

TOWARDS A NEW SCIENTIFIC UTOPIA: A BLOCKCHAIN-BASED FRAMEWORK TO SUPPORT OPEN SCIENCE IN PSYCHOLOGY

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ABSTRACT

In the last decade, the **Open Science movement** has proposed solutions to the proliferation of Questionable Research Practices, which undermined the **credibility** of psychological science. Among them, one the most successful has been the **Open Science Framework (OSF)**, which encompasses a set of tools for making the entire research process more open, and which has had a central role in defining innovative policies to promote **reproducibility**. In this project, we propose a **blockchain-based framework** designed to **complement** the existing Open Science Framework (OSF). By leveraging **blockchain technology**, **cryptocurrencies**, and **Web3 tools** – such as smart contracts, Non-Fungible Tokens and Decentralized Autonomous Organizations – this framework could **enhance** key aspects of the **research lifecycle**, including pre-registration, data collection, peer review and publication. This model also comes with a new **incentive** and **meritocratic** system which, by following the model of cryptocurrencies, has the potential to **motivate** individual actors to advance the goals of **Open Science**.

HOW TO OPEN SCIENCE: A STRATEGY FOR CULTURE CHANGE

To challenge the status quo and guide academia toward an **Open Science paradigm** [1], Nosek’s **Strategy for Culture Change** [2] aims to **engage all scientific stakeholders** through five sequential steps:

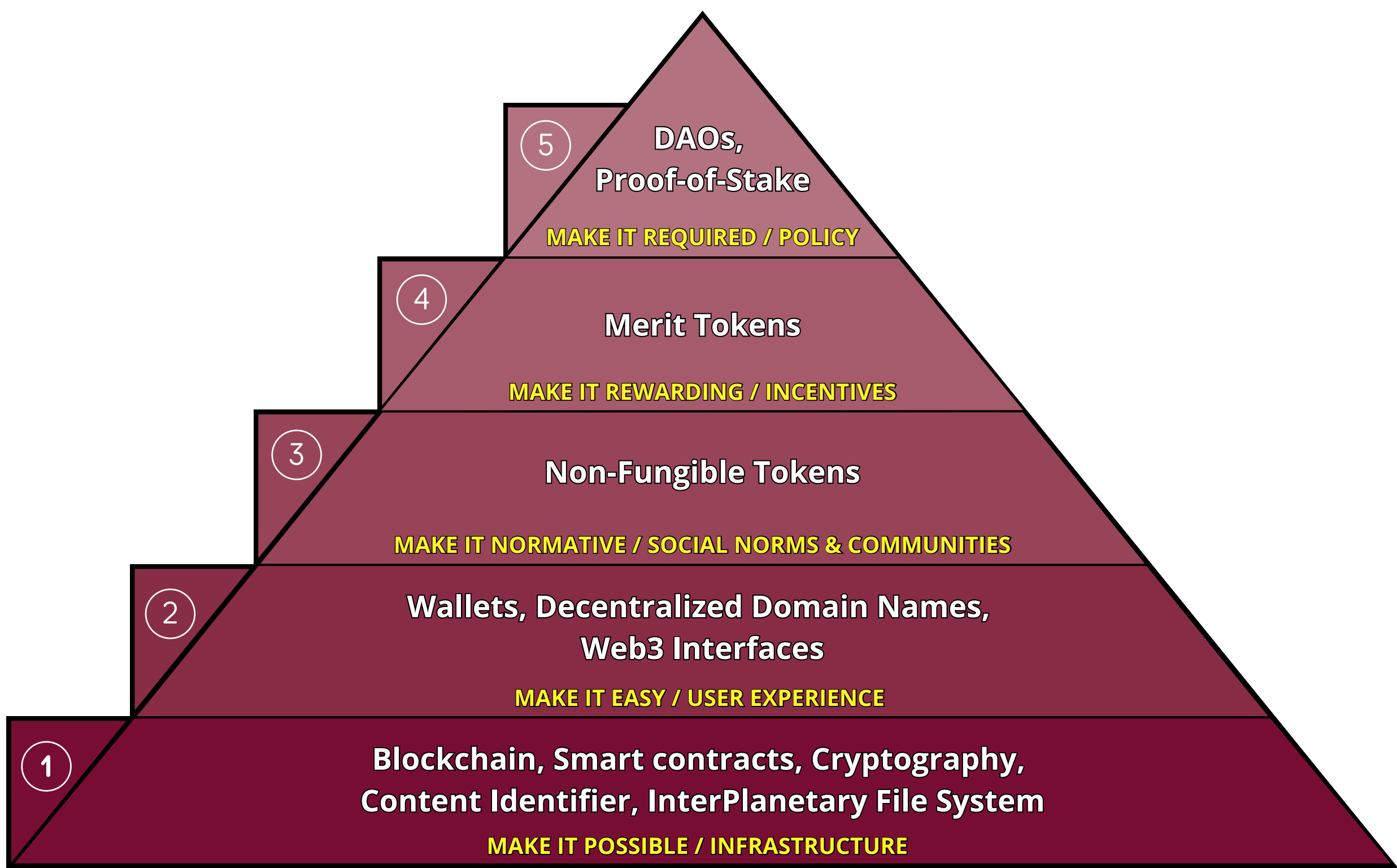
- 1. **MAKE IT POSSIBLE** – Highly motivated innovators need only **adequate infrastructure** and **tools** to implement OS practices;
- 2. **MAKE IT EASY** – Early adopters demand **user-friendly solutions**;
- 3. **MAKE IT NORMATIVE** – The **visibility** of early adopters' behaviour is crucial for the **normative influence** they exert on peers;
- 4. **MAKE IT REWARDING** – Real behavioral change necessitates **reforms** in the academic **incentive** system that make it **desirable**.
- 5. **MAKE IT REQUIRED** – Structural change also requires **new policies mandating open practices**.

