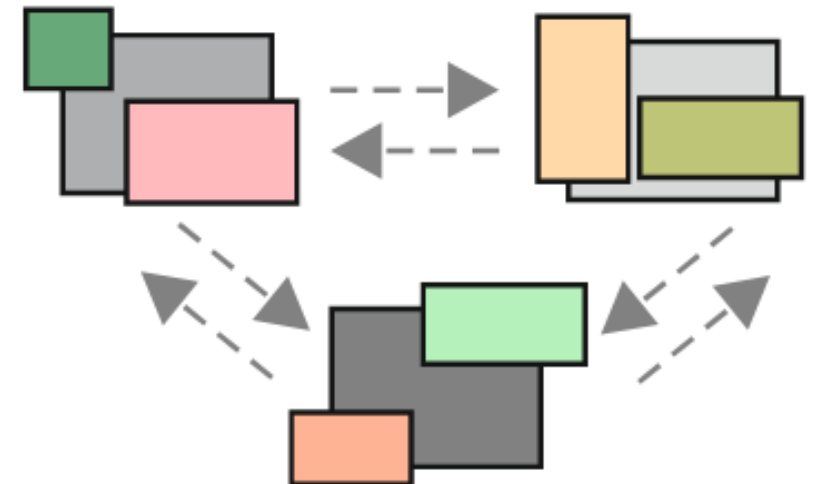


The Structure-Behavior-Action Framework in Scientific Enterprise

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GUARDIAN conference 2025
09 October 2025



Structure-Behavior-Function (SBF) framework in system design

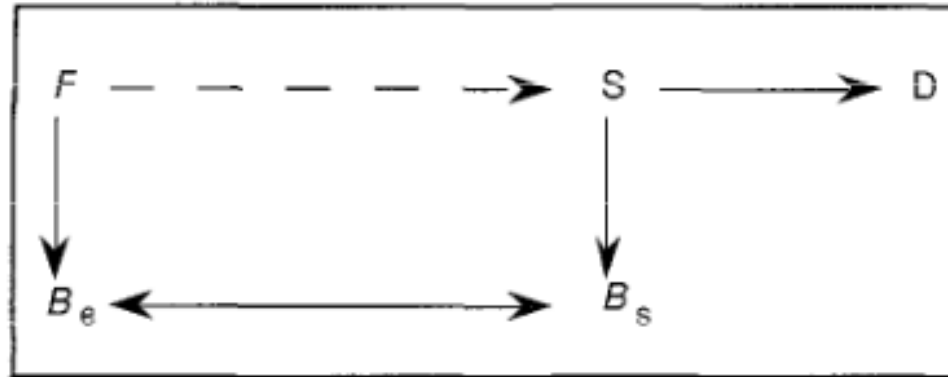


Figure 2. Model of Design as a Process.

