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Unblocking Recognition: A Token System for Acknowledging Academic Contribution

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Abstract

Here we present a blockchain-backed token recognition system to reward the contributions that academics make to the scientific ecosystem. Recognition is important in science but current methods, systems and incentives are limited. Specifically, the traditional focus on narrow publication metrics means diverse contributions are not captured, while bias toward senior, established scientists is common. To tackle this challenge, we explore the potential of harnessing blockchain's collaborative, decentralised and trust-brokering properties to develop a token reward system for use by research funders. Academics would be awarded tokens for undertaking common but vital tasks such as peer review, sitting on funding committees and submitting reports. These tokens would not be tradable or specifically monetisable but would serve as a validated record of scientific contribution. They would have value in professional recruitment and job placement, support grant and award applications, and inform performance appraisals and file reviews. Coordination and cooperation across multiple funding agencies in developing the platform would provide an opportunity to aggregate and standardise recognition, given academics often work with several funders. This system's goals are to expand recognition metrics, promote efficiencies, improve the robustness of professional assessments and enable cross-funder collaboration, thereby optimising research processes and practices in a decentralised and democratised manner.

Keywords: Blockchain, Token, Recognition, Reward, Peer Review, Research Management, NIHR

1. Introduction

Currently, the number of citations and papers published is the primary means of assessing the impact and productivity of researchers, a system widely recognised as having significant limitations (Ducrée et al., 2022; Kosmarski, 2020; Leible et al., 2019; Terheggen, 2021). The most common example of this is the author-level h-index which measures the productivity and citation impact of an individual's publications. This metric can have a significant impact on hiring decisions, promotion and funding competitions, but recent studies suggest it no longer correlates with scientific reputation, raising questions about the completeness and overall utility of these types of single modality measurement (Koltun and Hafner, 2021). Fundamentally, concerns exist regarding the use of citations to assess scientific output due to potential manipulation (e.g., self-citation and coercive citation) and lack of discipline-specific citation stratification. Relying on citation metrics may also fail to capture the wide range of contributions academics make to the research ecosystems and discriminates in favour of senior researchers.

Some of these broader achievements are captured on an academic's CV, which is equally important in professional development and funding acquisition. However, studies have also expressed concern about academic misconduct and fraud in CVs, particularly since information is often not validated in any meaningful way (Phillips et al., 2019). The Royal Society summarises this problem of generating a more holistic understanding of scientific contributions by stating, 'Too narrowly focused performance indicators can make it harder to see, reward or nurture the full range of contributions that are necessary to create the environments that enable excellence and steward it for the future.'[1]. In response to these and other challenges, some researchers and companies have

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Due to the complexity of blockchain, terms which may not be common knowledge have been supplemented with online links in footnotes.

suggested using blockchain[2] systems to enhance trust, verification and recognition in the scientific enterprise (Curmi and Inguanez, 2020; Mackey et al., 2019a).

Since the advent of Bitcoin[3] (Nakomoto, 2008), blockchain, the technology behind cryptocurrencies[4], has proliferated far beyond finance and into numerous sectors, being among the fastest expanding technologies in world history (Ducrée et al., 2022). In science, blockchain has the potential to improve data quality, build trust and facilitate collaboration (Ducrée et al., 2022; Extance, 2017; Leible et al., 2019; Van Rossum, 2017), while in the healthcare sector use cases include supply chain management, management of patient records and genomics data, Internet-of-Medical-Things (IoMT), trial management and even addressing fraud and abuse in healthcare delivery (Mackey et al., 2020; Mackey et al., 2019b; Tandon et al., 2020). More specific to research funders, blockchain could benefit research administration, data centralisation, publishing and academic recognition (Ducrée et al., 2022; Engelhardt, 2017; Janowicz et al., 2018; Leible et al., 2019; Mackey et al., 2019a; Swan, 2015). Blockchain-backed tokens[5] are prime candidates to realise these benefits (Ducrée, 2020), particularly in peer review (Avital, 2018; Jan et al., 2018; Kosmarski, 2020; Spearpoint, 2017; Swan, 2015; Tennant et al., 2017).

In this study, we explore and conceptualise a framework for a token recognition system in the context of academic achievement. We detail the technological features, practical implications, possible challenges and limitations, and future applications from the perspective of one of the world's largest funders of health-related research, the UK National Institute for Health and Care Research (NIHR).

