# The Rule–Tool–User Nexus in Digital Collective Decisions

Blue Sky Ideas Track

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## ABSTRACT

Collective decision making is experiencing a digital revolution. Online platforms offer to spread information, help groups make better decisions, incentivize people to exchange arguments, and force policy makers to take into account the public opinion. Social choice theory, a sub-discipline of economics, typically analyzes collective decisions, but rather overlooks the multitude of coalescent elements playing a role in them. To ensure that digital democracy is effective and scientifically grounded, we offer an original view of collective decisions as complex systems, and propose to study the systems' components in parallel with the interactions between them. We identify three eminent components: the individual agents in a group, i.e., some users of a platform, the voting rule that determines the final collective decisions, and the tools via which the users practically engage with a platform. The success of digital democracy relies on interdisciplinary and cross-methodological research. We indicate several paths in this direction.

## KEYWORDS

Digital Democracy; Computational Social Choice; Collective Decisions; Voting; Social Influence

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## 1 INTRODUCTION

From the classical Athenian era to the contemporary digital world, people with discordant opinions routinely engage with each other to reach outcomes that concern them as a whole: elect a president, spend public money, change climate policy. Nowadays, an increased effort is made to systematize public debates and deliberation, for example through initiatives of deliberative mini-publics such as citizen assemblies [47]. This kind of political decision making often materializes online, assisted by digital tools. Evidently, a multitude of platforms have been developed, both by academic researchers and practitioners, to promote participation and representation in collective decisions: DemocracyOS, Liquid Feedback, Polis, RoboVote, the Stanford Online Deliberation platform, Vodle, Voting, WeGovNow, and Whale. These platforms, together with similar future ones, constitute the application domain of this paper.

In a process of collective decision making, a group of people (*agents*) interact by expressing opinions about some issues at stake and submit certain data to a mechanism, e.g. by filling in a ballot. A final decision is usually produced by *tallying*—transforming this information into a result via a voting *rule*. In decision-making processes supported by a platform, agents act via their *user* profiles, while deliberation and tallying are carried out by a voting *tool*.

The three main components of digital collective decisions—the *users*, the *rule*, and the *tool*—are not independent. As in every *complex system*, governing forces are the feedback mechanisms and not the particular elements of the system in isolation. Importantly, although agents that form opinions and make decisions together within groups take part in a complex system as well, social influence and collective decision making have so far been studied separately, within the seldom intersecting fields of computational social *science* [15, 21, 34] and computational social *choice* [11, 17], respectively. The former field employs social simulation for modeling opinion dynamics, analyses social networks and media, and studies user behavior via digital trace data. The principal goal of computational social choice, on the other hand, is the mathematical modeling of opinion formation, elicitation, and aggregation, together with the complexity analysis and the algorithmic design of voting rules.

By treating digital collective decisions as a complex system, we improve our understanding of their properties and capabilities and endorse further progress on the platforms where they take place. We focus on the interplay between the system's different components and highlight many research questions arise under this fresh perspective. It is imperative to work towards filling the gap between (often idealistic) theory and (often ad-hoc) practice. To that end, we must be comfortable with moving across methodologies and techniques, combining empirical and theoretical research with multiagent modeling and simulations. This studdy asks for an interdisciplinary approach. We require sociology and experimental economics to examine the dynamics between agents in groups; user experience (UX) design, gamification, and software engineering to pinpoint the effects that specific voting tools have on their users; data analysis to further understand the significance of these effects; and psychology, cognitive science, and behavioral economics to

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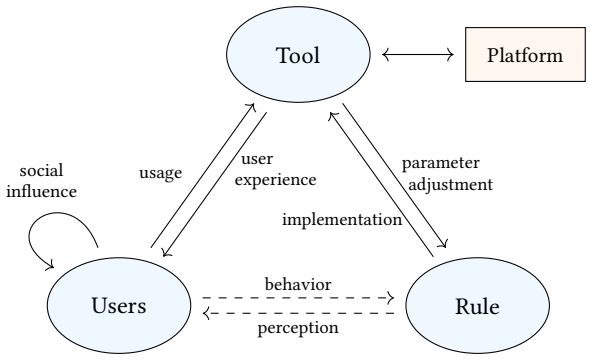


**Figure 1: The rule-tool-user nexus in digital collective decisions**

capture the input provided by the agents to a voting rule (as seen by the agents themselves), as well as the framing that a voting rule sets for the decision problem.

Figure 1 illustrates the rule-tool-user nexus in digital collective decisions. The outcome of a voting rule maps onto the behavior of users (Section 3) who deliberate and influence each other (Section 2). The ballot tallying is performed by a particular implementation of a rule in a digital tool (Section 4) designed to be handled by users that provide it with behavioral feedback (Section 5).

