Governance by Algorithms, Governance of Algorithms: Human-Machine Politics in Decentralised Autonomous Organisations (DAOs)

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Abstract

This paper situates Decentralised Autonomous Organisations (DAOs) in organisational theory as an expression of 'organising outside organisations' through algorithmic governance. Digital networks, such as the internet, make organising outside of traditional organisational structures possible (Shirky, 2008). DAOs are an attempt at decentralised organisation towards independence from external political influence. DAOs aim for self-governance using algorithms grounded in public blockchain technology, 'smart' contracts, and public key cryptography in complement to the traditional rule of law to enforce behaviours. As a relatively recent phenomenon, DAOs remain under-theorised in the field of organisational studies. This paper locates DAOs as organisations in relation to the 'organisational elements' proposed by Ahrne and Brunsson (2011) to respond to the research question, 'can algorithms, as a centralising process, be governed in a decentralised manner?'. I employ qualitative, digital ethnographic methods to trace the relations between human and non-human actors in decentralised networks to investigate algorithmic governance in the case of a DAO called "Gitcoin". DAO constituents are engaged in both the governance of algorithms, and governance by algorithms. I argue that algorithmic governance in DAOs constitutes a novel form of 'machine politics' that elevates algorithms to the position of new political actors who shape and determine how humans behave as well as organisational outcomes, while simultaneously needing to draw on the organisational structure to govern them. This piece contributes to a research agenda on the social implications of algorithmic governance and decentralised modes of organising.

1. Introduction

Blockchain-based Decentralised Autonomous Organisations (DAOs) are a nascent organisational form that offers an open-ended institutional framework for the articulation of shared objectives, codes of conduct, and organisational processes to guide the design of algorithmic governance systems. Algorithmic governance refers to the social ordering of actors, mechanisms, structures, degrees of institutionalisation, and distribution of authority in a coordination system where algorithms shape, enable and constrain activities (Katzenback & Ulbricht, 2019). DAOs utilise processes of algorithmic governance to encode and enforce organisational elements, including membership, hierarchy, rules, monitoring, and sanctions (Ahrne & Brunsson, 2011). Despite an ideology of decentralised organising outside of existing institutional structures, algorithms are inherently centralising processes, from coding, to

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training, to deployment and maintenance. This piece investigates DAOs as a site of digitally mediated organising through algorithmic governance to respond to the research question, 'can algorithms be governed in a decentralised manner?'. I employ Actor-Network Theory and digital ethnographic methods to determine how organisational elements are entangled with algorithmic processes to co-constitute decentralised governance. Through a case study on a DAO called 'GitcoinDAO', I find that GitcoinDAO leverages algorithmic governance across multiple organisational elements, whilst simultaneously needing to govern the algorithmic processes the community has created in a decentralised and transparent manner. With such a strong emphasis on algorithmic governance as a means to decentralised organising, algorithms emerge as new political actors in DAOs and 'peers' in the network, with the authority to enact governance over multiple organisational elements and constrain constituents. This research contributes to the literature on organisational theory and algorithmic governance by providing empirical into how governance operates in digital domains in practice, and how algorithms and people shape one another to generate social outcomes for people participating in these systems.

1.1. Methods

This piece employs the methodological approach of actor-network theory and digital ethnographic methods to trace relations between people and algorithms as key stakeholders in DAOs. The actor-network theory offers an approach to studying the 'relational' aspects of human and non-human multi-scale ensembles including software, physical hardware objects, development processes, system operators, and "users" (Latour, 2007). The work of Latour suggests that assemblages are generated by social processes of consensus-building within communities, including how networks emerge and come into being, how they are constructed and maintained, how they compete with other networks, and how they are made more durable over time. Latour emphasises that "artifacts can be deliberately designed to both replace human action and constrain and shape the actions of other humans" and how "technologies that are so commonplace that we don't even think about them can shape the decisions we make, the effects our actions have, and the way we move through the world" (2013).

This method is useful for describing emergent fields, as it affords an equal amount of value and agency to actors within a network, including machines as non-material objects, without externally prescribing values or hierarchies. Latour explores how artefacts can be deliberately designed to replace, constrain, and shape human action. As such, technological artefacts play such an important role in mediating human relationships, that we cannot understand how societies work without an understanding of how technologies shape our everyday lives (Latour, 1992). Through the study of the relationship between producers, machines, and users, ANT demonstrates how ideological goals can be pursued through the development and adoption of technologies. This is especially suitable for decentralised technology networks, that possess actants, actions, and are evolutionary in nature and form, whereby material changes entangle humans, forcing responses, adjustments, and dependencies, and vice-versa (Hodder, 2012). Ethnographic methods pay attention to the human, social and non-human, technical objects, and trace relational ties of what, who, and why, before accounting for the creation, politics, and implications of power or politics in a network. Through digital ethnography, qualitative data is gathered through the observation of online channels (including blogs, forums, and social media channels), interviews, and participation (Pink, et.

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al., 2015). This data arises from the social governance interactions and processes occurring in DAO governance and algorithm design, use, and maintenance. Thus, this is suitable for describing the multi-scale nature of decentralised organisations as a means of social ordering.