B_e = Set of expected behaviors

B_s = Set of actual behaviors D = Design description

F = Set of functions S = Structure

$\rightarrow$ = Transformation

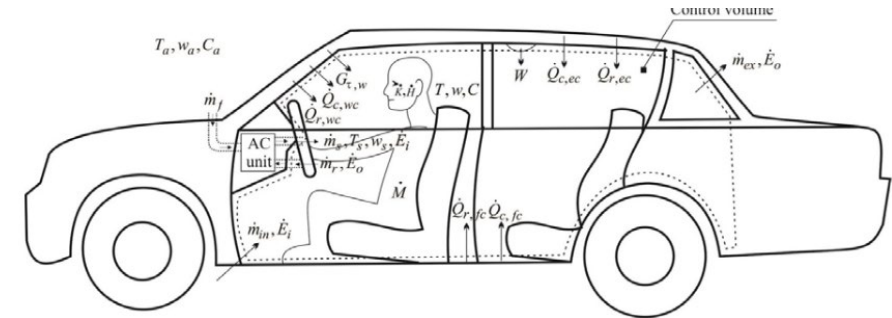
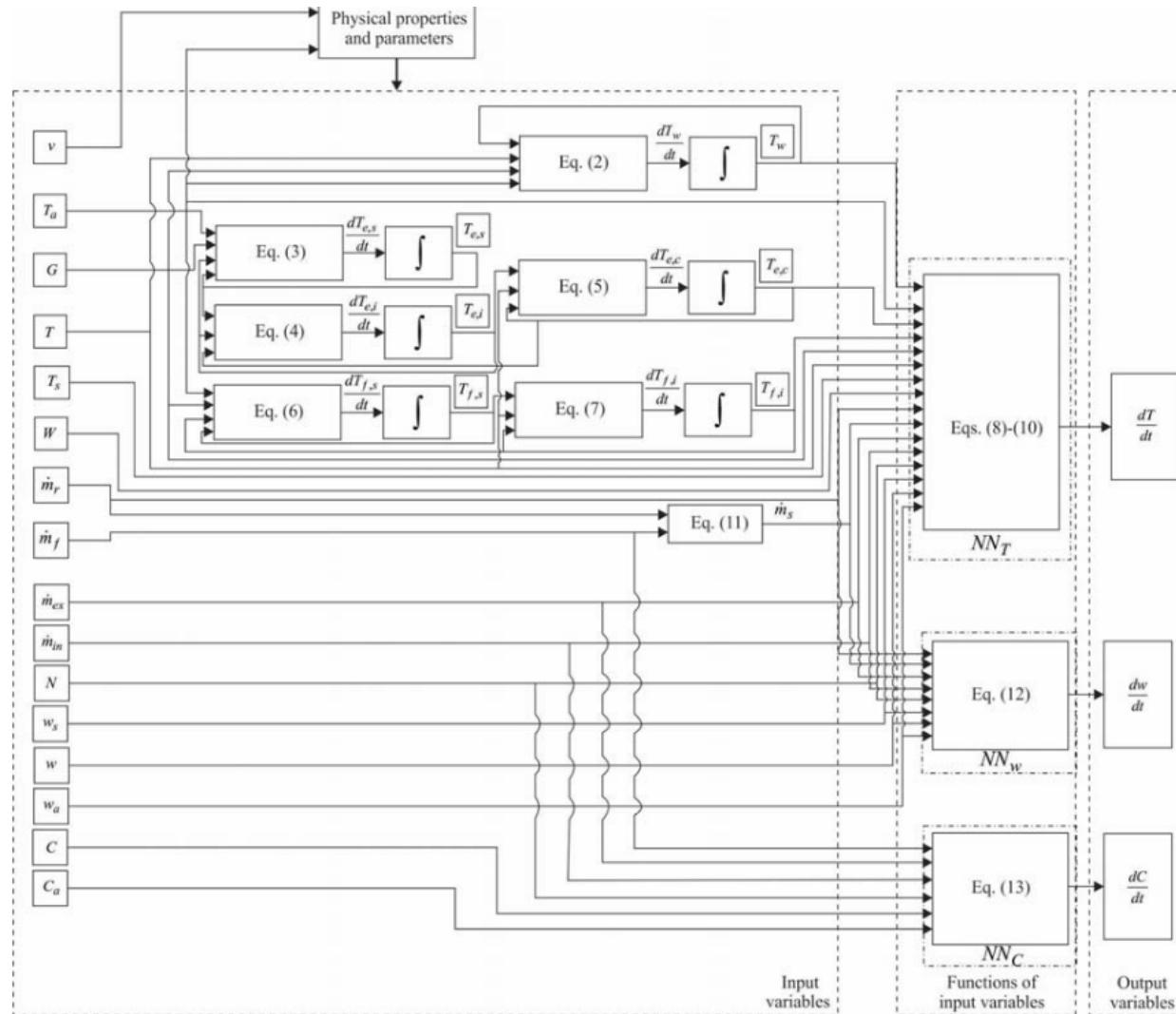
$---\rightarrow$ = Occasional transformation

$\leftrightarrow$ = Comparison

Functions are the goals. In system design, structure need to be modified to produce behavior that leads to the goals.

(Gero, 1990)

SBF in automotive engineering



The goal is to provide thermal comfort within the car cabin. It is achieved by engineering the structure of the car.

(Kristanto et al., 2018)

