2024 AOM Annual Meeting Presenter Symposium

Toward a General Theory of the Organization: From Cells to Societies

Tue, Aug 13, 2024 11:30 M ~ 1:00 PM CT
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What makes Individual I's a Collective We: Coordination mechanisms & costs

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How much regulation does simple life need?

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Unifying regulatory costs across complex adaptive systems

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Sponsor Divisions: Organization Behavior (OB)

OVERVIEW OF SYMPOSIUM

A central theme of organization studies is to understand how organizations composed of multiple actors each with different perspectives and motivations achieve coordination (March & Simon, 1958; Thompson, 1967; Mintzberg, 1980; Puranam, 2018). Whether it's the structured hierarchies within bureaucratic organizations (Weber, 1978; Monteiro & Adler, 2022) or self-managing entities without direct managerial control (Ashby, 1947; Lee & Edmondson, 2017), coordination is an essential, albeit additional, function beyond the primary operations of any organization. While organizational scholars have accumulated a substantial body of knowledge about coordination functions within human organizations, our symposium seeks to broaden the discussion to encompass a wider array of systems requiring coordination, where organizational scholars can derive novel insights. For instance, bee colonies, a remarkable super-organism that might seem to operate seamlessly, need coordination beyond genetic programming to adapt to the environment. Similarly, in bacteria, regulatory genes function akin to managers, orchestrating the activities within the cell. These examples from nature underscore the universality and importance of studying coordination processes beyond human society.

Therefore, we brought presenters from a variety of fields to this symposium, each of whom highlights the systems and definition of coordination functions in organizations across diverse systems including firms, self-organizing system, biological systems, and federal agencies. While each system faces a different set of tasks or problems to be resolved, our symposium centers on developing a unified science of coordination functions and its associated structure to answer the following questions: *What are the driving factors behind the cost of the coordination? Can we*

predict the amount of regulatory costs an organism or organization needs based on its size, function, and complexity?

Building on the theme of coordination across diverse systems, our symposium invites cross-disciplinary experts to mark a notable departure from the traditional themes at Academy of Management's (AOM). This multidisciplinary dialogue integrates biological paradigms with organizational theory. We believe that this fresh perspective enriches AOM's discourse, challenging its members to expand their analytical scope. This expansion is designed to deepen our collective grasp of organizational practices, which is aligned with the AOM's dedication to the advancement of management sciences. Finally, our symposium is poised to cultivate an intellectual community that embraces and explores these innovative intersections.

Presentations

The four presentations span a range of diverse systems, beginning with formal organizations and gradually expanding the scope to cover collective intelligence, biological systems, and federal agencies. At the end of the symposium, we present an extensive overview of coordination processes across biological and socioeconomic systems, aiming to develop a general theory of organization that encompasses a range from cellular to societal levels.

The first study, led by Harry Haochi Zhang, examines the decentralization of formal hierarchy design in organizations, focusing on the pivotal role of middle managers. Authors challenge the traditional view of hierarchy as a top-down structure, instead proposing that as organizations grow, the task of building formal hierarchies exceeds the capacity of top leaders and becomes a collective effort led by middle managers. The study conceptualizes organizations as communities of practice, where shared knowledge and structured practices evolve through social learning dynamics. Conducted in a leading technology company in China, the authors

combine qualitative and quantitative methods to reveal that middle managers, in their governance of units, conform to shared organizational design codes. This conformity is influenced by tenure, culture, and the institutionalization of these practices. This study contributes to the understanding of organizational structure, learning, and practice theory by highlighting the social construction of formal hierarchy and providing a unique quantitative approach to analyze it.