Despite advances in OS initiatives, a **substantial adoption gap** persists [3;4;5], which technology may help address [6]. I therefore propose a **blockchain-based framework** to **complement existing OS strategies**, drive cultural change **across all levels of Nosek’s pyramid**, and support the entire **research lifecycle** in psychology, while remaining adaptable to other disciplines.

ESSENTIALS OF BLOCKCHAIN TECHNOLOGY

Blockchain is a **Distributed Ledger Technology (DLT)** [7;16] that enables **secure, transparent, and immutable recording** of information in a “digital registry” distributed across a peer-to-peer **network** of computers (nodes), each maintaining a copy of the entire blockchain. **Data is stored in blocks** that are **cryptographically linked**, forming a chain, while nodes participate in **validating** these blocks. Blockchain underpins the functioning of **cryptocurrencies**.

BLOCKCHAIN CONTRIBUTIONS TO THE CULTURE CHANGE PYRAMID



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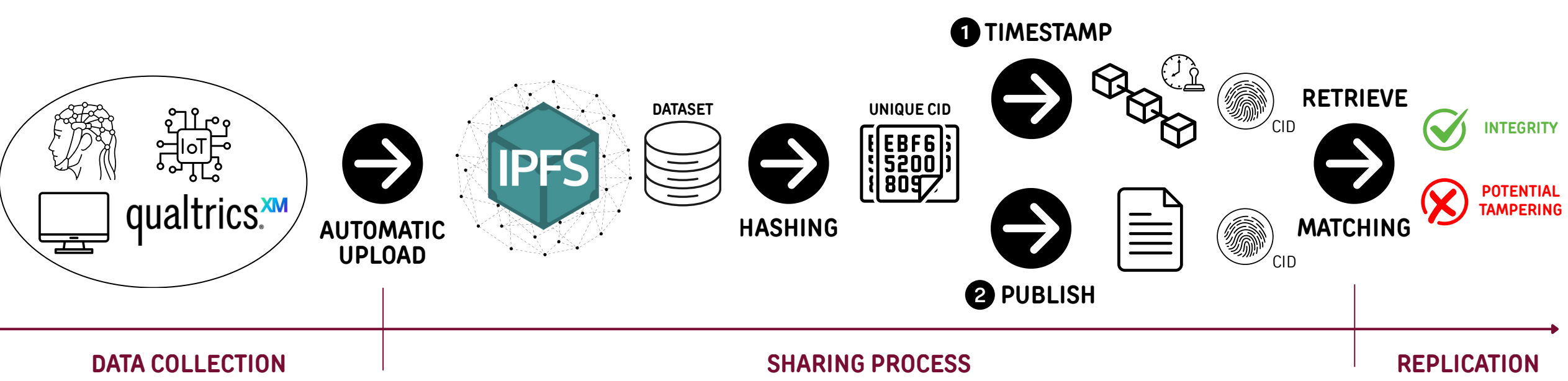
BLOCKCHAIN FOR OPEN SCIENCE: STEP BY STEP

I will illustrate how the proposed framework can **advance Open Science** by presenting a blockchain-based solution for **each stage** of Nosek’s pyramid, while recognizing that its applicability in academia extends beyond the examples provided [17].

