at the end of the star's life and therefore the black holes that form are more likely to survive to become a black hole binary.

# Confirm scientific claims

## 12 Feb 2004: Landmark paper

Woo Suk Hwang from Seoul National University and his colleagues announced that they have cloned human embryos and harvested stem cells from one of them (W. Hwang et al., *Science* **303**, 1669-1674; 2004). The work makes a significant step towards stem-cell therapies for disease. Other groups have claimed to clone human embryos, but supporting evidence has been sketchy. This paper provides further supporting evidence.

- [Cloned human embryos yield stem cells](#)

- What data do peer reviewers need?
- How are data used in peer review?
- What is the responsibility of peer reviewers to reproduce research?

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Published online 19 December 2005 | Nature | doi:10.1038/news051219-3

**News**

**Timeline of a controversy**

**A chronology of Woo Suk Hwang's stem-cell research.**

Concerns about ethics, errors (accidental or intentional) and possible fraud have dogged the stem-cell researcher Woo Suk Hwang, from Seoul National University in South Korea, since his landmark 2004 *Science* paper on stem cells from a cloned human embryo. Here [news@nature.com](mailto:news@nature.com) describes how events have unfolded from that initial paper - with the most recent events presented first (you may want to read from the bottom-up the first time you read this). Keep checking back for updates over the coming weeks.



Woo Suk Hwang faces questions. © Empics

**31 October 2006**

A confident and defiant Hwang takes the stand for the first time in court. The defence denies allegations of fraud and embezzlement, and has prepared a case against the charge of violating the bioethics law for the next hearing. A verdict may be handed down by the end of the year.

• [Hwang takes the stand at fraud trial](#)

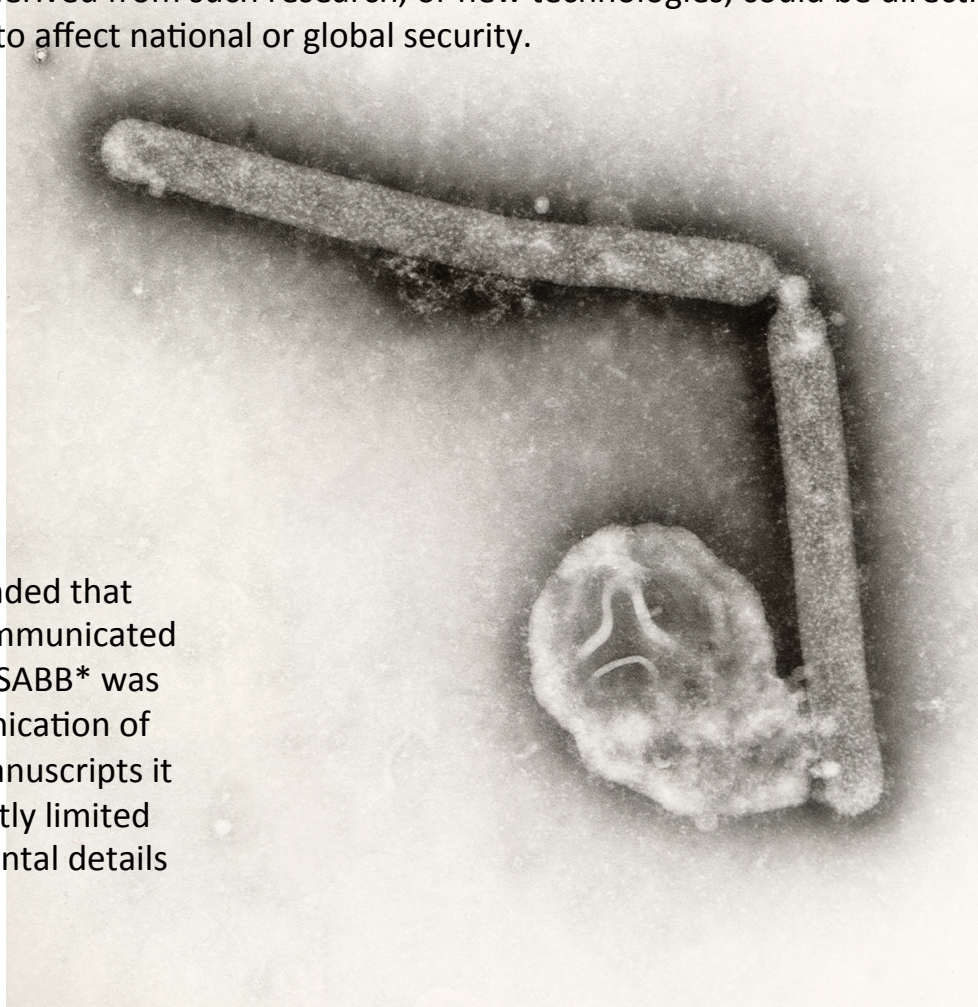


## Avian influenza A/H5N1 virions.

Efforts to describe or define life-sciences research of particular concern have focused on the possibility that knowledge or products derived from such research, or new technologies, could be directly misapplied with a sufficiently broad scope to affect national or global security.