2. Blockchain Background

2.1. What is Blockchain

A blockchain is a distributed public ledger[6] that records the origin of a digital asset or transaction in a peer-to-peer network[7]. This data is stored on connected blocks which, when viewed in its entirety, reveals the full history and provenance of all the data on the chain. By inherent design, the data on a blockchain cannot be modified, it guarantees the fidelity and security of a record and generates trust without the need for an intermediary. A blockchain can be described as a 'collaboratively managed database of shared, synchronized, and replicated records that typically does not rely on central governance' (Janowicz et al., 2018). Notably, the terms blockchain and distributed ledger technology[8] (DLT) are often used interchangeably, however they are not the same. DLT is wider-ranging, referring to decentralised databases managed by multiple participants. Blockchain is one form of DLT, using cryptography[9] and consensus protocols[10] to link blocks of data. There is no one version of blockchain, it is a class of technology with various platforms, ecosystems and protocols.

2.2. Blockchain in Science

Blockchain is best known for its role in cryptocurrencies, such as Bitcoin (Nakamoto, 2008) but is increasingly being used in more traditional industries and business areas. In science, it promises to make data more reliable, untamperable, open and decentralised. It has the potential to enhance trust, facilitate peer-to-peer interactions and it needs no central authority (Ducrée et al., 2022; Extance, 2017; Leible et al., 2019; Van Rossum, 2017). For research funders, it has promise in managing

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[1] royalsociety.org/topics-policy/projects/research-culture/tools-for-support/resume-for-researcher
[2] decrypt.co/resources/blockchain-basics-what-is-blockchain
[3] decrypt.co/resources/what-is-bitcoin-four-minute-instant-guide-explainer
[4] decrypt.co/resources/what-are-cryptocurrencies-super-quick-guide
[5] decrypt.co/resources/tokenomics
[6] investopedia.com/terms/d/distributed-ledgers.asp
[7] en.wikipedia.org/wiki/Peer-to-peer
[8] decrypt.co/resources/dlt
[9] kaspersky.com/resource-center/definitions/what-is-cryptography
[10] decrypt.co/resources/consensus-protocols-what-are-they-guide-how-to-explainer

health data (Swan, 2015), centralising research outputs and reducing administrative burden, particularly through the use of automated smart contracts[11] (Engelhardt, 2017). These characteristics appeal to modern science, a system with no single governing body but consisting of international collaboration bound by an implicit trust in the work of others (Kosmarski, 2020). Changing norms and requirements in the scientific field, including funders emphasising open-science practices and FAIR (Findable, Accessible, Interoperable, Reusable) principles for scientific data management can all be facilitated with blockchain technology (Van Rossum, 2017).

Tokens, programmable digital assets stored on the blockchain (Voshmgir, 2020), can be used to modernise legacy systems (e.g., static databases, file share systems, single indices, etc.) with Web 3.0[12] features of decentralisation and incentives. Token bounties could be awarded for contributions such as sharing data; identifying unreproducible data; volunteering for academic and scientific service; actively engaging in translation, dissemination, and implementation of science; and carrying out equality, diversity and inclusion (EDI) activities. These tokens could then be staked as collateral to support research priorities, grant proposals and evaluations (Ducrée, 2020). Non-fungible tokens[13] (NFTs) could also be used to track research data in much greater detail. NFTs provide an indelible, time-stamped record demonstrating proof of knowledge, allowing ownership of the idea, contribution, or finding to be more firmly claimed (Ducrée, 2020; Ducrée et al., 2022).

Publishing is another area fraught with issues concerning recognition, reproducibility, access, plagiarism, publication bias and metric manipulation (Janowicz et al., 2018; Kosmarski, 2020; Mackey et al., 2019a; Swan, 2015). Blockchain could address some of these challenges potentially leading to improved study design, greater trust in research, more collaboration and open access (Leible et al., 2019). Notably, some scholars suggest that blockchain could help improve the quality and responsiveness of a failing peer review system (Gropp et al., 2017; Smith, 2006) by awarding tokens for completing quality reviews. This is a strong use case given that peer review is the underpinning of virtually all scientific review processes, from publishing in scientific journals to funding decisions and even promotion, yet arguably lacks the appropriate incentives and measures to record and verify participation and recognition (Avital, 2018; Jan et al., 2018; Kosmarski, 2020; Spearpoint, 2017; Swan, 2015; Tennant et al., 2017; Warne, 2016).

2.3. Select Use Cases in Science

Both industry and governments are already using blockchain with many examples listed in the work of Kosmarski (2020) and Ducrée et al. (2022). For example, the ARTiFACTS[14] platform helps establish the origin of scholarly artefacts while the Bloxberg[15] consortium provides scientists with decentralised services worldwide. Pluto[16] offers a decentralised, token-backed system where scientific data can be submitted, reputation tracked, peer review rewarded and work published. Ovarium[17] differs, aiming to integrate into the existing publication lifecycle, offering tokens, open peer review and immediate provenance tracking. Several other projects are also looking at funding, NFT economies and decentralised organisations[18,19,20,21,22].