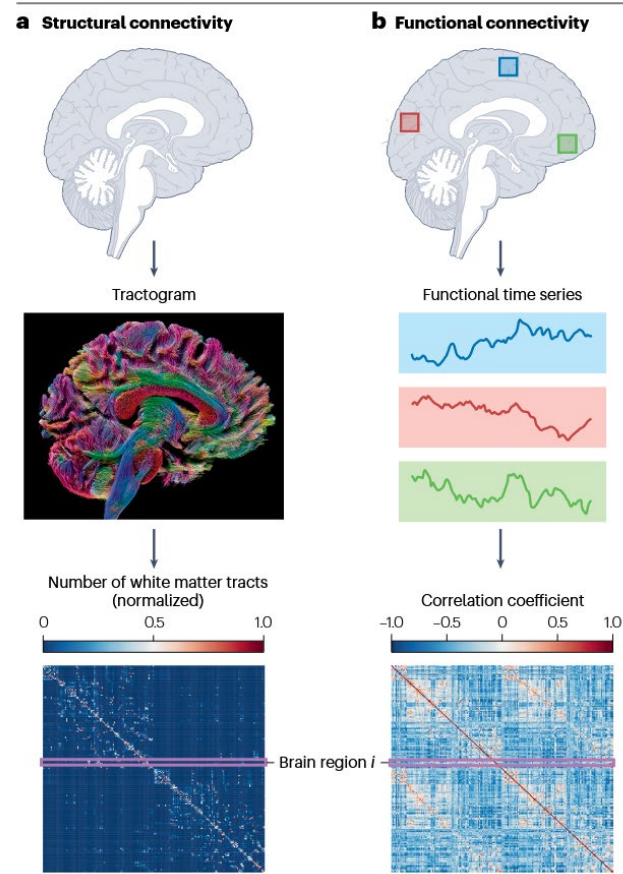
Structure, Function, and Behavior of Life

In engineering	In biology
Physical structure (hinges connect door to frame)	Bodies, organs, tissues, cells, organelles, molecules
Behavior of parts (door swings back & forth)	Circulation, nerve impulses, muscle contraction, etc.
Function of device (door allows or stops entry)	Hunting, feeding, elimination, reproduction, etc.

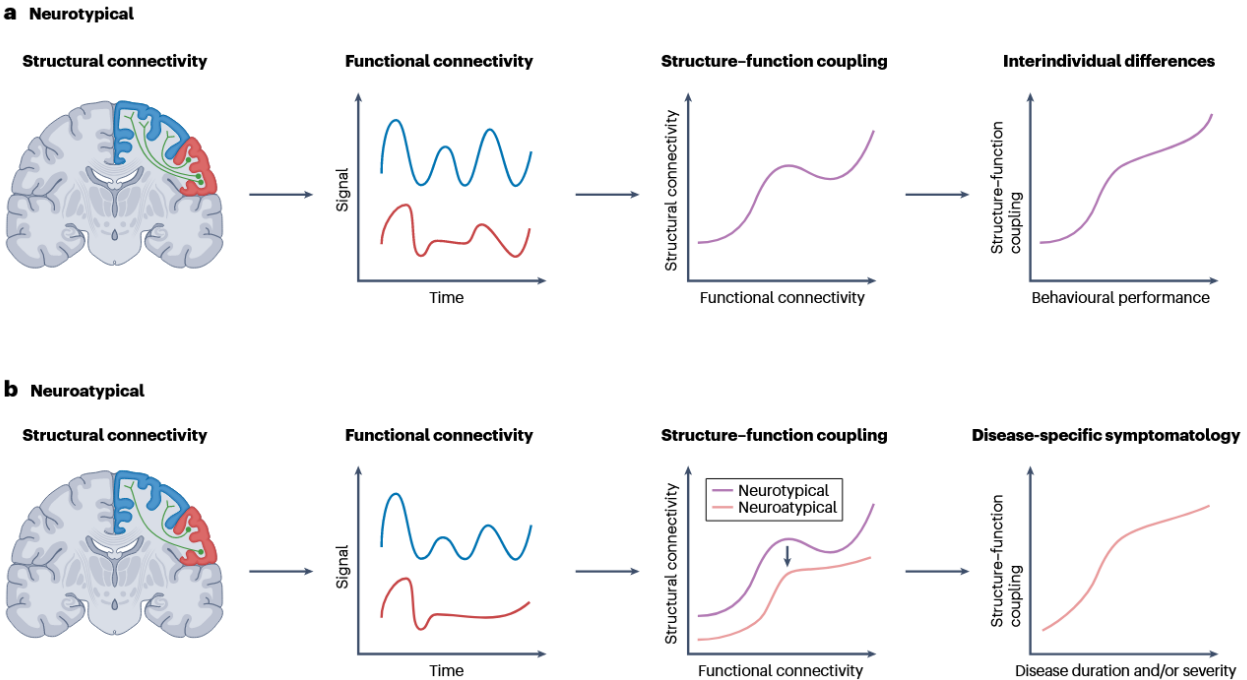
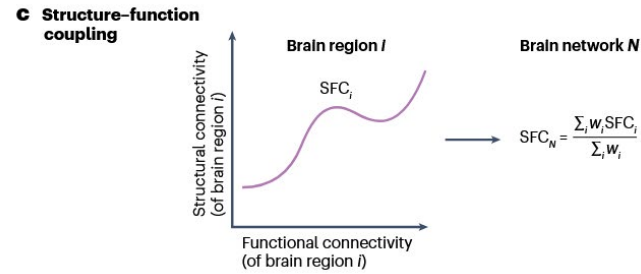
- Others have applied this paradigm to biology:
 - Helms, M., Vattam, S., Goel, A. K., & Yen, J. (2011, July). Enhanced understand of biological systems using structure-behavior-function models. In *2011 IEEE 11th International Conference on Advanced Learning Technologies* (pp. 239-243). IEEE.
 - Knüpfer, C., Beckstein, C., Dittrich, P., & Novère, N. L. (2013). Structure, function, and behaviour of computational models in systems biology. *BMC systems biology*, 7(1), 43.
 - Laubichler, M. D., & Müller, G. B. (Eds.). (2007). *Modeling biology: Structures, behavior, evolution*. MIT Press.
 - And many more...
- The key difference:
 - Machines: Built to fulfill one function.
 - Living beings: Evolved to perform all actions needed for life.