## 2 USERS ↻

> Users hold beliefs that are continuously and dynamically influenced by others in their social network.

### 2.1 Social dynamics for collective decisions

Digital collective decisions are not merely the result of voting rules applied to some fixed ballots. Users behave strategically, deliberate, and influence each other; their preferences that lead to the ballot formation are subject to complex processes of social dynamics, which are magnified in digital contexts and may severely bias the outcome [20, 35]. Online anonymity facilitates the expression of extreme opinions and sustains polarization, while social networks entail the risk of information bubbles that damage diversity [30]. When collective decisions are at stake, imitation effects might increase the predictability of results due to easy consensus, or decrease it due to multistability or oscillatory behavior [20, 24, 35].

**Wisdom of online crowds.** Whether social influence helps or harms collective decisions is determined by the voting context. Consider the *wisdom of the crowds* (WoC) effect. The basic idea is that a group of agents estimating some quantity independently are able to produce a better estimate than most agents could do individually. A stream of recent empirical work showed that this effect can be enhanced by social influence [23] and certain structures of social relationships [5]. Improvements upon independent decision making are obtained when the degree to which one is influenced is negatively related to their certainty about an initial guess [23, 24]. But social influence can also undermine the quality of a decision [22, 24, 36]. Theoretical work on WoC highlights that social-influence biases become particularly relevant for digital democracy. The speed of information exchange increases the weight that social influence has over collective decisions, relative to individuals' independently held opinions. In a similar vein, trolling in online votes (e.g. the 'Boaty McBoatface' vote, the 2008 MTV EMA public vote on best musical act, or the Austin, Texas crowdsourced name for the solid waste department) have demonstrated the velocity with which votes can be overturned due to social influence processes.

**Influence response functions.** Research to date has not led to a general theory of social influence. Rather, distinct theories are as abundant as their formalizations and have been empirically validated with varying degrees of success [20]. It is still under debate what influence response function is applicable in what context [20, 37]: we must consider what agents discuss, with whom, where, and how much skin they have in the game—there is no one-size-fits-all answer. Specifically, within digital platforms for collective decisions, users differ greatly in their responses to others. The literature on computer-mediated communication has shown that anonymity of the communication partner increases openness to the other's viewpoints [43], but also that the same statements are considered more polarizing compared to face-to-face communication [45].

**Networks.** Another particularly relevant aspect in the context of digital decision making is the visibility and connectivity of agents involved in deliberation procedures. It is long known that networks of influence are pivotal for collective outcomes [20], but the popularity of web 2.0 has come with a whole new set of obstacles for social influence processes, such as *algorithmic bias* [30], *misinformation* [46] and the overall *diversity in information diets* [40].

### 2.2 Open research questions

When conducted in digital settings, agents' opinion formation and voting behavior is affected. Many questions must be further studied:

- How should a digital voting process be designed to benefit from positive social-influence effects as in WoC?
- Is deliberation beneficial for collective decision making in digital platforms where anonymity prevails?
- Are there voting rules that mitigate extreme effects created by polarized or clustered opinions in social networks?
- What are plausible types of influence response functions?
- Are collective decisions vulnerable to cross-platform interaction?
- How can digital platforms for collective decisions encourage information-seekers and disincentivize fake news?
- How do we identify and prevent vote manipulation, in groups with strong tendencies to either grow together or grow apart?

## 3 USERS ↔ RULE

> Users provide the input to the voting rule, which in turn impacts user preferences and ballots.

### 3.1 Heterogeneity, voting context, and perception

As long as the goal of digital platforms for collective decisions is to support the open, equal, and transparent participation of everyone, the employed voting rules must ideally account for user heterogeneity. Users may differ in terms of their *strategic* or *collaborative* behavior, and their *motivation* [16]. This should be considered when trying to build rules that are hard to manipulate, and rules that

provide incentives for participation. In social choice work to date, well-known impossibility results rely on strong assumptions of homogeneity [12], but in digital contexts assumptions about a group of users should be directly linked to the platform in which the decisions take place—for example, a platform that requires several steps for registration will naturally attract more motivated users, while a platform that allows a user to create multiple accounts may increase strategic behavior.

**Heterogeneity of the user preferences.** A key challenge entailed in the design of a voting rule is the heterogeneity of user preferences and ballots—existing rules in computational social choice routinely assume that these take the same format for all users [11]. Several works assume cardinal preferences [7, 18, 42], rankings [2, 19, 51], or dichotomous orders [10, 33]. However, the format of the preferences and the ballots may in reality be different for each user. A user who views her options as black and white is likely to form dichotomous preferences and wish to report such a ballot, whereas a highly calculative user may induce cardinal utilities.