Closer to our work at the National Institute for Health and Care Research (NIHR), is the National Research Council of Canada. Their Industrial Research Assistance Program, an innovation funder, ran a pilot in 2018-19 where they ‘used the Ethereum blockchain to proactively publish grants and

[11] decrypt.co/resources/smart-contracts
[12] decrypt.co/resources/what-is-web-3
[13] decrypt.co/resources/non-fungible-tokens-nfts-explained-guide-learn-blockchain
[14] artifacts.ai
[15] bloxberg.org
[16] pluto.im
[17] orvium.io
[18] blockchainforscience.com
[19] decentralizedscience.github.io
[20] deip.world
[21] p1anck.com
[22] sciencefund.io

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contribution data in real-time'. Through this experiment, they demonstrated the possible use of blockchain by government funders to support proactive disclosure[23].

3. Recognition by Research Funders

3.1. The National Institute for Health and Care Research

The NIHR commissions over £1.2 billion worth of health and social care research each year (NIHR, 2021). Proposals are selected through a competitive commissioning process, usually involving two stages. Stage 1 applications are reviewed, discussed and scored by a committee of academics and members of the public. Shortlisted applicants are then invited to submit a full Stage 2 application which undergoes peer review by both expert and public reviewers. These reviews inform the assessment, discussion and scoring by the Stage 2 committee. If successful at Stage 2, proposals are recommended for funding to the Department of Health and Social Care, who then ratify the decision to fund. Once a research project is underway, award holders are required to submit regular progress reports and a final report. Throughout this commissioning and management process the NIHR often requires specialist academic advice for work such as priority setting, project advisory groups and strategic planning.

Formal recognition for this mostly unpaid work is extremely limited, consisting of inconsistently applied yearly letters acknowledging peer reviews completed. Letters for other tasks are only available upon request, with academics typically asking for them to account for their broader contribution to the research landscape as part of their continual professional development. These letters can be delayed, lost or forged and are an administrative burden for the NIHR. In short, they are an inadequate means of recognition relative to the contribution of those who provide their time to advance the NIHR's research portfolio.

3.2. Other Funders

These problems of recognition extend to other funders and the wider scientific community. Reviewing, advising, assessing and reporting all require a significant time and intellectual investment but are not formally captured. Consequently, this work does little to aid career advancement or grant funding, potentially reducing academic interest and engagement in these critical activities that support scientific progress. For funders, this can result in slower and lower quality grant assessment, delayed funding of good research and sloppy work slipping through systems meant to ensure checks and balances (Trovò and Massari, 2021). Current metrics also heavily discriminate against those who take career breaks, particularly women taking time off to have children (Swider-Cios et al., 2021). Recognition systems, therefore, need to change to ensure good and quality research, to foster a healthy and sustainable scientific ecosystem, and for academics themselves (Grant, 2021; Terheggen, 2021; Tite and Schroter, 2007; Trovò and Massari, 2021; Warne, 2016).

4. Token System Structure

Our proposal is centred around tokens for multiple reasons. By utilising tokens to reward scientific contribution we have the possibility of bolstering recognition, promoting efficiency, improving assessment, aiding collaboration and incentivising positive behaviour. Blockchain technology enables tokens to be assigned in a transparent, immutable and permanent way, their origin is rapidly traceable and there are no practical ways to create fraudulent tokens. This provides trust and assurance in the system.

This first iteration of the system, described below, will largely rely on consensus generated by the NIHR and other collaborating funders, who will validate token issuance based on recordable inputs, as described in section 5.2. In the future, as mentioned in section 5.5, token management could be

[23] nrc-cnrc.explorecatena.com

facilitated by smart contracts, designed in collaboration with the broader academic community. Operating on the blockchain system, these smart contracts can automatically deposit tokens when certain preconditions are met (e.g., completion of a peer review or report) to generate greater efficiencies.

In exploring this conceptual framework, we suggest a two-stage system. The pilot (Phase 1) will provide learnings and assess the suitability of the system in a smaller, more controlled non-production environment while also assessing the specific technology feature layers that will be used in the design of the blockchain. It would involve a pre-launch phase, focusing on beta testing with nodes and users who would interact with the system, evaluating utility and functionality. Phase 2 represents the wider, live rollout of the system with the goal of enabling greater cross-funder collaboration and awarding a wider range of tokens.

4.1. Tokens Awarded

Tokens can be awarded for any number of activities but generally they should match the core and regular work of the funding organisation. For example, tokenising peer review makes more sense than tokenising reporting if the awarding organisation does lots of peer review and not much reporting. In Phase 1, the pilot, we plan to award tokens for six distinct and binary tasks (Table 1). These represent core NIHR work and were developed through extensive collaboration with NIHR staff and external academics.