The second study, led by Jisung Yoon, explores coordination functions in self-organizing systems, Wikipedia. Authors categorize coordination actions in Wikipedia into two types: *one-way coordination*, asymmetric guided by rules and authority, and *two-way coordination*. The study found consistent scaling factors of coordination costs with system size. Authors found that two-way coordination scales superlinearly – faster than organization size growth –, and one-way coordination grows sublinearly – slower than organization size growth –, suggesting a common organizational dynamic among contributors. Analyzing individual project growth reveals that, while contributor influx initially leads to increased interactions, projects transition to formal oversight within a decade, echoing Weber's organizational evolution. Indeed, study reveals the emergence of a nascent hierarchical structure, even in self-organizing systems, as evidenced by the analysis of the world's largest collective intelligence platform.

The third paper, led by Chris Kempes, presents a novel comparative study between the optimal functioning of biological organisms, specifically bacteria, and human organizations. By examining the efficient regulatory mechanisms in bacterial cells, which manage numerous functions through complex gene regulation, authors develop a mathematical model that describes how these regulatory functions scale with cell size. This model reveals a critical transition point in regulatory architecture, applicable beyond bacteria. The core aspect of this study lies in

applying these biological principles to human organizations, proposing that insights from the adaptive and efficient regulation seen in bacteria can offer valuable guidelines for optimizing management structures in human institutions.

In the final study, Vicky Chuqiao Yang presents a comprehensive analysis of regulatory functions and their associated costs in both biological and socioeconomic systems, drawing parallels between diverse entities like cells and companies. The authors examine the necessity and impacts of regulatory components within these systems, highlighting the significant costs involved, as exemplified by the administrative spending in U.S. colleges. The findings reveal that while centralized systems exhibit sublinear scaling in regulatory functions, decentralized systems show superlinear scaling. Additionally, the study distinguishes between proactive and reactive regulation across these systems and develops a mathematical model to explore the optimization strategies under various regulatory costs.

The symposium will feature Dr. James Evans as the discussant. Dr. Evans is one of the foremost thinkers about collective cognition and innovation. His research explores how ideas and habits of reasoning are formed and shared, covering topics like attention distribution, agreement processes, and the development of certainty and doubt.

RELEVANCE TO DIVISION

Organization and Management Theory (OMT)

Many members of the OMT study how organizations are structured and designed for efficiency, effectiveness, and adaptability. Key contributions of our proposed symposium include introducing scaling framework for understanding the endogenous shift in coordination functions and costs in a quantitative and systematic way, insights into the emergence of hierarchical

dynamics in self-organizing systems, and the development of mathematical models to understand these dynamics. These findings not only challenge and expand current organizational theories, particularly in the areas of organizational design and evolution but also bridge the gap between academic research and practical application in management. This symposium thus stands as a significant step forward in understanding and optimizing coordination in diverse organizational structures.

Technology and Innovation Management (TIM)

Our symposium will be of interest to the TIM division because of the topic of organizational change due to technology, studying how technological advancements impact organizational structures, processes, and culture. Specifically, our symposium covers organization structure in Wikipedia, which is novel organizations powered by Information Technology and decentralization of formal hierarchy design in organizations led by technology geeks. We believe understanding coordination functions in a fundamental way would help to understand how technology would redefine role of organizations and management, significantly enriching the field of TIM.

Organization Behavior (OB)

Our symposium is evidently relevant to the OB division's interest of developing theories and models to understand individuals and groups within an organizational context. The papers to be presented provide interdisciplinary insights into coordination mechanisms across various systems. Its exploration into how these mechanisms influence individual and group's cooperation and conflicts within organizations offers a deeper understanding of key OB concepts like organizational structure and design, conflict, and communication. Additionally, the development of predictive models for coordination costs is a valuable tool for OB practitioners, enhancing the

design of organizational structures and team dynamics. These contributions, underscored by their global and cross-cultural relevance, make the symposium a valuable asset for both theoretical advancements and practical applications in the field of organizational behavior.

PROPOSED FORMAT OF SYMPOSIUM

Length: 90 min

Minutes 0-5: Welcome and Introductions

● Hyejin will greet the audience, introduce the overarching theme of the symposium, and introduce the presenters and their paper presentations.