Example application: Studying the human brain

Aspect	Accomplishes	Example(s)	Measured with
Structure	Supports/constrains behavior	Thickness, cortical folding, myelination	T1-/T2-weighted MRI
Behavior	Prepares for, then carries out action	Coactivation of brain regions	Functional MRI (BOLD signal)
Action	Keeps organism alive	Recruiting regions needed for task	Psychometrics (task speed, acc.)



Structure is used to explain the function. The coupling of structure and function is widely studied to explain individual differences. (Fotiadis et al., 2024)



Structure, Function, and Behavior of Societies

In engineering	In society (material)	In society (cultural)
Physical structure (hinges, frame, etc.)	Technological structures (buildings, computer systems, etc.)	Incentive structures (Rewards, punishments, etc.)
Behavior of parts (rotation, translation, etc.)	Physical behaviors (Movement of people, writing, etc.)	Cultural practices (Traditions, fads, etc.)
Function of device (Protection, transportation, etc.)	Physical actions (Production & transportation of goods, record-keeping, etc.)	Cultural actions (Protecting vulnerable groups, improving quality of life, etc.)

- Others have applied this paradigm to many kinds of social systems:
 - Rosenberg, A. (1985). *The structure of biological science*. Cambridge University Press.
 - Raza, A. (2024). The Role of Social Structures in Human Behavior: A Sociological Perspective. *Social Science Review Archives*, 2(1), 11-19.
 - Caporaso, J. A. (1978). Dependence, dependency, and power in the global system: a structural and behavioral analysis. *International organization*, 32(1), 13-43.
 - Parsons, T. (2017). The school class as a social system: Some of its functions in American society. In *Exploring education* (pp. 151-164). Routledge.
 - And many more...
- The key difference:
 - Machines are physical objects, each with a single job.
 - Societies need to survive and develop along both material and cultural dimensions.

Structure in scientific enterprise

The goal of the scientific enterprise is to **translate** research findings into **practice**. To achieve this, research must be **reproducible**, **valid**, performed with **integrity**, and **cumulative**, with new findings integrating with and building upon previous work.

Challenges facing science

- Many areas of science face issues with reproducibility.
- Research in animals often does not translate to humans.
- Research on humans must observe ethical boundaries.
- Complex systems, like humans, are too multifaceted to fit into one discipline.