Token	Description
Peer Review	Every valid application made to the NIHR is peer reviewed with thousands of reviews conducted each year. A single Peer Review Token would be awarded for delivering a single accepted peer review. If possible, tokens should be awarded to whoever wrote the bulk of the review as well as the senior academic contacted if that is not the same person.
Committee	Academics sit on committees which assess if applications are funded, most of the time this is unpaid. A single Committee Token would be awarded for participating in a single committee meeting.
Stage 1	Success at Stage 1 will carry a Stage 1 Token, awarded to lead and co-applicants to avoid bias toward senior academics.
Stage 2	Success at Stage 2 will carry a Stage 2 Token, awarded to lead and co-applicants to avoid bias toward senior academics.
Reporting	Funded projects must submit regular progress reports and a larger final report. A Reporting Token would be awarded for submitting a single accepted report by the agreed deadline or extension. Tokens should be awarded to whoever wrote the report as well as the lead applicant if possible.
Advisory	Completing one instance of official advisory work such as meetings, workshops, calls or equivalent would earn an Advisory Token.

Table 1: Categories of tokens for the proposed Phase 1 of the token recognition system.

Moving past Phase 1 and into the wider evaluation and deployment of Phase 2, a new range of tokens would be introduced (Table 2) to complement the core tokens described in Table 1. These reward a wider range of activities while supporting EDI objectives.

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Token	Description
Training and Mentoring	Awarded for mentoring an individual or delivering training including taking interns, supervising students and general skill development.
Impact	Submitting a single accepted piece of impact evidence or equivalent would earn an impact token.
Best Research for Best Health	The government's health research strategy and NIHR's guiding document, 'Best Research for Best Health: The Next Chapter' (Department of Health and Social Care, 2021), has seven key strategic priority areas. Tokens could be awarded for funding applications which support one or more of these areas, for example including public members in research, nurses in a trial team or supporting diversity.
Career Break	Awarded to ensure the system does not penalise career breaks, in particular women having children (Swider-Cios et al., 2021). Nominal career break tokens could be given for extended periods out of work provided the individual has previously contributed consistently to the NIHR. The number of tokens awarded would be the average expected tokens earned over the period of time in question.

Table 2: Categories of tokens for the proposed Phase 2 of the token recognition system.

Awarding tokens in separate categories is deliberate as the purpose of this system is to recognise contribution, not ascribe value. If just an 'NIHR Token' existed then either a single token would be given for any single task or different numbers of tokens given for different tasks. In both cases it would cause value to be ascribed, either saying all work is equal or making a judgement of how much more valuable one task is than another. Separating tokens into categories and awarding one specific token for each task completed addresses this problem and gives richer data for analysis.

Generally, for an innovative, disruptive blockchain solution to be successful it must be simple and efficient, solving one or two clear problems rather than being overly complex (Kosmarski, 2020). Seamless integration into scientists' daily workflow, working with existing practice and not making life harder is paramount (Leible et al., 2019; Kosmarski, 2020). Therefore, our system does not assess quality and awarding is binary; if the job is completed to existing quality standards then a token is given. This means there is no additional workload, increasing the likelihood of support and adoption while removing value judgement as mentioned previously, though value assessment and rating could be designed in future iterations if deemed valuable.

4.2. Token Use

Proposed tokens on the NIHR system would not inherently be utility tokens, as they would not be tradable or worth money to avoid creating potential perverse incentives and changing the reasons people carry out roles. Instead, the goal is they act as a verifiable, immutable, and tangible expression of appreciation and recognition of service completed.

The token's utility will be as a validated transaction history of scientific contributions for use in professional assessments such as job interviews, award and funding applications, performance appraisals, and academic file review, where currently such records of work are less quantifiable and may lack validity. For senior researchers, tokens may have less perceived value in interviews (as they will be assessed on different criteria by employers) however token status could bolster personal award applications such as the NIHR Senior Investigator Award, where a key element of selection is 'contribution to the NIHR'[24]. For more junior researchers, validation of these scientific contributions can directly support favourable hiring and promotion decisions as academic service remains an element for file review and those early in their career need to differentiate themselves. For scientists who are looking to transition to non-academic careers in industry, non-profits or the

[24] nihr.ac.uk/documents/nihr-senior-investigators-guidance-for-applicants/21593

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government, such digital assets and proof of service can also assist in translation of technical skills outside of academia.

4.3 Token Benefits

4.3.1. Improved Recognition

This token system would act as a permanent, more comprehensive and near immutable record for both the funder and the scientist. Data would be easily accessible for both parties, high quality, consistent and fast to record.

Those who complete peer reviews or sit on funding committees stand to benefit from this approach. In general, reviewers strongly feel their work is not adequately recognised and they value reward initiatives (Warne, 2016). This token system would record those contributions and assist the academic's career development, a reason behind 42% of academic's decisions to review (Publishing Research Consortium, 2022).