1) OPENING DATA WITH BLOCKCHAIN & IPFS

**To make OS possible**, the **foundational infrastructure** could be reinforced with blockchain features. In particular, the open sharing of data, materials, and methods could be enhanced through blockchain-based **time-stamping** [8] and the **decentralized storage** provided by the **InterPlanetary File System (IPFS)** [9]. To illustrate this process, I will outline how IPFS and blockchain could **facilitate data sharing**:

- 1. A researcher **collects data** through laboratory instruments, online survey platforms, or Internet of Things devices;
- 2. The raw data is **automatically uploaded** to **IPFS** for decentralized storage, thus **preventing** potential **manipulation** by the researcher;
- 3. IPFS assigns each dataset a unique **Content Identifier (CID)**, a hexadecimal string generated via cryptographic hashing [10]. The CID is intrinsically **linked to the file’s content**, so that even minor modifications produce a different identifier;
- 4. The CID is **recorded** in a specific **blockchain block**, thereby creating a **tamper-proof timestamp** that certifies the dataset’s existence at a given moment with that exact content;
- 5. The researcher publishes the results, including the **block identifier** and **CID** to enable **retrieval** of the raw dataset from IPFS and the **verification of its integrity**;
- 6. To verify that the open raw dataset used in a study **corresponds** to the one **timestamped** on the blockchain, the associated **CIDs** are **compared**: a match indicates that the underlying data are **consistent** and untampered, whereas a mismatch signals potential **manipulation**;
- 7. Anyone can **retrieve** the raw data from IPFS using the CID and attempt to **reproduce** the results. However, **encrypting** the CID prior to its blockchain time-stamping still allows verification of the information’s integrity **without immediate disclosure** to the scientific community.



2) BLOCKCHAIN WALLETS: VERIFIABLE ACADEMIC IDENTITIES

**To make OS easy**, scholars interact with the blockchain via **digital wallets**, which uniquely identify them. Wallet addresses, expressed as hexadecimal strings, can be replaced with human-readable **decentralized domain names**. Wallets can hold NFTs and Merit Tokens, serving as **verifiable academic profiles**. This architecture offers greater **programmability** than traditional identifiers such as DOI and ORCID [15], while enhancing **user experience**. Additional Web3 interfaces, originally designed for economic applications, could also be repurposed to support scientific research.

3) NFTs: CERTIFIED CREDENTIALS

**To make OS normative**, Open Badges [11] can be issued as **Non-Fungible Tokens (NFTs)** [16]: digital credentials anchored on the blockchain that can denote **qualifications**, academic **achievements**, **intellectual property**, skills, areas of **expertise**, and **adherence to OS practices**. NFTs are **resistant to forgery**: validated and immutably recorded by blockchain consensus, their authenticity is verifiable without involving third parties.

4) MERIT TOKENS: INCENTIVES FOR OPEN SCIENCE

**To make OS rewarding**, blockchain and cryptocurrencies can also establish a novel **incentive system** for scientific research. **Merit Tokens (MTs)** could be **awarded** to stakeholders who perform virtuous actions aligned with **OS principles**. [12]. MTs can be earned in various roles (such as Author, Reviewer, or Reader) and an equation could yield a **Merit Score (MS)**, reflecting an individual’s impact on science. MTs could incentivize honest, high-quality **peer reviews** [13]. Additionally, MS could serve as a qualitative, decentralized **measure of academic reputation** grounded in OS principles, complementing traditional quantitative scientometrics. The **selection of optimal reviewers** for the OPR could rely on their **MS**, complemented by certified skills and areas of expertise validated through **NFTs** [14].

5) DAOs: DECENTRALIZED GOVERNANCE OF OPEN SCIENCE

**To make OS required**, journals could operate as **Decentralized Autonomous Organizations (DAOs; 16)**: blockchain-native entities **collectively owned** and governed through **smart contracts**, algorithms that automatically execute predefined actions when conditions are met. Editorial boards would consist of scholars who **lock their MTs** within smart contracts, signaling **commitment** to transparent and equitable publishing [18]. This **Proof-of-Stake** mechanism quantifies participants’ **trustworthiness** and safeguards the integrity of voting rights in DAO governance decisions.

CONCLUSIONS

This blockchain-based framework aims to enhance **transparency, fairness, and incentive alignment**, fostering a more robust and reproducible scientific ecosystem. Its **feasibility, benefits, and effectiveness** require further study, alongside **critical technical aspects** such as blockchain architecture, consensus mechanism, and tokenomics design.