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.

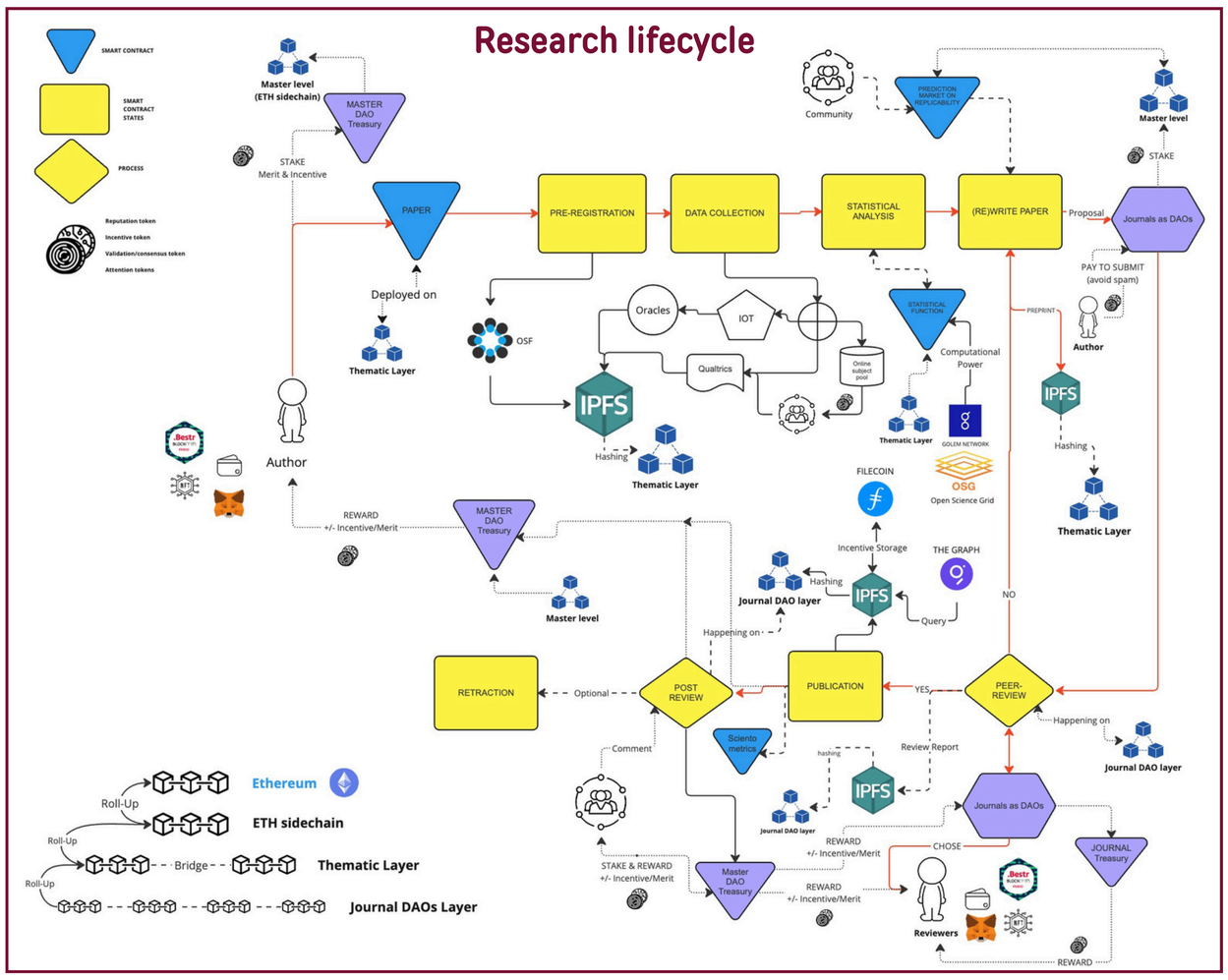
What is blockchain technology?

Blockchain is a Distributed Ledger Technology (DLT) [8–15] 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, such as Bitcoin.