Structure-behavior-action explains some challenges

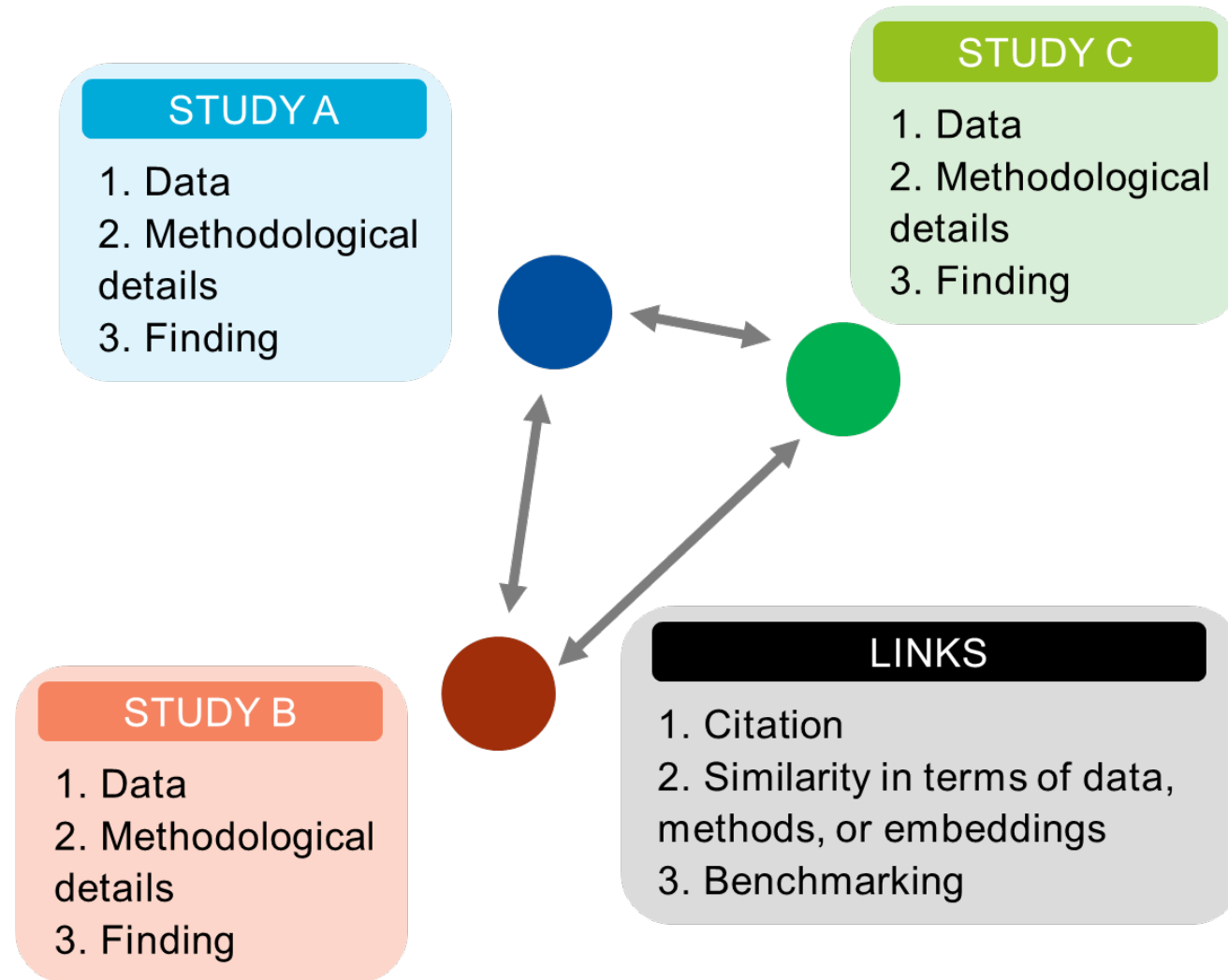
Desired action	Structure	Behavior	Realized action
Research builds on, fills gaps in existing knowledge.	Records of past research in prose, tables, and figures in articles scattered across for-profit journals, divided by discipline.	Researchers pick out and skim over only a few articles before designing new projects.	New projects unknowingly duplicate old ones, fail to adopt the best available methods.
Funding agencies support productive researchers, empowering them to do more.	Research productivity measured by metrics of how often other researchers cite articles.	Researchers invest time in self-promotion instead of literature reviews or well-designed research, avoid citing competing projects.	Funding goes to the most media-savvy, not the most productive, sometimes supporting research fraud.

Proposing better structures

Structure	Behavior	Action
Independent organizations use distributed server infrastructure (the NPDS Cyberinfrastructure) to serve community knowledge spaces representing knowledge from many studies.	Researchers quickly explore the overall state of knowledge in a field, identify gaps, and find methods they can use to fill those gaps.	Science advances instead of retreading the same ground.
Journals, universities, and other organizations evaluate works based on metrics (e.g., the FAIR Metrics) of how accurately they represent which claims are new and which come from prior work.	Researchers find, read, and cite existing works, then go on to answer new questions that those works have not already answered.	Funding organizations gain a clear idea of which ideas and results came from which researchers and allocate funds accordingly.

What kinds of structures for science?