2. The origins of DAOs

DAOs are a broad organisational format for blockchain-based coordination among a group of actors towards a shared objective. Defined as "a blockchain-based system that enables people to coordinate and govern themselves mediated by a set of self-executing rules deployed on a public blockchain", DAO governance is decentralised from central control (Hassan & De Filippi, 2021). DAOs stem from the philosophical origins of public blockchains as socio-technical, algorithmic assemblage of human and machine components (Voshmgir & Zargham, 2019). Blockchain as a distributed ledger technology provides a coordination mechanism for distributed governance. By providing a shared record of history to geographically dispersed participants, blockchain technology enables the possibility to create new economies, markets, and governance institutions (Davidson, De Filippi, & Potts, 2016). The rules of blockchain-based governance are embedded in the software code of the protocol itself. The innovation of public, decentralised blockchains is that these rules leverage digital assets (known as "cryptocurrency") to align incentives and behaviour as a coordination system, in what is known as the new field of institutional economics known as 'cryptoeconomics' (Berg, et. al., 2019). The ideology of public blockchain technology stems from a countercultural group of "hacker-engineers" known as "the Cypherpunks" (Brekke, 2021).

The Cypherpunks operated on a mantra of self-organisation and direct action in building privacy-preserving, cryptographic software tools to counter the threat of corporate and state surveillance in the digital age. They believed that "software can't be destroyed", and "a widely dispersed system can't be shut down" (Hughes, 1997). The Cypherpunks sought to enable an anarchic interpretation of "autonomy", meaning the ability to communicate freely through self-governance via the digital infrastructure they built. In 'The Crypto Anarchist Manifesto', outspoken contributor and co-founder of The Cypherpunk's Mailing List, Timothy C. May, states that computer technology and cryptography will "fundamentally alter the nature of corporations and of government interference in economic transactions" (May, 1988). Cryptoanarchy is a means of 'governance without government' against digital authoritarianism (Beltramini, 2020). For the cypherpunks, anarchist modes of 'organising without organisations' emphasises the use of that are decentralised from political control of any single authority to enact do-it-yourself politics to create a new order from within (Nabben, 2022a). Crucial to the design of public blockchains is the idea that governance is established and enforced through software code, rather than subjective, human judgment. The innovation of "Bitcoin" emerged from the Cypherpunk sub-culture as the first fully functional peer-to-peer blockchain, designed to be *post*-governance (Nakamoto, 2009; De Filippi. 2019). The Cypherpunk's political ideology of autonomy and self-governance through technological means has largely informed the concept and development of DAOs.

The actual phrase "Decentralised Autonomous Organisation" first appeared in the field of cybernetics to describe "smart" home systems with self-executing rules (Dilger, 1997), before it was adapted and adopted by blockchain communities. The concept of a "Decentralised Autonomous Corporation" was originally proposed in blockchain communities by Dan

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Larimer to describe cryptocurrency as profit-earning shares in a free market economy (Buterin, 2013). Vitalik Buterin, Co-founder of the Ethereum blockchain, then adopted the phrase "Decentralised Autonomous Organisation" or "DAO", which appeared in the white paper and a series of blogs (Buterin, 2014a). As an important actant in the theorisation and experimentation in DAOs, Buterin describes the term 'decentralisation' as both physical distribution of the computers in a network, as well as political distribution of the individuals that control the network (Buterin, 2017). A Decentralised *Organisation* as "a set of humans interacting with each other according to a protocol specified in code, and enforced on the blockchain" that control a treasury, and a Decentralised *Autonomous* Organisation as "an entity that lives on the internet and exists autonomously, but also heavily relies on hiring individuals to perform certain tasks the automation itself cannot do" (Buterin, 2014b). In this conception, artificial intelligence is the "Holy Grail" of decentralised governance, whereby "autonomous agents" process information to make adaptive decisions and control some aspects of their environment. Some refer to the political ideology of Ethereum as a form of radical democracy termed "radical markets", to describe how participatory computational markets can bring "fairness and prosperity to all" (Posner & Weyl, 2018). From these origins, DAOs have proliferated as an active area of experimentation among decentralised technology communities.

As a unit of analysis, DAOs are elusive. There has been rapid uptake and prolific growth of the number, size, and purposes of DAOs since the term was first adopted in blockchain communities in 2013 (Faqir-Rhazoui, Gallardo, & Hassan, 2021). Yet, the theoretical concept remains under-theorised and practical examples do not ascribe to one particular model or implementation. DAOs are heterogenous, varying in objectives, participants, scale, and tooling. While there are a number of legal frames for DAOs, this depends on the legal jurisdiction, and if a DAO chooses to register a legal organisational entity at all. The organisational categories and goals of DAOs have since expanded to such generality that the term can refer to an investment vehicle, a social club, a service provider, or a combination of all (Brummer & Seira, 2022). DAOs possess varying interpretations across disciplines, from a unique form of organisation, in law, a species of corporate governance in institutional economics (Davidson & Potts, 2022) and a new form of democratic institution (Allen, et. al., 2020), to a qualitative object of digital infrastructure (Nabben, 2022b). In some communities, the discourse has shifted from "post-governance" to governance of "public goods" or stewardship of "commons" (The Commons Stack, n.d.). What remains common among DAOs is that their organisational infrastructure is based on blockchain technology to enable the creation of organisations where members collaborate on a peer-to-peer basis towards a shared goal (Wright, 2021).