**Heterogeneity of the utility measures.** Heterogeneity also comes into picture while measuring each user's utility from the outcome. Existing literature in social choice presumes that there exists one function that maps every possible combination of ballot and outcome to the utility derived by the user reporting that ballot [3]. Clearly, we need to consider that this function may be different for each user. An optimistic user can derive high utility even if her ballot is remotely taken into account, whereas some other user may not derive utility unless the outcome is highly favorable to her.

**Rule perception.** The relation between a voting rule and a group of users is usually considered one-way: the users provide the input to the rule. But the other direction of the relation is also important: the rule can affect the users, steering them towards a specific type of ballots and preferences [49] (for instance, a rule that asks for approval ballots will more likely incite binary preferences than a rule that asks for complete rankings). A rule may be perceived by a user through three lenses: the *properties* it satisfies (i.e., its *axioms*), the *procedure* it follows, or the *outcome* it produces.

First, the correlation between the properties desired by the user (such as fairness, representation, etc.) and their interpretation as formal axioms is not straightforward [44].

Second, the users of a digital platform are not expected to read the mathematical definition of a voting rule, but will be presented with a voting procedure. Understanding such a procedure may be cognitively demanding [6], and obtaining satisfactory explanations may be non-trivial [9] (the tools described in Sections 4 and 5 can help with that). But more importantly, the description of the procedure may bias how users evaluate it, and consequently how they behave when taking part in it. Consider for example the 'random dictatorship' rule, described as randomly selecting a voter and having them make the final decision—despite being the only rule that satisfies some interesting and convincing axiomatic properties [1, 4], it is probably still perceived as unfair by some users who directly look at its procedure.

Finally, a user may perceive a rule based on the utility she derives from its outcome, notwithstanding the properties satisfied by it or the procedure followed to achieve it (it is indeed conceivable that the loser and not the winner of an election feels that the voting method leading to the specific outcome was problematic).

**Voting rule and social influence.** As hinted in Section 2, the voting rule does not only affect individual users, but also greatly impacts the effects of social influence on the quality of the collective decision [24, 39]. For example, when decisions are made sequentially, an error may be amplified and lead to information cascading [22]. In fact, any social influence stemming from aggregated information rather than full information may bias individual estimations [39]. Even under full information, the collective uncertainty about the best outcome needs to be high in order for social influence to have a positive effect, which, arguably, happens only rarely [38].

### 3.2 Open research questions

Examining closely the interaction between users and rule highlights several research gaps, both on the theoretical and empirical fronts.

- What are the potentially heterogeneous attributes of users? What are the multiple values or forms they may take?
- Which aspects of user behavior are influenced by the voting context, and how should a rule account for user heterogeneity?
- How does the goal of a voting rule relate with its definition?
- How can the human perception of values such as fairness and representation be translated precisely into formal axioms?
- How can the human perception of the definition or the procedure of a voting rule be captured precisely?
- How do different voting contexts affect the quality of the collective decision through social influence?

## 4 RULE ↔ TOOL

> Voting rules are practically implemented as tools, which collect information on the users and inform the rule.

### 4.1 Software tools for collective decisions

Many voting rules require voters to provide more detailed information than a usual plurality voting ballot, and are much easier to tally with a computer than with pen and paper. For this reason, real-world applications of such rules typically employ some form of software tools, which mediate all the effects described in Sections 2 and 3 and introduce further ones. At the least, these tools let users set up decision problems, list options, and fill in their secret ballots, before performing the tallying and reporting the results.

**Ballot elicitation.** A tool might offer several different ways for filling ballots, e.g., specifying an integer rank for each option or dragging options up and down to specify a ranking. It may provide help in the form of explanations of the intended ballots or the voting rule, tutorials, or live hints such as "You rank only one option. You can rank further ones by dragging them here." If theory suggests that certain ways of filling a ballot are usually individually or socially beneficial, the tool might nudge or outright ask voters to fill ballots in such a way. E.g., "You approve only one option. It often makes sense to approve all options you consider better than average." When reporting results, tools might provide justifications that refer to formal criteria such as axioms [41].

**Interactivity.** For voting rules where an effective use of one's ballot depends on beliefs about others, the tool might help in forming these beliefs, e.g. by providing voters with voting data and letting

them adjust their ballot once, several times, or as often as necessary until some deadline [27] (note that a tool's interactivity can trigger the kind of social influence dynamics discussed in Section 2).