Minutes 5 to 65: Paper Presentations (15 minutes each)

● Managing formal organization hierarchy. *Presented by Harry Haochi Zhang*

● What makes Individuals I's a Collective We: Coordination mechanisms & costs. *Presented by Jisung Yoon*

● How much regulation does simple life need? *Presented by Chris Kempes*

● Unifying regulatory costs across complex adaptive systems. *Presented by Vicky Chuqiao Yang*

Minutes 65-90: Discussion (15 minutes) & Audience Q&A (10 minutes)

● Discussant James Evans will present comments and feedback on the presentations.

● Co-organizers will lead a Q&A session and discussion between presenters and the audience.

PRESNTATION SUMMARIES

Managing Formal Organizational Hierarchy

Harry Haochi Zhang* and Jianhua Ge

Formal hierarchy is a fundamental property of all organizations and has been of central interest to organization and management scholars for many years (Burton & Obel, 2004; Mintzberg, 1979). It essentially manifests decisions about the delegation of formal authority and role relationships in an organization. But who makes these delegation decisions to create the formal hierarchy of an organization? To date, most of the literature still treats the formal hierarchy as a *policy* designed by top leaders of the organization and then examines the implications of organizational-structure-related policies from the outlook at the apex of the organization (Whittington, 2002). The dominant structure-as-policy perspective obscures the fact that, as organizations grow past the start-up stage (Vaara, Harju, Leppälä, & Buffart, 2021), the construction of a formal hierarchy for hundreds or thousands of employees soon exceeds the cognitive capacity of the top manager(s). Thus, in practice, the construction of the formal hierarchy becomes a decentralized task, such that a group of senior middle managers often become responsible for carrying on the delegation of authority respectively in the governance of their units. This phenomenon is so ubiquitous that even companies led by technology geeks who championed the delayering fads of management have found it to be inevitable to become increasingly dependent on middle managers for these tasks. For example, in the early 2000s, Larry Page and Sergey Brin learned from an experiment at Google that the multi-layer formal hierarchy remains critical for contemporary organizations and that it is particularly important to understand and support the roles of middle managers in decentralized organizing and designing

of the evolving hierarchy as Google grows (Garvin, 2013; Harrell & Lauren Barbato, 2018; Mautz, 2019).

With the decentralization of formal hierarchy design, the question is, may we simply view middle managers' governance of units as managing "mini-organizations," which is then metaphorically the same as a top manager's exercise of discretion on a whole company? Or are there other important social mechanisms that underpin the middle managers' work in delegating authority and building unit hierarchies? I contend that it is illuminating to consider the middle managers' embeddedness in a densely connected system – an organization – with a sizeable group of peers performing similar tasks through comparable practices. This implies the usefulness of the lens by the practice theories on organizational phenomena (Feldman & Orlikowski, 2011; Jarzabkowski, 2005; Nicolini, Pyrko, Omidvar, & Spanellis, 2022; Whittington, 1996, 2002, 2006). In this study, I set forth a structure-as-practice perspective by examining the interplay between these organizational design practitioners and the social and technical context in which they are embedded. From this approach, I seek to develop our knowledge about formal hierarchy not just as something that an organization *has*, but also as something that an organization and its actors *do*.

The practice-based studies of organizations are built upon the social theories of Bourdieu (1977, 1990) and Giddens (1979, 1984) that emphasize the actual practices of the relevant practitioners as the unit of analysis for us to truly understand the structuration of organizational phenomena and their implications. Following this epistemological approach, researchers conceptualize an organization as multiple communities of practices (Brown & Duguid, 1991, 2001; Lave & Wenger, 1991; Nicolini et al., 2022). These communities emerge from the categorization of work identities led by salient social or technical factors. Social learning

dynamics then occur within and across these communities as structured practices and shared knowledge evolve (Bechky, 2003, 2006; Cook & Brown, 1999; Valentine, 2018). In this paper, I focus on middle managers' practices in the delegation of authority to develop our knowledge about the social mechanisms that constitutively shape the formal hierarchy in an organization. Based on the practice-based perspective, as middle managers undertake the decentralized task of delegation, they collectively create and share knowledge – which I label as *organizational design codes* - during this task. The Figure at the end of the document illustrates the structuration processes of the organizational design codes.