In practice, DAOs fit into existing organisational theory as either complete organisations which possess all organisational elements of membership, hierarchy, rules, monitoring, and sanctions, or partial organisations which possess some of these elements (Arhne & Brunsson, 2011). Of course, this depends on the DAO being examined, as the organisational structure and expression of governance in DAOs differ depending on the culture of the community that creates and participates in it. Organisation is a common strategy for those who want to engage in radial politics to change the existing power relations, behaviour, identities, or status orders that are institutionalised (Ahrne & Brunsson, 2011). DAOs, like other organisations, are a tool for collection action (Perrow, 1986).

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The section that follows focuses on how algorithms are employed and deployed as governance mechanisms in DAOs, as an inherently centralising force within the ethos of 'decentralised' organisations.

2.1. DAOs as the site of algorithmic organisation

Algorithmic governance is central to the organisational ontology of DAO developers, as these communities pursue alternative organisational models through open-source, decentralised, encrypted, software-based infrastructure. Algorithms are computer-based epistemological procedures, constructed of "if-then" rules by software developers that shape procedures through mathematical logic (Katzenback & Ulbricht, 2019). Blockchain communities and DAOs embrace the notion of "government by algorithm", that society can be organised via software code, automation, and DAOs. Some scholars have categorised DAOs as 'algorithmic', meaning reliant on highly autonomous software that runs on blockchain technology, or 'participatory', that allow social processes to propose and approve upgrades to the underlying infrastructure (Wright, 2021). Interactions in DAOs are governed by software, as participants rely on technology to directly enforce the rules of the system (De Filippi & Hassan, 2018). The phrase "algorithmic governance" has been employed to describe how an online community gradually converts social norms and governance mechanisms into formalised, algorithmic mechanisms (Müller-Birn, Dobusch, & Herbsleb, 2013). The phrase "government by algorithm" has been adopted to describe the impact of social media technology on society and the state (Leadbeater, 2011) as well as the use of algorithmic decision-making systems and artificial intelligence in public administrative agencies (Ho & Engstrom, 2021). Algorithmic decision-making systems are systems, software, or process that uses computation to aid or replace government decisions, judgments, and/or policy implementation that can involve predicting, classifying, optimising, identifying, and/or recommending (Richardson, 2022). Other phrases that have developed from the idea of government by algorithm that are relevant in an analysis of DAOs include 'algocracy', meaning rule by algorithms, and 'cyberocracy', to refer to rule by the effective use of information to govern in the information technology age, or cybernetics (Aneesh, 2016; Ronfeldt, 1991; Ronfeldt, 1992). DAOs leverage algorithms to conduct governance at scale between geographically distributed stakeholders. Yet, this ideological attempt is about co-designing and participating in technical infrastructure (including the rules of governance), to remove the need for existing institutions.

Interactions between actors in DAOs that contribute to "shaping the rules of play", or the boundaries within how participants in the organisation can act, are recorded both on the blockchain ("on-chain"), as well as in discussion forums and via social media ("off-chain") (Rennie, et. al., 2021). Governance in DAOs is a human-machine ensemble that is both social and technical, tacit and explicit. Explicit governance is structuring the rules of governance in software code that is automatically executed by algorithmic processes, such as "smart contracts" that automatically execute cryptocurrency transactions according to pre-coded conditions. Tacit governance, on the other hand, refers to the social processes and cultural norms of communities of participants in a system in the social rituals, processes, and politics that are necessary to develop and maintain these systems (De Filippi, 2019). For example, many functions of governance are still a manual process, carried out through social processes, such as agreeing to "terms and conditions" or "constitution" before joining a DAO's "Discord" chat channel, or manually making governance "proposals" by posting on public forums where

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they can be debated and advocated for before being voted on. These implicit social norms and rules are often not formally defined in the rules of an organisation, whereas algorithmic processes are often formally defined but not clearly understood by all participants.

What remains unique about DAOs is the collective pursuit of decentralised organising through the use of algorithmic processes which are an inherently centralising force. Algorithmic processes both govern and require governance to function. DAOs are not only a site of governance *of* infrastructure, and governance *by* infrastructure (Filippi & Loveluck, 2016). As such, DAOs must simultaneously innovate on decentralised governance *by* algorithms across organisational elements, as well as decentralised governance *of* algorithms, as rules are decided and iterated on. This algorithmic automation, whereby machines automatically control the operation of a process or system to enforce these rules, is often misconstrued as synonymous with individual autonomy. Very little empirical evidence exists on efforts to design algorithmic processes in a decentralised manner, or the social outcomes of these attempts. GitcoinDAO presents a case study field site on how a DAO community governs an algorithmic process and is governed by it as an emergent phenomenon.