This proposal will also benefit the 44% of NIHR funding applicants successful at Stage 1 but not at Stage 2 (Lee, 2022). Producing a Stage 2 application is very time intensive and if it is unsuccessful, the prior Stage 1 success comes with no recognition. This is likely to cause frustration and, in some cases, disincentivise applying. Rewarding initial success would recognise the effort taken to produce the full application and the contribution of knowledge. This will potentially encourage applications, leading to a larger pool of proposals to choose from and higher quality research being funded.

This system also helps improve equality of recognition. By equally rewarding all contributing team members, rather than just the Principal Investigator, it supports early career researchers, while through career break tokens it helps reduce discrimination against those who take breaks, particularly women having children. Alongside that, the data captured could help understand patterns in who is working within organisations (e.g., race, gender, geography) which could help better shape EDI initiatives to make the scientific workplace more equal and supportive.

4.3.2. Improved Efficiency

Currently, only 14.8% of peer reviewers contacted deliver a completed review (Lee, 2022) meaning NIHR operational staff have to source, contact and chase vastly more peer reviewers than are required. This is a very significant drain on time that could be better repurposed for other research and management-related activities. If assigning tokens can encourage a higher uptake of peer reviewers it will result in a notable efficiency increase.

Chasing award holders to provide reports, particularly after the project is finished, is an equally common and time-consuming problem. An analysis of 6371 reports from NIHR data showed overall just 0.6% of post-funding reports are completed on time, a figure of 5.5% for final reports, 24.5% for online progress reports and 3.8% for offline progress reports. In total, only 712 were delivered by their deadline, a figure of 12.6% (Lee, 2022). Incentivising reporting on time by offering a token bounty for timely submission has the potential to reduce the time spent chasing reports while also enabling faster mobilisation of results to evidence users, potentially increasing the impact of the funded research.

4.3.3. Robust Assessment

By recording contributions, a funder provides the wider research ecosystem with another method to support objective assessments. There is less opportunity for academics to falsify or overplay their role or accomplishments which benefits honest individuals and adds credibility to achievements by giving assurance the information is valid.

Currently, nomination for and assessment of the NIHR Senior Investigator Award takes time due to the need to collate disparate or difficult-to-obtain information. A token system would recognise all

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hard-to-quantify activities in one place and serve as a numerical representation of the individual's contribution to the NIHR and scientific community. This would turn currently qualitative, subjective measures into quantitative ones, improving the efficiency, robustness and transparency of the competition.

4.3.4. Cross-funder Collaboration

Involving other funders provides an opportunity to aggregate and standardise recognition. Researchers typically work with a range of funders so a single system which captures all their work would simplify their experience while increasing reach and buy-in to the system. It could also enable portability of information, such as when identifying potential reviewers and committee members. In this sense, a future iteration of this framework could move from a more private blockchain design focused on a single or small number of funders to a larger consortium model that includes multiple funding agencies and implementation organisations.
Once produced, this shared record could then be viewed and authenticated by any party, would be intrinsically trustworthy and support the narrative CV proposal developed by the Royal Society[25].

5. Discussion

Along with the benefits outlined in section four above, this proposal comes with a number of potential barriers and challenges, some general to blockchain and others specific to the framework design currently conceptualised. To realise the full utility of the proposed framework, further community-based consultations with funding agency stakeholders, scientists and academic administrators will be needed. We outline some of these challenges below.

5.1. Public Perception

Many hurdles come down to public perception. The regular negative media portrayal of cryptocurrency may tarnish the reputation of blockchain regarding its application to academic and scientific processes. The lack of understanding which causes this is the root of much of the scepticism, confusion and fear that blockchain attracts. When the basics are understood but little known about the practical applications it is often judged to be an indulgent new technology which sounds useful but is 'not for us' (Kosmarski, 2020). For our system, it is primarily academics, their employers, their professional bodies and those working for research funders who will need to be won over. To do this, a programme of engagement and communication will need to be deployed to promote understanding and dispel misconceptions. To aid buy-in, our solution is not aiming to reshape an entire ecosystem, as many proposals do (Janowicz et al., 2018; Mackey et al., 2019a). A complex and fundamental shift requires the support of many stakeholders, a difficult feat to achieve (Kosmarski, 2020). Instead, we aim to solely address the problem of recognition, evident to thousands of researchers, and integrate our solution into current practices as seamlessly as possible.

5.2. Data Protection and System Architecture

Tension between blockchain technologies and General Data Protection Regulation (GDPR) exist, primarily relating to the data controller, erasure of data, data minimisation and purpose limitation. Given different types of blockchain technology can have very different characteristics, coupled with conceptual uncertainty about GDPR itself, it makes this problem complex and situation dependent. While there is conflict between the two, a general relationship cannot be established and therefore must be determined on a case-by-case basis. Consequently, compliance needs to be designed into the system framework from the beginning to overcome data protection hurdles (European Parliament, 2019).