The Bourdieusian and Giddensian theories (Bourdieu, 1977; Giddens, 1984; Jarzabkowski, 2008; Whittington, 2015) contend that as a result of the structuration of social practices, the institutional realm of legitimation arises. This implies a foundational proposition for understanding middle managers' work in building the formal hierarchy: when a middle manager's unit hierarchy design practice deviates from the shared knowledge in the organization, the effectiveness of the unit will likely suffer normative sanctions as subordinates and peers deem the management of the unit to lack legitimacy and thus decrease their engagement. In other words, even if the task of authority delegation is completely decentralized with little or no organizational control mechanisms enforced in the top-down direction by top executives to directly monitor middle managers' design of the unit structures, there will exist social control mechanisms that operate in the bottom-up and horizontal directions to normatively ensure middle managers' conformity to the shared knowledge about unit structure design.

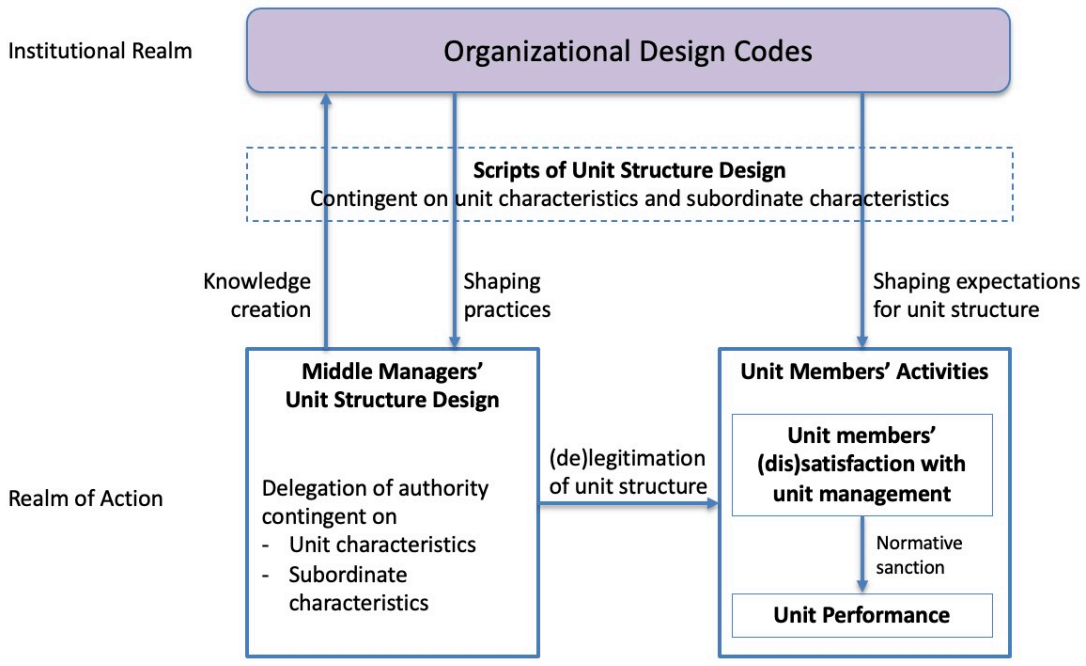
To develop and examine this proposition, I conducted empirical work with access to both qualitative and quantitative data in the context of a high-growth, leading technology company in China, alias Zen. Through collaboration with Zen's people analytics department, I obtained