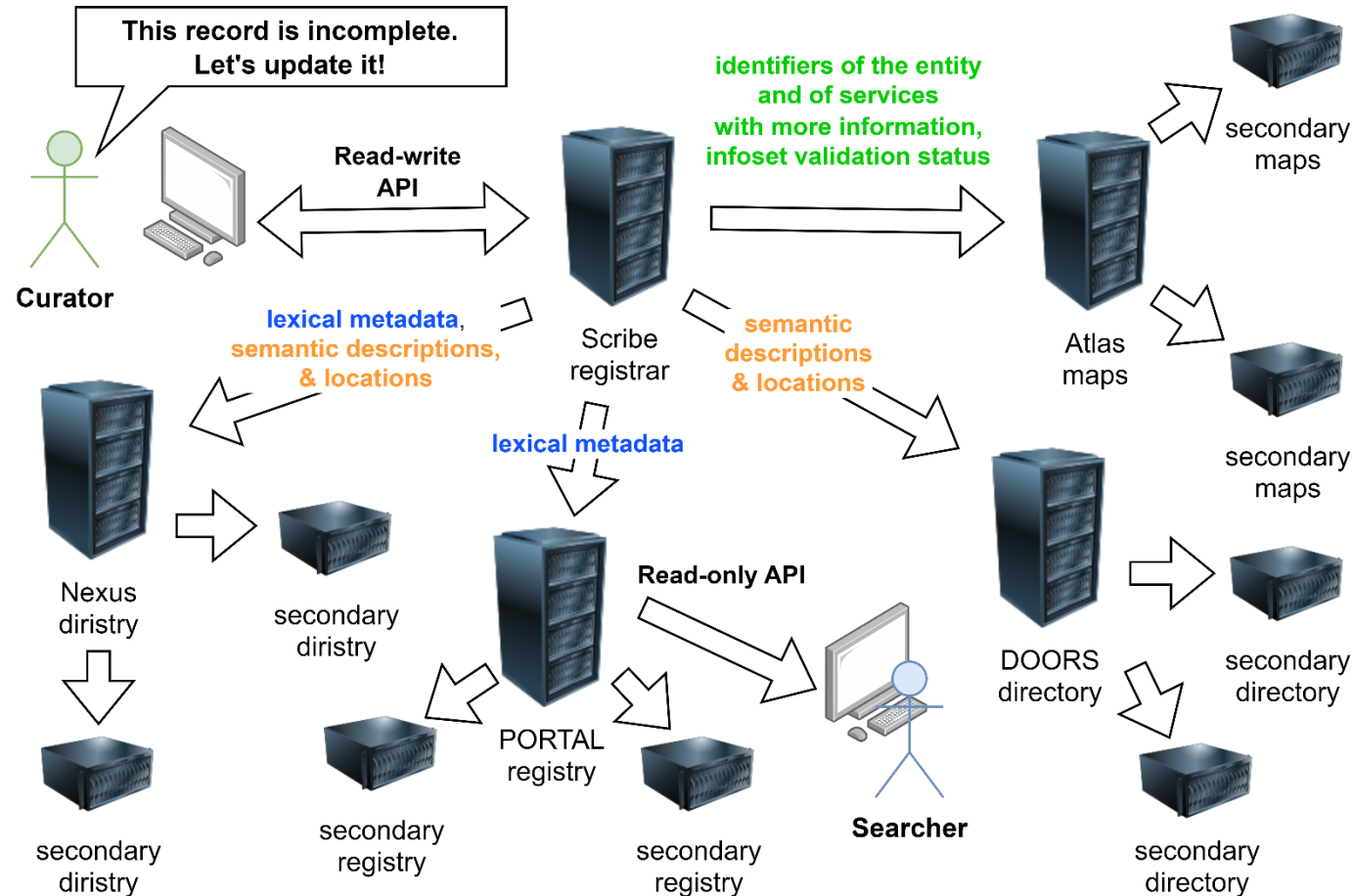
Structuring research resources and outcomes



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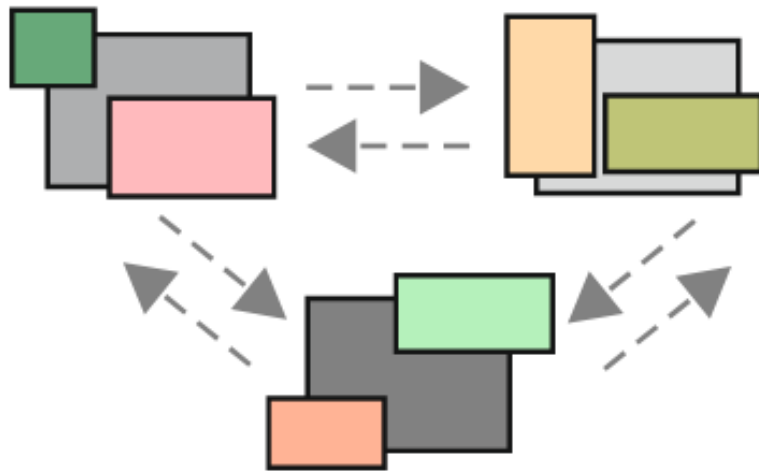


Sharing knowledge via the Nexus-PORTAL-DOORS-Scribe System



The **PORTAL-DOORS** architecture separates resource registration from publishing across two specialized networks. Agents (resource owners) interact with the lexical **PORTAL** network to **register unique entity labels and tags**. They then use the semantic **DOORS** network to publish the **entity's locations and a rich, semantic description**. This allows users to find resources through simple keyword searches in PORTAL or advanced, meaning-based queries in DOORS. (Taswell, 2008; Taswell, 2010; Craig & Taswell, 2025, SEASON conf.)