One potential method to address these GDPR concerns is to run the system on a micro-site and to only publish the academic's wallet address[26] (an alphanumeric string analogous to an email address

[25] royalsociety.org/topics-policy/projects/research-culture/tools-for-support/resume-for-researcher
[26] bitprime.co.nz/wallets/beginners-guide

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identifying the location to which tokens are sent) and token status to the public blockchain, not their name. The association between names and wallet addresses would be recorded by the funder in a private, off-chain database, which would be drawn upon within the microsite to associate wallet addresses and token status with the names of individuals. The funder would be able to log in as an admin user and view to whom tokens had been awarded however individual academics or third parties would not. Each academic would be provided with their personal wallet address and be able to use this to login and view only their record, they would then be able to share this with any third party to show their record. This way data remains pseudo-anonymised and to erase someone's data the awarding funder would simply have to delete their own record of the wallet address to render that academic's data unidentifiable. The small loophole remains that a sufficiently motivated and skilled actor who had previously been given the wallet address could search a block explorer (such as Etherscan[27]) for that specific address and mine the data. This, however, does not pose a real-world problem as the risk of it happening is low, the data that could be extracted is very limited and the wallet address would have been shared by the academic themself. The key limitation of this approach is that by attempting to extensively incorporate GDPR requirements a single trusted party is introduced (the funder which holds the record of wallet addresses and names). The private data this party holds weakens the decentralised and open benefits of blockchain, given the fact you need to refer to this off-chain information in order to link the individual to their tokens.

A possible solution to this problem is for those participating in the token system to waive the right to be forgotten and have their name published alongside token status on the public blockchain, this could potentially be achieved in two ways. Obtaining consent from the academic in question to publish their data permanently, as is done when a book or paper is published for example, is perhaps the simplest option. Alternatively, the academics themselves could be the ones to record their work on the blockchain, with the funder just serving a verification function. The individual in question would complete a task, such as a peer review, and submit a request for a token, upon acceptance by the funding body their details would be published on the public blockchain and the token awarded. In this system the funder is not the data custodian, the academic is, they publish their activity to the blockchain in the knowledge they cannot undo it, thereby waiving the right to be forgotten. The main issue with this latter approach is that it adds additional workload for the academic and therefore could reduce engagement, something our system seeks to avoid. Additionally, while a senior scientist could be contacted to complete work such as a review or report, and submit for a token after completing it, the work could have been done by a junior team member. This practice exists currently, with recognition not always going to the individuals who do the work, so the proposed system would seek to also record who completed the bulk of the work as mentioned in Table 1. This approach of making all data public and not introducing a central authority allows the full decentralised power of blockchain to be realised, however it requires additional steps and administrative work to comply with data protection regulations.

5.3. Token Value

If we cannot ascribe meaningful value to the tokens the system may not be used as intended, the benefits could be unrealised and behaviour not driven as desired. This risk exists as these tokens do not hold intrinsic value, but rather are a representation of work done. To overcome this a combination of interventions may be needed, including but not limited to: (1) generating education and awareness about the purpose of the token and its utility in providing a verifiable record of accomplishments relative to existing incomplete and unverifiable sources of information (e.g., traditional CV, website profiles, etc.); (2) adoption of tokens into research and funding evaluation and assessment; and (3) integration of recognition tokens into university and employer professional development, assessment, and promotional policies and practices.

5.4. Unintended Consequences and Manipulation

A new incentive scheme always risks unintended consequences and people may try to exploit it; in our case it risks changing the reasons people carry out work. To mitigate this the tokens would not

[27] etherscan.io

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be worth money or be exchangeable for any specific opportunities, in other words they have no 'active' use. This serves two purposes. Firstly, it disincentivises fraud, given that the token's value is simply a validated record of work performed and is generated by consensus from the issuing organisation (e.g., the funder). Hence, the opportunity for fraud and the utility of engaging in misleading or fraudulent activity is greatly diminished. Secondly, the multiple token categories mean not all work is classed as the same, preventing people from doing the most straightforward job they can just to earn the maximum number of tokens. Furthermore, tasks cannot just be done at the academic's wish, they have to be invited, this removes the opportunity to 'mine' the system for as many tokens as possible.

5.5. Future Work

An expanded system with a wider range of tokens along with greater levels of automation and integration provides huge potential for system improvements, cost savings and efficiency making, particularly by using smart contracts as previously discussed. For example, when a potential reviewer accepts the application review request then a smart contract could automatically inform them of the requirements such as deadline, writing structure and conflict of interest policy. Once a valid review is submitted that meets the conditions of the smart contract then the tokens could be released automatically to the individual. If the review is late then tokens could be withheld and an automated email reminder sent to inform that the review is due (Mackey et al., 2019a). Linking this with current, established academic recognition systems such as ORCID provides the opportunity for greater integration and reach. Alongside this, a future possibility is to enable a more active use of tokens, as discussed in section 2.2. This may involve allowing token holders to undertake specific activities such as participation in workshops, research prioritisation and evaluation of grant proposals (Ducrée, 2020).