access to Zen's HR record from January 2019 to April 2021 and also conducted 26 interviews with the employees. My quantitative analytical framework builds upon the "residual approach" from the contingency school (Van de Ven & Drazin, 1984; Zajac, Kraatz, & Bresser, 2000). As I will contend later, this methodological framework is particularly suitable for quantitatively validating the shared, normative "codes of practice" (Jarzabkowski, 2004: 532) or "scripts" (Barley, 1986; Barley & Tolbert, 1997) based on practitioners' actions. Moreover, by developing an instrumental variable strategy based on Zen's mentorship program in which employees receive quasi-random assignments of mentors, I causally examine the performance implications of adhering to vs. deviating from the shared practices in designing unit hierarchies. This methodological framework also enables the examination of the socialization of managers by the company culture and norms with regard to the appropriate governance of units. Results show that managers become increasing socialized by deviating less from the scripts, as their tenures at the company increase. However, such a learning process is attenuated by managers' pre-Zen tenures. Last but not least, I found evidence for the institutionalization of the scripts, such that as Zen grows and matures, middle managers' unit structure design practices increasingly converge,

This study contributes conceptually and methodologically to the literature on organizational structure, organizational learning, and practice theory. For the literature on organizational structure, my study provides new insights by underscoring the actual organizational designers and their work in the warmly debated "problem of flatness" in both academic and practitioner spheres (Lee, 2022; Puranam, 2022; Vaara et al., 2021). For studies on organizational learning, which often account for formal structure and hierarchy as a *context* for organizational learning (Valentine, 2018), my study evokes new questions by foregrounding and endogenizing the design of organizational structure as something that organizations and their members socially

learn to construct, instead of being some exogenous factor in the background. Finally, for practice theories, I pick up insightful early calls (Ranson, Hinings, & Greenwood, 1980; Whittington, 2002) to pay long overdue attention to the social construction of formal hierarchy as a fundamental organizational phenomenon. Moreover, I develop a distinctive quantitative methodological framework to complement the qualitative approaches that have been dominant in the practice literature. As my analysis will unfold, this quantitative approach, in conjunction with qualitative work, has great potential to offer practical insights that help both academic and practitioner audience to understand the collective creation, use, and sharing of knowledge in organizations.

Fig. 1 The Structuration of Organizational Design Code



What makes Individuals I's a Collective We: Coordination mechanisms & costs.

Jisung Yoon*, Vicky Chuqiao Yang, Chris Kempes, Seoul Lee,

Geoffrey West and Hyejin Youn

Coordination mechanisms are crucial for integrating many components into a unified whole. To successfully transition from individual I's to collective We, coordination mechanisms should go beyond simply setting up channels for communication through shared goals and interaction within the system (Malone, 2018; Tuomela, 2007; Weinberg, 1994). Notably, the implementation of these coordination mechanisms demands considerable effort and resources (Van et al., 1976; Coase 1995) across many diverse systems. Then, what factors influence the increase in coordination costs, and how can these factors be empirically understood?

In this paper, we examine the factors influencing coordination costs in collectives, using Wikipedia as a case study. Wikipedia, with its vast record of individual activities and small communities focused on specific projects, provides an ideal setting to study coordination dynamics (Yasseri et al., 2012). These projects, though varied in size, share the common goal of building comprehensive knowledge on specific topics, involving collaborative efforts (Zhu et al., 2013). Moreover, unique to Wikipedia is its decentralized volunteer community, functioning more as an ecosystem than a traditional organization, yet it still displays a hierarchical structure that enhances coordination effectiveness (Shaw & Hill, 2014). Then, how can we study the coordination processes and their associated costs in Wikipedia, considering Wikipedia as a noble form of organization? Is there a resemblance or common ground with traditional formal organizations such as firms?