Benefits of the NPDS Cyberinfrastructure



- ❖ **Rich and layered metadata:** Five-level metadata (Entity, Record, InfoSet, Representation, Message metadata)
- ❖ **Versatile resources types:** Not only articles, can also be software, datasets, or other research entities
- ❖ **Collaborative network with cross-references:** Supports linking related entities
- ❖ **Decentralized and owner-managed:** Ensures data accuracy, democratizes search (Taswell, 2008; 2010)

See also: Anousha Athreya, Adam Craig, S. Koby Taswell, and Carl Taswell, 2023, Opening democratised portals and doors to the free flow of findable facts

Research Features (ISSN 2399-1534) Issue 148 pp 54-57

Which kind of incentive structures encourage research integrity?

Table II
FORMULAS FOR FAIR METRICS WITH CONDITION
 $0 < S(T|C) \leq K(C) \leq R(T|C)$

Symbol	Formula
$F_1(T C)$	$= Q(T C)/S(T C)$
$F_2(T C)$	$= [Q(T C) - M(T C)]/S(T C)$
$F_3(T C)$	$= [Q(T C) - P(T C)]/S(T C)$
$F_4(T C)$	$= [Q(T C) - N(T C)]/R(T C)$
$S(T C)$	$= M(T C) + Q(T C) + P(T C) \leq K(C)$
$R(T C)$	$= M(T C) + Q(T C) + P(T C) + N(T C) \geq K(C)$

FAIR: *Fair Acknowledgment of Information Records, or Fair Attribution to Indexed Reports*, Metrics for maintaining fair standards of citation in scholarly research and publishing.
(Craig et al., 2019)

Symbol	Definition
C	set C of statements in a Control paper or in a Comparison Collection of papers
$F_1(T C)$	FAIR metric scaled on interval $[0, 1]$ for T compared with C (dependent on Q and S)
$F_2(T C)$	FAIR metric scaled on interval $[-1, +1]$ for T compared with C (dependent on Q , M and S)
$F_3(T C)$	FAIR metric scaled on interval $[-1, +1]$ for T compared with C (dependent on Q , P and S)
$F_4(T C)$	FAIR metric scaled on interval $[-1, +1]$ for T compared with C (dependent on Q , N and R)
$G(A)$	function G operates on set A
$G(A B)$	function G operates on set A in comparison with set B (on set A given set B)
$M(T C)$	number M of Misquoted (incorrectly cited) statements found in T compared with C
$N(T C)$	number N of Novel (uncited) statements found in T compared with C
$K(C)$	number K of Known statements found in C
$P(T C)$	number P of Plagiarized (uncited) statements found in T compared with C
$Q(T C)$	number Q of Quoted (correctly cited) statements found in T compared with C
$R(T C)$	number R of Reported statements found in T compared with C
$S(T C)$	number S of Similar statements found in T compared with C
T	set T of statements in a Test paper

Which kind of structure(s) we need in scientific enterprise?