Key features:

- **Decentralization**: In a blockchain network, there is no central authority or single point of failure, making the system resilient and resistant to censorship.
- **Consensus**: To add a new block, the network must validate its content using a consensus algorithm such as Proof of Work or Proof of Stake, ensuring a trustless system.
- **Traceability & Transparency**: Every transaction on a blockchain is visible to all network participants because the ledger is publicly accessible, allowing anyone to verify its accuracy.
- **Immutability**: Once a block is added, its data cannot be altered or deleted due to cryptographic hashing, ensuring data integrity.
- **Security**: Blockchain employs advanced cryptographic techniques to protect data and prevent unauthorized modifications.
- **Scalability & Modularity**: By leveraging solutions like layer-2 scaling, sidechains, and roll-ups, blockchains can efficiently support a high volume of transactions.
- **Programmability**: Smart contracts, self-executing contracts with predefined rules, can be deployed on blockchains. These contracts automatically execute actions when conditions are met, reducing the need for intermediaries and improving efficiency.
- **Tokenomics**: Cryptocurrencies and NFTs are built-in mechanisms that enable the exchange of value within blockchain ecosystems.

Research lifecycle



How could blockchain help Open Science?

By exploiting the features of blockchain and other Web3 technologies, we can advance the goals of Open Science [5] and introduce structural changes across the research lifecycle. This approach fosters new meritocratic and incentive-based models [7]. Specifically, we propose integrating the existing Open Science Framework (OSF) with an Ethereum sidechain as a master-level chain, which communicates via roll-ups with layer-2 solutions hosting various research lifecycle phases.

Actors engagement

- **A New Incentive System**: Researchers can be rewarded with cryptocurrencies for virtuous actions such as peer reviews and reproducibility studies. Additionally, a transparent funding system for researchers can be introduced [3–10].
- **Merit Tokens:** These tokens are awarded for each virtuous action, representing a researcher's reputation as a complement to traditional scientometric measures [1].
- **Open Badges** as **NFTs** or **Blockcerts**: These digital credentials can represent qualifications, expertise, academic achievements, intellectual property (IP), and recognition of open research practices [2].
- **Citizen science** and **crowdsourcing**: Cryptocurrencies can incentivize knowledge creation by rewarding contributors who comment on reviews or implement replication studies.

Data management

- **Hashing**: Due to block size limitations, full datasets and research papers cannot be directly stored on-chain. Instead, only their cryptographic hashes are recorded, ensuring data integrity—if two hashes match, the underlying data has not been altered or manipulated [14].
- **Storing**: Data can be stored and distributed via InterPlanetary File System (IPFS), a decentralized repository where files are located by content rather than location. Participants who contribute storage resources can be rewarded with cryptocurrencies [11].
- **Pre-registration**: Hypotheses, theses, methods, and datasets can be timestamped, encrypted, and distributed on the blockchain, proving authorship and ensuring transparency while preventing questionable research practices (QRP) [14]. Encryption ensures that sensitive information remains private until the owner decides to disclose it.
- **Data integrity**: Automatically recording collected data on-chain ensures that no manipulations occur. Additionally, real-world data can be gathered in ecological settings via Internet of Things (IoT) devices, which relay information to the blockchain through smart contract-based Oracles.
- **Accountability**: Any dataset modification can be recorded as an immutable blockchain transaction, enabling full auditability and fraud detection.
- **Reproducibility**: Transparent and immutable blockchain records facilitate real replications. Furthermore, prediction markets with Automated Market Makers (AMMs) can be leveraged to forecast reproducibility outcomes.

Governance

- **Decentralized Autonomous Organizations (DAO)**: Governance of the system can be managed via a DAO, where researchers stake Merit Tokens to gain voting rights. The more merit accrued, the greater the decision-making influence.
- **Journals as DAOs**: Academic journals can be decentralized and researcher-led, with the Editorial Board composed of scholars who stake their Merit and Incentive Tokens, reclaiming control over knowledge dissemination [9].

Open Practices

- **Open Access/Data**: IPFS enables free and unrestricted access to research papers and datasets.
- **Open Methods**: Statistical analyses can be encoded into smart contracts, ensuring reproducibility and preventing post-hoc modifications. Detailed workflows can also be automated.
- **Open Collaboration**: Researchers can contribute computing resources (e.g. via the Open Science Grid or the Golem Network) and be rewarded for participation. Additionally, decentralized social networks (DeSoc) can facilitate research planning and collaboration.
- **Open Peer Review**: Peer review workflows can be automated using smart contracts and virtual machines. A keyword-based matching algorithm can pair papers with qualified reviewers based on NFT metadata and Open Badges, ensuring a merit-weighted selection process, further reinforced by Merit Tokens [4–12–13].
- **Open Identity**: Researchers can be represented by wallet addresses linked to decentralized domain names. These wallets can be associated with Open Badges, NFTs, and research as smart contracts. This structure allows greater programmability compared to traditional identifiers like DOI and ORCID [6].

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