To study coordination mechanisms in Wikipedia, we focus on the four major coordination efforts in Wikipedia including discussion, revert, authority actions, and bot enforcement. To

provide additional context, we choose the Phil Spector project page to illustrate our quantities in Fig.1. Within the edit history, a pattern of successive reversions by contributors in similar contexts becomes evident. On the associated talk pages, contributors engage in discussions on which of Phil Spector's musical achievements and the crime he committed should be highlighted. In response to these conflicts or discussion, administrators intervene and protect the project by temporarily restricting editing to mitigate ongoing conflicts and restore order. Lastly, the bots monitor and enforce established rules by detecting obvious vandalism, incorrect, references, and inappropriate reverts. Furthermore, we categorize discussion and revert into two-way coordination and categorize authority actions and bot enforcement into one-way coordination focusing on existence of the authority in the coordination processes.

First, we find how coordination mechanisms evolve in projects with the increasing size of the organizations. Here, we define the size of organizations as the number of contributors to each project. To study how coordination costs increase with the number of contributors, we use the scaling framework (West, 2018). Using the number of unique contributors on each page N, as the measure of organization size, we consider power-law scaling to take the form of $Y = Y_0 N^{\beta}$ where Y denotes the observed coordination cost, while Y_0 serves as a normalization constant. The parameter β characterizes the rate at which Y increases in response to relative changes in N, with values of β exceeding 1 indicating a faster increase and values of β below 1 indicating a slower increase compared to expected if it were linear.

This scalding factor allows us to quantify differential economy of scaling. We find different scaling relationships by classification of coordination costs proposed in our paper. *Two-way coordination*, measured by the amount of discussion and conflicts (mutual interactions), scales superlinearly with the number of contributors ($\beta > 1$), meaning mutual interactions per

contributor increase as the organization's size grows. Conversely, *one-way coordination*, measured by the activity of authorities and bots (supervision and rule enforcement), scales sublinearly ($\beta < 1$), indicating a decrease in supervision per contributor as project size increases, reflecting an economy of scale. We discovered that modules play a crucial role in explaining the emergence of economies of scale in supervision and rule-based coordination.

Second, we identify two primary axes of coordination in Wikipedia in Fig.1c with principal component analysis where arrows indicate the correlation of each coordination cost on identified principal components. All variables have positive loadings on principal component 1 (PC1, controversy axis), while principal component 2 (PC2, compensation axis) shows a trade-off mechanism of coordination: one-way coordination suppress two-way coordination, which is mainly driven by the rule enforcement by bots. Building on these observations, we measure the extent to which each project depends on impersonal coordination with alignment to the compensation axis. In Fig.1d, we show the transition from personal coordination to impersonal coordination of Wikipedia projects. In the early stage of the project, projects tend to rely more on impersonal coordination (high alignment with PC1, left-bottom in Fig 1d). However, as an organization matures, projects tend to transition towards impersonal coordination (high alignment with PC2, top-right in Fig 1d), echoing Weber's theory of organizational formalism (Weber, 1947).

In conclusion, our study offers significant insights into the dynamics of coordination within large-scale online collaborations, Wikipedia. By categorizing coordination efforts into one-way and two-way interactive types, we have uncovered notable patterns in how these coordination costs scale with system size. Particularly, the superlinear scaling of two-way coordination and the sublinear growth of one-way coordination suggest inherent organizational dynamics. Our

findings also resonate with Weber's theories on the evolution of organizations, as evidenced by the transition from initial contributor-driven interactions to more formalized oversight mechanisms. Ultimately, we hope this study contributes to a deeper understanding of organizational behavior in the digital era, offering valuable insights for both theorists and practitioners in the field of organizational studies.