$$F_T = (A_T - M_T)/(A_T + M_T) \quad (1)$$

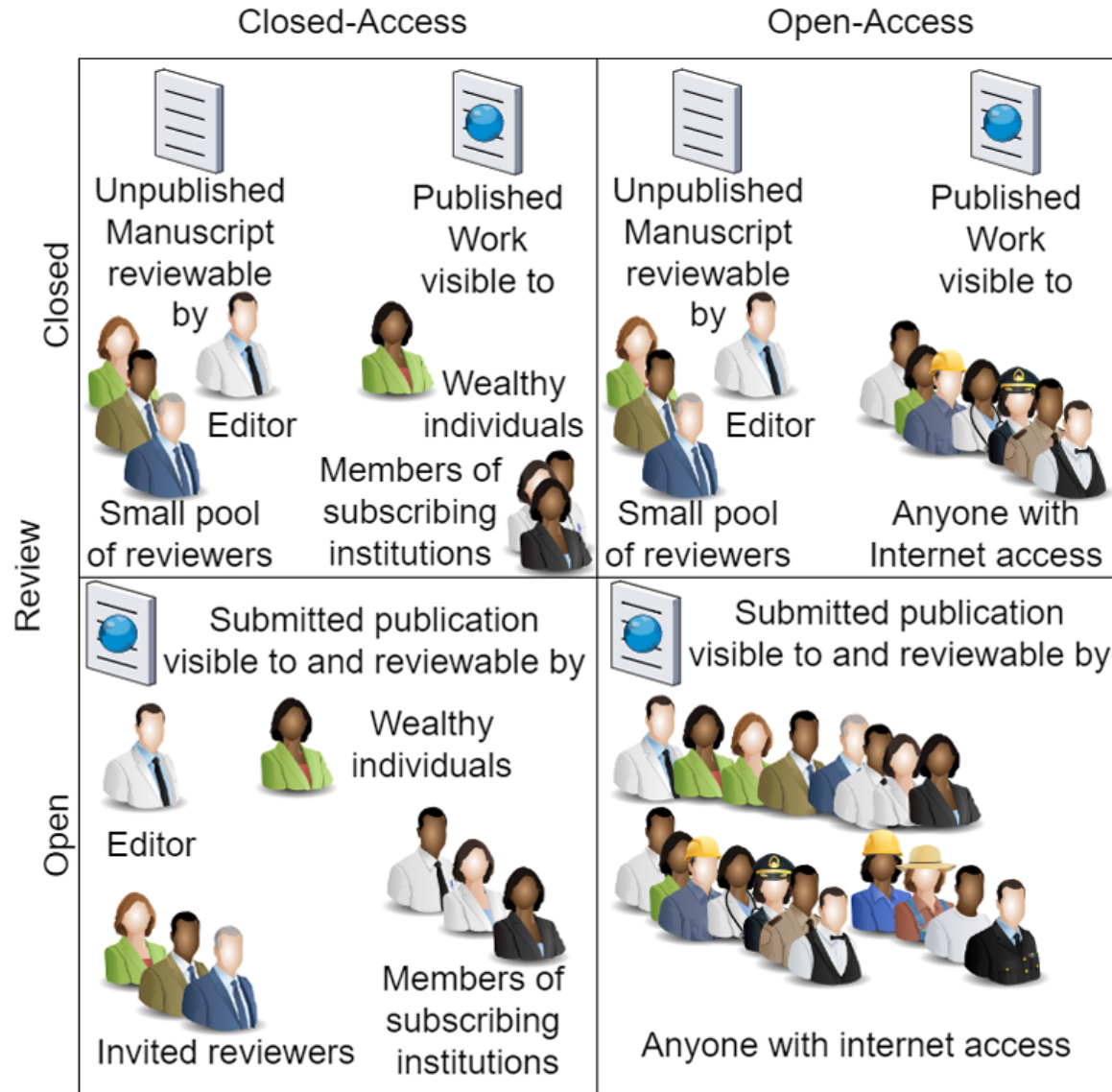
$$F_V = (A_V - M_V)/(A_V + M_V) \quad (2)$$

$$F_D = (A_D - M_D)/(A_D + M_D) \quad (3)$$

$$F_J = \frac{A_T + A_V + A_D - M_T - M_V - M_D}{A_T + A_V + A_D + M_T + M_V + M_D} \quad (4)$$

These formulas represent the **FAIR Metrics system**, a method to quantitatively measure the **reproducibility of a scientific peer review**. The approach works by analyzing a reviewer's factual claims and classifying them as either **Correctly Attributed (A)**, meaning they are accurately supported by a source, or **Misattributed (M)** if they lack a source or misrepresent it. The claims are sorted into three distinct categories: those about the **Target paper being reviewed (T)**, the publication **Venue's standards (V)**, or the broader scientific **Domain knowledge (D)**. The first three formulas (F_T , F_V , F_D) calculate separate scores for each category, ranging from -1.0 for entirely misattributed claims to +1.0 for perfectly attributed claims. The final formula, then combines all of these counts into a single, overall Justification score, providing a holistic measure of the review's factual integrity and quality (Craig and Taswell, 2024)

What kind of publishing will support public engagement with science?



We believe that quality peer review, and peer review of peer review, must be motivated and maintained by elevating their status and prestige to an art and a science. Both peer review itself and peer review analyses of peer reviews should be incentivised by publishing peer reviews as citable references separately from the research report reviewed while crossreferenced and crosslinked to the report reviewed. (Craig et al., 2023)

Briefly: More people who can see and comment on a work → More chances to see and recognize good or bad practices.

Structuring scientific enterprise to achieve its goal is a collaborative effort from different stakeholders

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