3. Case study: GitcoinDAO

I got the message at 7 a.m. on a Saturday morning when I checked my phone. "Join this call link if you're awake. We're designing Gitcoin's anti-sybil machine learning algorithm pipeline now!". It came from a researcher at a 'complex systems research and development firm' called "BlockScience (a firm I informally collaborated with at the time, that I now work with). I sat up in bed and plugged in my headphones to join the call. BlockScience was just one of a number of actants involved in designing the "anti-sybil machine learning pipeline" for a DAO called Gitcoin. Gitcoin is a crowd-funding platform based on the Ethereum blockchain that aims to fund open-source software (and related) development (Gitcoin, n.d.a). On the call, we discussed the system design question at hand: "how do we define, detect, and mitigate adversarial behaviour in a Gitcoin Grant round to pursue the goal of funding Ethereum public goods?". At the outset, there was an express tension between community engagement and involvement in designing and overseeing the algorithmic process of a machine learning pipeline that was being proposed as a solution, and the desire by some stakeholders to automate the process as much as possible and minimise the possibility for human intervention in the funding process overall. As a social scientist studying blockchain communities and decentralised governance, I became an active participant in the phenomenon of algorithmic governance that followed.

Anyone with an account can be considered a participant in the platform, and thus an actant in the assemblage of Gitcoin. People can register an account and submit a project for a grant, while others can donate cryptocurrency to project that they would like to see funded if they also register for the service. To have a grant approved to be listed on the platform, it must pass a manual 'grant verification process'. Grants that appeared suspicious against the rules of the platform (for example, were listed twice or had already raised venture capital funding) were referred to a human evaluation process that looked at the grant, the grantee profile, and matching points of identification to determine if they were legitimate participants or not. Sanctions are graduated by human evaluators, from "high severity", meaning a grant, donation, or user can be removed from the platform to "low severity", which amends

Submitted 13/12/2021 – Accepted 02/11/2022

contribution rewards that a project can receive in a round. Disputes are publicly reported via a Twitter account for transparency to the community (Gitcoin Disputes, n.d.). Projects can choose to accept the sanctions allocated, or to "follow the community norm" in line with the code of conduct and exclude themselves from receiving matched funds (Weiss, 2021).

The sybil attack problem had become increasingly apparent in Gitcoin grants round 9. Sybil attacks are when people create fake identities online to subvert the reputation rules of a system for disproportionate influence. The funding round consisted of 168,000 donations totalling $1.38 million and was matched by a further $500,000 in funding (Emmett, et. al, 2021). The projects with the most donations according to the number of contributions receives "matched" funds from a shared pool to reward according to volume of donations rather than dollar amount funded to reduce plutocracy (known as 'quadratic funding') (Gitcoin, n.d.b). The problem with the quadratic funding algorithm is that it incentivises people to create multiple, fake identities to donate small amounts of currency multiple times to their own projects to maximise their portion of the "matched" funds (Jiajia, 2021). Sometimes, they use bots to do so. Despite multiple algorithmic mechanisms to verify people's digital identity, such as "trust scores" where people can link their identity to other services to provide uniqueness (such as social media profiles) and a "sybil score" algorithm, which assigns users a score based on activity (Kimbwala, 2021), sybil attacks were becoming more prevalent as the amounts of funding became for significant. Further iterations on Gitcoin's platform governance were needed. Yet, amidst the sybil attacks, the organisational structure was undergoing its own transformation. Gitcoin decided to distribute governance tokens to its community (membership) to become a DAO (Owocki, 2021). Governance tokens allow the community to vote transparently on the blockchain ("on-chain") on decisions relating to how the GitcoinDAO treasury is allocated, as well as participate in day-to-day running of operations, alongside other volunteers or paid community members.

Designing the machine learning pipeline was a policy-making process (Zargham & Nabben, 2021). Amidst Gitcoin's transition to becoming a DAO, a special 'council' of actants who were identified by the Gitcoin team as engaged stakeholders in the community or open critical voices of the Gitcoin grants process (Disruption Joe, 2021). Now, the project's founding team, BlockScience, Vitalik Buterin, and Gitcoin community members needed to solve the sybil attack problem. The process was messy, with asymmetric power relations between BlockScience which had been hired as a consultant on the process, the founders of Gitcoin, and influential figureheads in the broader blockchain community. People's opinions differed strongly over whether human intervention in the funding round should be permitted at all, or whether Gitcoin should automate as much as possible to remove the possibility of human collusion. In public reflections on the process, Buterin states that "some ongoing reliance on centralised moderation will be required, though hopefully this can be simultaneously reduced and made more accountable to the community" (Buterin, 2021). Meanwhile, BlockScience argued that subjective human involvement will always be required in designing, governing, and maintaining algorithmic processes. "Not everything needs to be automated away, and what is, should be done so carefully" states BlockScience in a public-facing blog, "appropriate human intervention and strong community engagement is essential to the proper operation of socio-technical systems" (Emmett, et. al., 2021). The solution that was proposed by the council was a machine learning pipeline to detect and "flag" sybil behaviour, governed by the DAO.