A future system should also reward public contributors (patients and members of the public who are involved in research). Awarding them with the same tokens given to academics would reinforce their equal status, provide a formal record of their contribution and complement the reward payments they currently receive. This would help continue the drive to put patients and the public at the centre of everything the NIHR does.

6. Conclusion

Our proposal builds on an emerging body of work exploring the use of blockchain to upgrade legacy healthcare and research management systems in the exciting emerging era of Web3. Blockchain is proliferating in almost every sector and holds huge potential however it is not a remedy to all problems. The power of blockchain comes when it is purposefully applied to relevant situations that would benefit from increased trust, decentralised governance and blockchain application layers such as tokens and smart contracts. All these solutions, including the framework proposed here, have challenges associated with implementation, adoption and acceptance which need to be further assessed in collaboration with the scientific community. Crucially, the presence of challenge should not be used as an excuse to stifle innovation and advancement. Within the NIHR, we aim to increase efficiency through this incentivisation while improving our offering to academics, leading the way to more collaborative, integrated and fair recognition in health and care research. We hope that soon the valuable contributions academics make to the processes underpinning research will be recognised by the scientific community in a more dynamic and meaningful way.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

J.L: Project lead, conceptualization, solution design, manuscript writing.
M.M: Project sponsorship, steering, guidance, manuscript review.
T.M: Manuscript review and suggestions.

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References
Avital, M., 2018. Peer Review: Toward a Blockchain-enabled Market-based Ecosystem. Communications of the Association for Information Systems, 42, pp.646-653.

Curmi, A. and Inguanez, F., 2020. Academic Achievement Recognition and Verification Using Blockchain. Euro-Par 2019: Parallel Processing Workshops, pp.153-165.

Department of Health and Social Care (2022). Best Reseach for Best Health: The Next Chapter. Avaliable at: https://www.nihr.ac.uk/documents/about-us/best-research-for-best-health-the-next-chapter.pdf (Accessed: 9 August 2022).

Ducrée, J., 2020. Research – A blockchain of knowledge?. Blockchain: Research and Applications, 1(1-2), p.100005.

Ducrée, J., Codyre, M., Walshe, R. and Barting, S., 2022. DeSci-Decentralized Science. Preprints, 2022050223 (doi: 10.20944/preprints202205.0223.v1).

Engelhardt, M., 2017. Hitching Healthcare to the Chain: An Introduction to Blockchain Technology in the Healthcare Sector. Technology Innovation Management Review, 7(10), pp.22-34.

European Parliament (2019). Blockchain and the General Data Protection Regulation. Can distributed ledgers be squared with European data protection law? European Parliamentary Research Services, Scientific Foresight Unit (STOA). Available at: https://www.europarl.europa.eu/RegData/etudes/STUD/2019/634445/EPRS_STU(2019)634445_EN.pdf (Accessed: 27 July 2022).

Extance, A., 2017. Could Bitcoin technology help science?. Nature, 552(7685), pp.301-302.

Gropp, R., Glisson, S., Gallo, S. and Thompson, L., 2017. Peer Review: A System under Stress. BioScience, 67(5), pp.407-410.

Grant, G., 2021. Academic Incentives and Research Impact: Developing Reward and Recognition Systems to Better People's Lives. AcademyHealth. Available at: https://academyhealth.org/sites/default/files/publication/%5Bfield_date%3Acustom%3AY%5D-%5Bfield_date%3Acustom%3Am%5D/academicincentivesresearchimpact_feb2021.pdf (Accessed: 20 July 2022).

Jan, Z., Third, A., Bachler, M., and Domingue, J. (2018). "Peer-reviews on the blockchain," in 1st Workshop on Reframing Research (RefResh 2018) (Cologne), 1–5. Available at: http://oro.open.ac.uk/58593/1/Peer_reviews_on_the_blockchain.pdf (Accessed: 20 July 2022).

Janowicz, K., Regalia, B., Hitzler, P., Mai, G., Delbecque, S., Fröhlich, M., Martinent, P. and Lazarus, T., 2018. On the prospects of blockchain and distributed ledger technologies for open science and academic publishing. Semantic Web, 9(5), pp.545-555.

Koltun, V. and Hafner, D., 2021. The h-index is no longer an effective correlate of scientific reputation. PLOS ONE, 16(6), p.e0253397.

Kosmarski, A., 2020. Blockchain Adoption in Academia: Promises and Challenges. Journal of Open Innovation: Technology, Market, and Complexity, 6(4), p.117.

Lee, J., 2022. Business Case | Blockchain Token Recognition System. Internal NIHR report. Unpublished.