We found the potential risk of public harm to be of unusually high magnitude.

We therefore recommended that the work not be fully communicated in an open forum. The NSABB\* was unanimous that communication of the results in the two manuscripts it reviewed should be greatly limited in terms of the experimental details and results.



This is an **unprecedented recommendation** for work in the life sciences .... Our concern is that publishing these experiments in detail would provide information to some person, organization, or government that would help them to develop similar mammal-adapted influenza A/H5N1 viruses for harmful purposes.

K I Berns et al. *Science* 2012;335:660-661

\*U.S. National Science Advisory Board for Biosecurity





Sharing data ↔ reproducibility?



# Gold or Fool's Gold?



<http://www.goldalert.com/>



[http://en.wikipedia.org/wiki/File:Pyrite\\_Fools\\_Gold\\_Macro\\_1.JPG](http://en.wikipedia.org/wiki/File:Pyrite_Fools_Gold_Macro_1.JPG)



## Not Exactly Rocket Science

« A shiny dinosaur –four-winged Microraptor gets colour and gloss  
I've got your missing links right here (10 March 2012) »

### A failed replication draws a scathing personal attack from a psychology professor



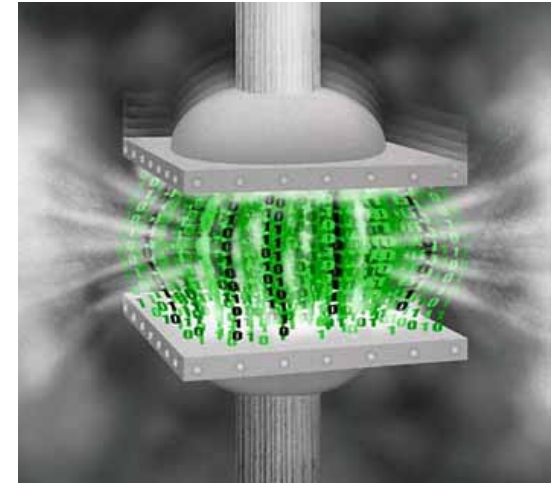
**John Bargh**, a psychologist at Yale University, has published a scathing attack on a paper that failed to replicate one of his most famous studies. His post, written on his own blog on Psychology Today, is a mixture of critiques of the science within the paper, and personal attacks against the researchers, PLOS ONE, the journal that published it, and me, who covered it. I'm going to take a closer look at Bargh's many objections.



# Conclusions



- Reproducibility is a driver of data sharing policies
- Reproducibility is the “gold standard” for science
  - Resolve disputes
  - Confirm scientific claims
  - Protect public interest
- Reproducibility is a social process
  - Epistemological disputes
  - Policy disputes
  - Tacit knowledge and interpretation
- Exemplar problem for digital social research







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- National Science Foundation
  - *CENS: Cooperative Agreement #CCR-0120778*, D.L. Estrin, UCLA, PI.
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  - *Towards a Virtual Organization for Data Cyberinfrastructure*, #OCI-0750529, C.L. Borgman, UCLA, PI; G. Bowker, Santa Clara University, Co-PI; T. Finholt, University of Michigan, Co-PI.
  - *Monitoring, Modeling & Memory: Dynamics of Data and Knowledge in Scientific Cyberinfrastructures: #0827322*, P.N. Edwards, UM, PI; Co-PIs C.L. Borgman, UCLA; G. Bowker, SCU; T. Finholt, UM; S. Jackson, UM; D. Ribes, Georgetown; S.L. Star, SCU)
  - *Data Conservancy: OCI0830976*, Sayeed Choudhury, PI, Johns Hopkins University.
  - *Knowledge and Data Transfer: the Formation of a New Workforce*. C.L. Borgman, PI; S. Traweck, Co-PI.
- Microsoft External Research: Tony Hey, Lee Dirks, Catherine van Ingen, Catherine Marshall
- Sloan Foundation: *The Transformation of Knowledge, Culture, and Practice in Data-Driven Science: A Knowledge Infrastructures Perspective*: . C.L. Borgman, PI; S. Traweck, Co-PI. Josh Greenberg, program director
- Comments on talk: Jillian Wallis, Laura Wynholds, Elizabeth Rolando, Ashley Sands, Karen Crawford, Morgan Currie, Rebekah Cummings