What was constructed by BlockScience for Gitcoin was a "policy process" that situated Machine Learning (ML) within the governance of a decentralised organisation. "Machine

Submitted 13/12/2021 – Accepted 02/11/2022

learning" is commonly used in the technical literature to refer to AI, although it encompasses a range of algorithmic processes that can be either passive or active (Crawford, 2021). The process to govern the ML pipeline (which the engineers termed "Sybil Account Detection", or 'SAD'), was based on the rules set out in the Terms and Conditions of the Gitcoin platform. It involved a four-step policy-making process, including "defining" adversarial behaviour according to the terms and conditions set out to all users of the Gitcoin platform, "detecting" potential sybil behaviour using a machine learning algorithm, human "evaluation" of detected events to judge the context of the behaviour and determine if it was sybil, and "sanctioning" offenders on a graduated scale, according to how severe the adversarial behaviour (Emmett, et. al., 2021).

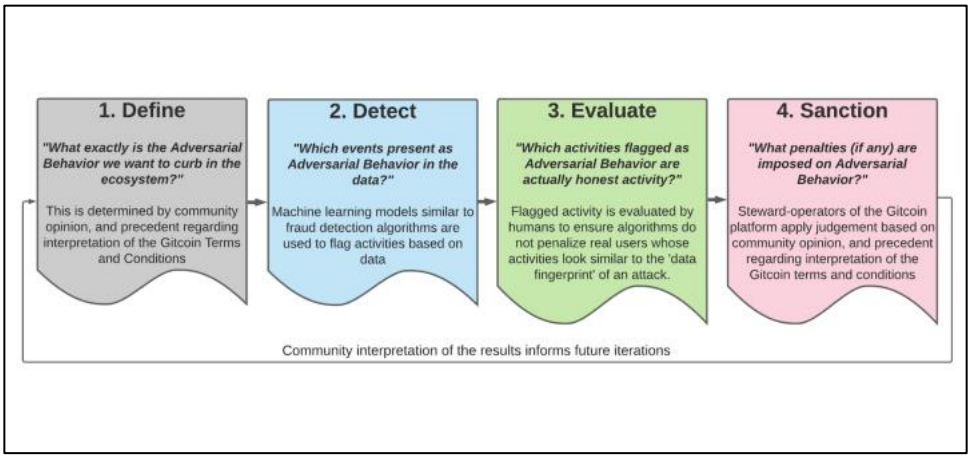

Figure 3.1. A 4-step framework for deterring adversarial behaviour at scale (based on Emmett *et al*., 2021).

Potential cases of sybil attacks were flagged by the ML algorithm and reflected in a spreadsheet. In line with European Union General Data Protection Regulation (GDPR), the fully automated anti-sybil system built on a machine learning (ML) algorithm falls into the category of "automated processing", and thus the designers decided it was necessary to have some method of human supervision in the system or a method of appealing the decisions the system makes. Therefore, human evaluators evaluate a sample of all flagged cases two-to-five times each quarterly grant round, manually filling out a "sybilness score" and determining, "is_sybil" or not. Evaluations in the spreadsheet included comments such as "organic contribution", "very sus", and "sybil af". The role of those evaluations is to train the ML algorithm. In that sense, the ML flags are really about expanding the evaluators' bias towards the entire dataset, so the humans do not need to evaluate the entire dataset. This was then handed over to the community to maintain and govern, as Gitcoin transitioned to become a DAO.

3.1. Decentralising the algorithm

Meanwhile, Gitcoin was transitioning from a start-up company project into a DAO. The core team had conducted its governance token distribution based on people's previous participation in the platform (termed 'retroactive funding') and the organisation now allowed 'governors' to vote on all matters relating to the governance structure and operation of the

Submitted 13/12/2021 – Accepted 02/11/2022

DAO. Organisational elements emerged gradually, beginning with membership and some rules, monitoring, and sanctions, before a hierarchy of 'DAO' and core working groups composed of governors, volunteers, and sometimes staff employed by the DAO (known as 'sub-DAOs') emerged to conduct specific operational functions. A call for skilled volunteers, mentored by the BlockScience engineers that had designed the ML pipeline resulting in me joining very early morning calls in my time zone for the Fraud Detection and Defence" (FDD) sub-DAO. Although my participation in the sub-DAO was riveting and highly relevant to my research, I had little incentive to remain involved over the long term in what I saw as a complex, messy organisational arrangement. BlockScience ran the machine learning process in conjunction with the Gitcoin team and publicly reported to the community on design decisions made and results in Gitcoin Round 10, before handing it over to FDD as their contract with Gitcoin wound down. Deferring decision-making to "the community" is seen as becoming more "decentralised", and thus, "credibly neutral" and legitimate for the DAO (Owocki, 2021). Sub-DAOs were accountable for reporting to the DAO governors at large to request funding each quarter, in the structure of a multi-scale organisational hierarchy. Decentralised governance was intended to transition control and responsibility away from the Gitcoin team and towards the community for long-term, sustainable funding mechanism. "Gitcoin's choice to decentralize our platform's governance to a DAO will fully empower the community to govern itself" stated Gitcoin project Co-founder and CEO Kevin Owocki, who remains an authoritative voice in the overall direction of the DAO (2021). Governance of the DAO, and governance by the DAO of the ML pipeline, were both crucial in the transition to decentralised governance and the continuation of community funding.