Tools might also combine a voting rule with other informal or formal ways of interaction. The ballot-filling might be complemented by deliberation possibilities, e.g. via a chat or forum, and might provide human moderators with additional aid. Also, voters might be allowed to delegate their ballot or part of it (e.g., the numerical ratings of certain options) to others as in Liquid Democracy [8, 29].

**Cross-decision interaction.** For groups that take several decisions simultaneously and/or over time, tools might provide interaction possibilities across these decisions, e.g., by giving users voting credits that they may spend to gain voting weight in certain decisions as in Quadratic Voting [50] or that may evolve over time as in Perpetual Voting [32].

**Integration with platforms.** Importantly, voting tools are sometimes integrated into larger platforms that support groups in various other ways, providing general communication and social networking, knowledge acquisition, collaborative editing, etc. In such cases, the voting rule that a tool implements must be compatible with the aims of the platform, its regulations, and the users it attracts.

### 4.2 Open research questions

Being the main interface between users and voting rules, voting tools need to be understood and designed properly, to assess and improve the impact of digital collective decisions. We locate a number of imperative research questions.

- How can or should a certain formal rule be turned into a tool? Which of potentially several equivalent representations of its input, algorithm, and output shall be chosen?
- How can complex tallying processes be represented transparently and verifiably? What justification of the results can or should be generated alongside?
- How can theoretical advantages of the chosen rule (e.g. fairness) be preserved or further be improved by the tool? How can theoretical disadvantages (e.g. manipulability) be mitigated by it?

Feedback from tools can also help in improving decision rules:

- How can usage data from a tool be exploited to assess quantitative formal properties of a voting rule (such as welfare or satisfaction metrics, frequencies of axiom violations or strategic behavior, degree of engagement, etc.) and test related theoretical claims?
- How can such data be used to adjust the parameters of an underlying parameterized family of voting rules (such as thresholds, numbers of votes, exponents, etc.)?
- How can data from tools implementing different rules be used to advance theory (e.g., by suggesting additional formal criteria, ballot designs, or more complex game theoretical models of a decision rule in the context of certain interactions)?

## 5 TOOL ↔ USERS

> Tools are designed for users and affect their behavior; user behavior provides feedback to the tools that are expected to respond to it.

### 5.1 Aspects of tool-user interaction

In digital contexts, users can only take part in collective decisions through a voting tool. To guarantee user satisfaction and repeated participation, the interaction with the tool needs to be pleasant. Of course, user experience will depend on users' earlier exposure to tools, their cognitive capabilities, personality traits, and values.

**Roles and expectations.** Most users of a collective decision tool take the role of voters, some that of admins, and other roles like moderators might exist. All these roles have goals and expectations regarding the tool's user interface, the way it represents and justifies the decision results, the type and amount of information about other voters' behavior it provides, and properties such as accessibility, ease of use, quality of results, and privacy protection.

**User experience design.** Software tools can be designed to provide quite varying user experiences [26]. Evidence from behavioral experiments in economics and social psychology suggest that the choice of language and terminology and the overall visual design (colors, fonts, imagery, etc.) might induce framing effects and prime user behavior in certain ways, e.g. to be more cooperative or competitive, individual- or social-value oriented, honest or strategic, process- or outcome-oriented, etc. [14, 25, 28]. Design details during voting or deliberation such as the order of questions, hints or nudges, or information on other users' behavior can influence users in wanted, unwanted, or unpredictable ways [13, 31, 48].

### 5.2 Open research questions

Designing collective-decision software tools requires answering a number of additional questions:

- What effects do design details (language, layout) have on users' perceptions, voting behavior, social dynamics, and satisfaction?
- How to make wanted voting behaviors and social dynamics more likely and unwanted or unpredictable ones less frequent?
- Which default settings and customization options help address users' heterogeneous needs and capabilities to reduce bias and privileges without introducing other biases or privileges?
- How can or should tools be integrated with other software?

Due to the multilateral interactions possible in collective decisions, tools might also provide fruitful environments for studying more general questions from social and cognitive sciences such as:

- Which behaviors are triggered by different framings, nudges, and additional information given in contexts of collective decisions?
- Do new social dynamics arise within collective decisions?
- How does regularly participating collective decisions feed back on social structure and attitudes such as social value orientation, trust in institutions, etc.?

## 6 CONCLUSION

Platforms for digital democracy are a current trend, but we observe that they often lack solid scientific foundations that could accelerate their success. Simultaneously, research on collective decision making rarely engages with practical applications. One reason for this disconnection is the inherent difficulty of interdisciplinary work: before any collaboration is possible, terminology must be unified, methodologies must be merged, and central questions must be agreed upon. We have laid the ground for this endeavor.

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