Leible, S., Schlager, S., Schubotz, M. and Gipp, B., 2019. A Review on Blockchain Technology and Blockchain Projects Fostering Open Science. Frontiers in Blockchain, 2.

Mackey, T., Shah, N., Miyachi, K., Short, J. and Clauson, K., 2019a. A Framework Proposal for Blockchain-Based Scientific Publishing Using Shared Governance. Frontiers in Blockchain, 2.

Mackey, T., Kuo, T., Gummadi, B., Clauson, K., Church, G., Grishin, D., Obbad, K., Barkovich, R. and Palombini, M., 2019b. 'Fit-for-purpose?' – challenges and opportunities for applications of blockchain technology in the future of healthcare. BMC Medicine, 17(1).

Mackey, T., Miyachi, K., Fung, D., Qian, S. and Short, J., 2020. Combating Health Care Fraud and Abuse: Conceptualization and Prototyping Study of a Blockchain Antifraud Framework. Journal of Medical Internet Research, 22(9), p.e18623.

National Institute of Health and Care Research (NIHR)(2021). NIHR Annual Report 2020/2021. Available at: https://www.nihr.ac.uk/documents/about-us/our-contribution-to-research/research-performance/Final-NIHR-Annual-report%2020_21.pdf (Accessed: 19 July 2022).

Nakamoto, S., 2008. Bitcoin: A peer-to-peer electronic cash system. Whitepaper.

Phillips, T., Saunders, R., Cossman, J. and Heitman, E., 2019. Assessing Trustworthiness in Research: A Pilot Study on CV Verification. Journal of Empirical Research on Human Research Ethics, 14(4), pp.353-364.

Publishing Research Consortium (2022). Peer review Survey 2015. Available at: https://www.elsevier.com/__data/assets/pdf_file/0007/655756/PRC-peer-review-survey-report-Final-2016-05-19.pdf (Accessed: 26 July 2022).

Smith, R., 2006. Peer review: a flawed process at the heart of science and journals. Journal of the Royal Society of Medicine, 99(4), pp.178-182.

Spearpoint, M., 2017. A Proposed Currency System for Academic Peer Review Payments Using the BlockChain Technology. Publications, 5(3), p.19.

Swan, M., 2015. Blockchain: Blueprint for a New Economy. O'Reilly Media, Sebastopol, CA; 2015; ISBN: 978-1-4919-2044-2.

Swider-Cios, E., Solymosi, K. and Srinivas, M., 2021. Why science needs a new reward and recognition system. Nature, 595(7869), pp.751-753.

Tandon, A., Dhir, A., Islam, A. and Mäntymäki, M., 2020. Blockchain in healthcare: A systematic literature review, synthesizing framework and future research agenda. Computers in Industry, 122, p.103290.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 14 September 2022 doi:10.20944/preprints202209.0199.v1

Tennant, J., Dugan, J., Graziotin, D., Jacques, D., Waldner, F., Mietchen, D., Elkhatib, Y., B. Collister, L., Pikas, C., Crick, T., Masuzzo, P., Caravaggi, A., Berg, D., Niemeyer, K., Ross-Hellauer, T., Mannheimer, S., Rigling, L., Katz, D., Greshake Tzovaras, B., Pacheco-Mendoza, J., Fatima, N., Poblet, M., Isaakidis, M., Irawan, D., Renaut, S., Madan, C., Matthias, L., Nørgaard Kjær, J., O'Donnell, D., Neylon, C., Kearns, S., Selvaraju, M. and Colomb, J., 2017. A multi-disciplinary perspective on emergent and future innovations in peer review. F1000Research, 6, p.1151.

Terheggen, P., 2021. Re-evaluating reward and recognition in science. Elsevier Connect. Available at: https://www.elsevier.com/connect/re-evaluating-reward-and-recognition-in-science (Accessed: 20 July 2022).

Tite, L. and Schroter, S., 2007. Why do peer reviewers decline to review? A survey. Journal of Epidemiology & Community Health, 61(1), pp.9-12.

Trovò, B. and Massari, N., 2021. Ants-Review: A Privacy-Oriented Protocol for Incentivized Open Peer Reviews on Ethereum. Euro-Par 2020: Parallel Processing Workshops, pp.18-29.

Van Rossum, J., 2017. Blockchain for Research: Perspectives on a New Paradigm for Scholarly Communication. Digital Science. Available at: https://digitalscience.fig.com/articles/Blockchain_for_Research/5607778 (Accessed: 21 July 2022).

Voshmgir, S., 2020. Token Economy: How the Web3 reinvents the Internet. 2nd ed. Shermin Voshmgir, pp.19-24.

Warne, V., 2016. Rewarding reviewers - sense or sensibility? A Wiley study explained. Learned Publishing, 29(1), pp.41-50.