Governance of the ML pipeline formed only part of the broader organisational re-structure. Actants were not only trying to collectively structure the governance of the ML pipeline but to establish new governance processes, manage budgets, coordinate volunteers and workers, and introduce algorithmic governance to automate and 'decentralise' multiple organisational elements. The algorithmic governance process deployed to detect sybil attackers gradually transitioned from the control of the Gitcoin team and Blockscience to volunteer and paid stewards (FDD) in GitcoinDAO that had the expertise and training to govern and manage the algorithm at a local level. FDD was subject to the guidance of the broader objectives, rules of operation, norms, budgetary constraints, and terms and conditions of the GitcoinDAO community, to guide algorithm design and iterations. Although governance of the ML pipeline was decentralised from the main GitcoinDAO and localised to the FDD working group, inherent points of centralisation and hierarchy were still necessary. For example, the data related to sybil detection is confidential as it contains Personally Identifiable Information (PII), for which working group participants such as evaluators needed to sign legal privacy agreements with the Gitcoin registered entity to do.

3.2. "The sybils are getting smarter"

A series of actions and counter-actions played out between sybil attackers and the FDD ML pipeline. The sybil attackers are getting smarter with each funding round. With every policy and algorithm designed to prevent sybil attacks, including trust scores, sybil scores from algorithms, and community flags, a new strategy emerges to attack the system. Jia, a researcher at BlockScience and volunteer steward in FDD states: "One project is getting 600% of a matching round…they are getting smarter each round". Sybil attackers developed new

Submitted 13/12/2021 – Accepted 02/11/2022

software scripts to evade the rules of the platform and game the system, such as "auto-commit" functions to give repeat donations of $1 each and increase their percentage of matched funds. New accounts were registering on the platform, sometimes hundreds at a time from one region, such as China. FDD has to determine whether this was a legitimate community participating in the funding round, or a sybil attacker trying to game the system. Even the weekly Gitcoin "kudos" community airdrop of free Gitcoin cryptocurrency tokens to thank participants was "getting sybil attacked pretty heavily" states Disruption Joe, a Gitcoin project core team member. Team members were detecting profiles that were redeeming tokens from the same computer IP address.

Not only does the FDD working group need to run the anti-sybil, anti-collusion, process, they also need to adapt it as the sybils adapt in iterative, co-constructive cycles. "The sybil and Gitcoin stewards are playing an ever-escalating evolution game – only the smartest sybil survives, as a result, they get smarter and smarter" (Jiajia, n.d.). Furthermore, reports needed to be shared with the overall DAO governors each quarter for transparency, without revealing any trade secrets that will help sybil attackers improve their tactics. Opinions on how to manage the ML pipeline continued to differ among actants. In one public comment, Owocki states that "Sybil attackers have exponential power…we need to have…INSTANT or NEAR-INSTANT feedback to the Gitcoin algorithms, so that sybil attackers can't run away with the round" (2021). In response, FDD "tuned" the algorithm for "sensitivity", "specificity", and "aggressiveness" to inform and teach the algorithm to flag potential attackers as fairly as possible, in a sensitive balance between allowing some sybil attacks to pass the process and wrongfully flagging a legitimate contributor (BlockScience, 2021).

In conjunction with algorithmic parameterisation, governance processes for the algorithmic pipeline were also being developed and documented in an "Anti-sybil Handbook". Gitcoin grants round 11 had a matching fund of $956,000, doubling the previous year. Sybil detection was becoming more effective, costing from 6.6% of the Gitcoin Funding in Round 9, to 0.6% in Round 11 (Zartler, et. al., 2021). Yet, sybil attackers also learned to merge new user accounts with new accounts on GitHub to subvert the flagging algorithm and contribute to reputable grants for one round before turning to suspicious grants. The challenge to algorithmic governance in Gitcoin is to not solely depend on ever-improving algorithmic governance against sybil attackers but to continue to develop their organisational structures to manage, maintain, and improve how the algorithmic pipeline operates.

4. Analysis: decentralised governance of centralised algorithms

In general, a DAO is an organisational framework for decentralised governance that is heterogenous in practical expression. As just one example of a DAO, the case study of GitcoinDAO provides qualitative evidence to locate 'Decentralised Autonomous Organisations' within existing organisational theory. Each organisational element articulated by Arhne and Brunsson (2011) of membership, hierarchy, rules, monitoring, and sanctions are present and entangled in algorithmic processes in GitcoinDAO. The organisational structure evolved from a partial organisation to a full organisation during the transition from platform to DAO as organisational elements were incorporated to address immediate concerns. The DAO provided the institutional framework to guide algorithmic governance design and organise outside of organisations. Rather than the system being "decentralised", governance

Submitted 13/12/2021 – Accepted 02/11/2022

was structured with many decision centres that have limited and autonomous prerogatives and operating under an overarching set of rules, and decisions were made at the local level by experts of a specific domain (Aligica & Tarko, 2012; Hasinoff & Schneider, 2021). Membership was defined by creating a profile on the platform. Different membership classes emerged with the distribution of governance tokens to holders. 'Stewards' who had tokens delegated to them volunteered to labour in the sub-DAO working groups, creating a natural hierarchy between owner/decision-makers and labourers. The rules of what constitutes "adversarial" behaviour that was reflected in the algorithmic pipeline were based on Gitcoin terms and conditions of use. The purpose of the ML pipeline was to monitor compliance with the rules of the organisation. Other monitoring functions occurred through the finance core working group sub-DAO, which reported to the overall DAO, to guide voting approvals on quarterly budget requests. Sanctions were also present at multiple scales in the DAO. The 'trust score' for people's reputation was a positive sanction that improved based on algorithms that tracked their use and engagement with the platform. In contrast, the negative sanctions in the ML pipeline were subjective and graduated, based on previous offences and the severity of the sybil attack.

As the DAO matured, a meta-governance layer began to emerge between the overarching DAO governors and the sub-DAOs. Meta-organisations are organisations with other organisations as members, rather than individuals (Arhne, et. al., 2016). The sub-DAOs in Gitcoin became functionally autonomous members with clear boundaries, including Fraud Detection and Defence and "Memes, Merch, and Marketing", that provided diverse services to the main DAO. The boundaries of these entities became more distinct as they grew more operationally autonomous. This process to create a nested hierarchy of organisations was not pre-planned but evolutionary through the co-constitution of both human and machine governors and those being governed. Although operational decisions were localised to the FDD working group, unavoidable points of centralisation arose, such as signing nondisclosures for handling personal information, and making quarterly budget requests to continue to operate sub-DAO functions. The latter of these became a focal point of inter-organisational tensions, with the FDD sub-DAOs initiating governance forum discussions to propose becoming their own DAO in an effort to diversify their revenue streams by providing their services elsewhere and reduce the overheads of budget requests and overall dependency on GitcoinDAO (Lessa, 2022).

GitcoinDAO also provides empirical data as an experiment in decentralising the governance of algorithms, in pursuit of governance by algorithms. GitcoinDAO's Fraud Detection and Defence working group is an example of an attempt to decentralise the governance of an algorithmic decision-making process. Decentralisation of the DAO led to some decentralisation of the algorithm. Governance of the anti-sybil algorithmic process was localised to the Fraud Detection and Defense working group of volunteer and paid contributors. This opened up participation in algorithm design and tuning of the algorithm for specificity and sensitivity to the broader DAO community. By encoding the rules of governance as algorithms that participants must adhere to, software developers are creating policy, which is itself a governance process. The way the algorithm was designed was as part of a policy-making process, with machine learning in the context of objectives and human processes. In this context, software design decisions shape and direct governance dynamics (Zargham & Nabben, 2020). The process of algorithmic policymaking to structure the processes of governance by applying different algorithms is inherently political and subjective,

Submitted 13/12/2021 – Accepted 02/11/2022

defining search, aggregation, observation/surveillance, forecast, recommendation, content production, allocation, and more (Latzer & Festic, 2019). Algorithms were able to be governed in a more decentralised way than by traditional institutions, and this required careful development of organisational elements to do so.

According to the organisational ontologies of DAOs, algorithms are elevated to the status of peers in peer-to-peer networks. They are viewed as critical actants in the practice of governance. Algorithmic governance proved to be a critical threat to DAOs, as well as a core defence mechanism. Algorithms shape social processes in DAOs by design, as a core ideological aspect and mechanism of decentralised governance. Governing by algorithms is performative in nature as it subjectively problematises, calculates, and enacts to constitute subjects. This 'machine politics' is indicative of an ideological lineage to achieve governance by code. Machines are a vital resource for organising but also create numerous challenges for managers and organisations, requiring specific techniques and know-how (Fineman, et. al., 2009). If algorithms are to become increasingly autonomous in their operation towards a vision of 'AGI agents' operating on decentralised blockchains, algorithms are themselves political actors in DAOs that co-constitute individual behaviours in the system and the assemblage as a whole. With algorithms as political actors in peer-to-peer networks, they formulate a core part of the stability, adaptability, and resilience of DAOs as an organisational form. During the sybil attacks against GitcoinDAO, humans and algorithms co-constitute one another as actants in a dynamic network, in the interplay of algorithmic games between attack bots and defence sybil flagging. Algorithms have been theorised as political tools in other domains, yet they have not yet been recognised as autonomous actors in politics themselves (Mittelstadt, 2016). Thus, DAOs also offer a unique contribution to organisational approaches that contribute to organisational theory, as a field site for the study of algorithmic governance.

Inherent ontological tensions still exist among DAO actants regarding the authority that algorithms should hold in relation to humans as decision-makers, with some advocating for algorithms to be more powerful, and others forewarning the need for consistent oversight. With "algorithms at the centre, and humans at the edges", it is not always clear if humans have an oversight and evaluation role, or are subject to government by algorithm (Buterin, 2014b). DAO participants must be careful not to design algorithms in a way that undermines their own objectives of autonomy (Nabben, 2021). As with other studies of algorithmic governance, the risk of increasing algorithmic efficiency is decreasing the capacity for governors to apply discretion (Gritsenko & Wood, 2020). Some DAOs are attempting to automate governance entirely and abstract away human involvement (Chitra, 2020). GitcoinDAO continues to test and research the effects of different mechanism designs as they evolve, "Defending us from us" states Disruption Joe, a Gitcoin project core team member. The subjective nature of algorithmic governance design in the hands of a select few, although it can be partially decentralised and held accountable, may also cause the threat to DAOs to be themselves. Because of this, there is a risk of power asymmetry between software engineers that determine the design of algorithmic rules, and participants.

Using decentralised technologies to organise does not mean organising outside of governance. This research has surfaced the tensions in balancing human and automated approaches in governing participatory, online systems in the desire to "decentralise". DAOs as an organisational form provided a framework for both governance of and by algorithms in GitcoinDAO, as well as introducing new dynamics of human-machine politics between people and algorithms as they governed as peers in this organisational form. As such, this research

Submitted 13/12/2021 – Accepted 02/11/2022

demonstrates the interdependencies of human and machine components in decentralised technology assemblages as organisational infrastructures. Digital infrastructures cannot rely solely on transparent governance practices when algorithms operate as political actors to enforce policy and require specific domain expertise to design and maintain. Decentralised organising relies on the articulation of shared values and objectives as a governance practice to align community members for continued participation, even in transition or against attacks. The framing of algorithms as political actors in online community governance allows us to critically evaluate system design and maintenance to better shape the algorithmic systems of the future. In GitcoinDAO, the governance structure that emerged to allow both governance by and of algorithms was polycentric and multi-layered. In other words, "The key is that humans must deliver the code and other outcomes, but those same people cannot control the protocol" states Kain Warwick, Founder of Decentralised Finance DAO, 'Synthetix' (Warwick, 2021).

5. Conclusion and further directions

This piece has explored DAOs as a decentralised organisational framework for distributed coordination of shared resources in relation to the phenomenon of algorithmic governance. Situating DAOs as organisations within the existing organisational theory, I have demonstrated how the political ideology and ontology of DAOs emphasise governance by algorithms ('cyberocracy') in both theory and practice as a mode of organising outside of incumbent institutional structures. In the context of DAOs as organisational forms for governance by algorithms, this piece explores if the governance of algorithms can be collectively managed and maintained in a decentralised fashion. I have focused on how DAOs organise in a decentralised manner to govern algorithms as an inherently centralising process, in what appears to be a paradoxical tension in the philosophy and practice of DAOs. By studying a decentralised organisation in practice, I account for the complexity of how the system and its actants of algorithms and humans work together to govern one another. I find that DAOs provide an institutional framework for the governance of algorithms through the articulation of shared objectives in constitutions and code, to locate humans and algorithms as peers in organising through the organisational structure. I argue that this establishes algorithms as political actors in shaping and determining the outcomes of decentralised governance, introducing a new mode of practical tensions or 'machine politics' between algorithms and people as peers and political actors in co-constituting and shaping decentralised assemblages between both the governance of and by algorithms. Where power lies in decentralised organisations is a dynamic tension between influential inside decision-makers that hold governance rights across organisational elements, as well as the constituents of a DAO that are involved in shaping and operating specific algorithmic processes that shape and constrain others through algorithmic power in certain organisational elements of the system.

Critical to DAOs as an institutional framework for organising outside organisations is the initial design and ongoing maintenance of and by algorithms. The case study of GitcoinDAO illustrates how decentralised organising is not just about political decentralisation away from external influences on decision-making but determining the hierarchy between humans and algorithms in algorithmic systems. The internal rules of governance that set become embedded in algorithmic decision-making systems, highlighting the subjective role of software engineers

Submitted 13/12/2021 – Accepted 02/11/2022

as bureaucrats in designing governance policy and encoding it into the rules that govern DAOs. Decentralisation of algorithm design and maintenance, as well as human oversight for evaluation and accountability emerge as critical in the enactment of DAOs as a structure for algorithmic governance.

This scholarship is pertinent to the areas of public policy and sociology as algorithmic decision-making systems become more prevalent in the governance of modern society. The study of governance by algorithms captures the intentional and unintentional steering effects of algorithmic decision-making systems in everyday life (Latzer & Festic, 2019). Understanding these systems through human-machine interaction, rather than solely focusing on the 'machine' generates insights into how they imbue politics and power dynamics to impact rights, access, individual liberty, collective autonomy, and safety. Empirically assessing the goals, practices, and human outcomes of algorithmic systems is a prerequisite for the development of adequate public policies toward algorithmic governance.

By constructively engaging with the algorithmic shaping of worlds to better understand if and how 'Decentralised Autonomous Organisations' delineate themselves from existing digital platforms in practice, this piece contributes to scholarship on organisational theory and algorithmic governance towards better social outcomes for those that engage with these systems. As algorithm design becomes a policymaking task and algorithms themselves become political actants in governance, the guiding documentation of decentralised organisations that set out the objectives and norms of behaviour of participants become increasingly important to how they operate. These findings can be extrapolated to other contexts of governance in and through digital infrastructures on algorithmic governance, governance of algorithms, and the machine politics that ensues.

Keywords:

blockchain, decentralised autonomous organisations, algorithmic governance, automation, cryptocurrency, platform

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