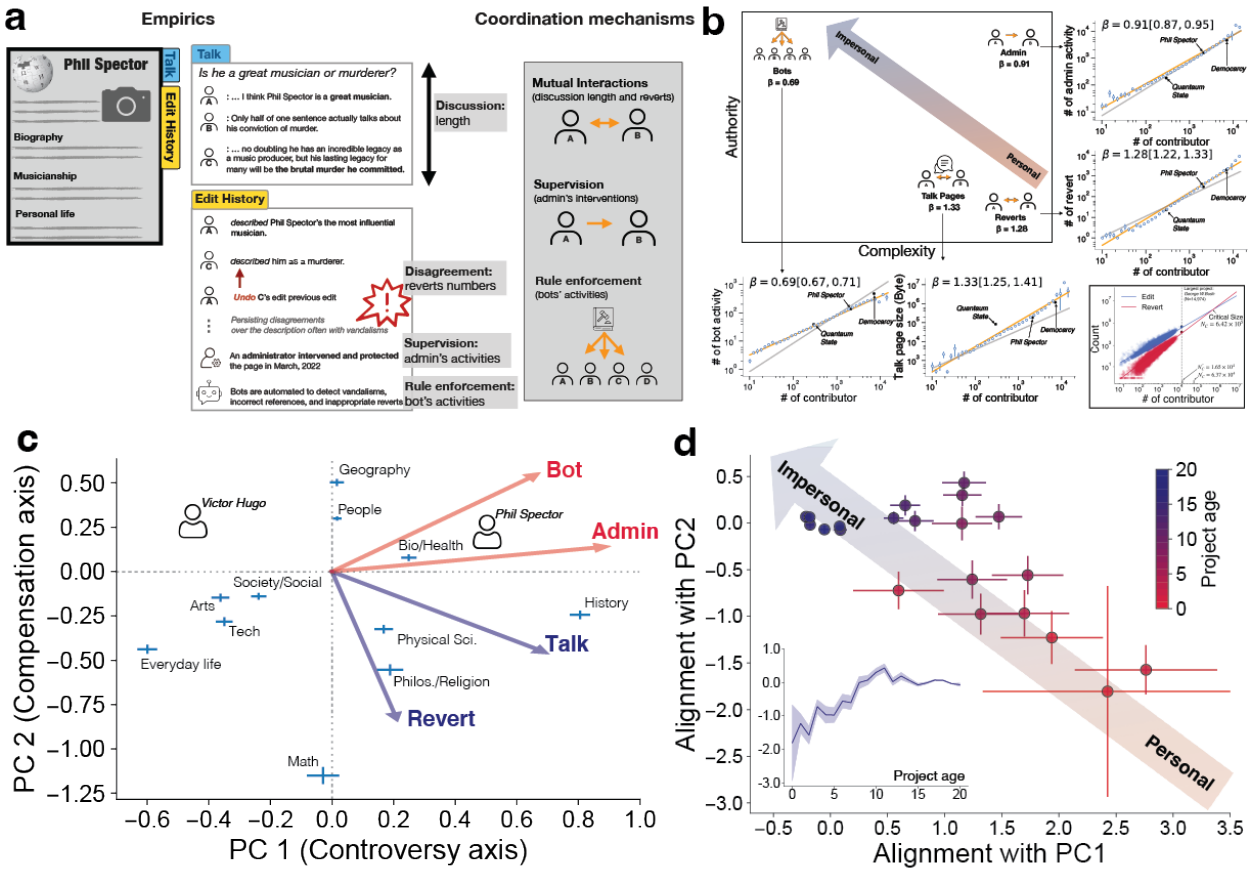


Fig 1. Coordination Mechanism in Wikipedia.

How much regulation does simple life need?

Chris Kempes, José Ignacio Arroyo, Shawn McGlynn, Riddhi Gondhalekar, Geoffrey West, Hyejin Youn, James Holehouse, and Vicky Chuqiao Yang

A major consideration for all human organizations is the question of how much history, contingency, and path dependency contribute to current structure, function, and output. A related nested question is, how far from optimal performance is an organization and how can we even measure this? Interestingly, for biological organisms, we don't have the same questions. The long history of evolution, extinction, and adaptation, coupled with huge populations of highly competitive species implies that many organismal features can be assumed to be optimal (Kempes et al., 2019). This is especially true in bacterial populations where very small improvements in costs can be eliminated by natural selection.

But what do human organizations have to learn from cells? Here we present a comparative approach for human organizations: we take seriously that organisms must deal with many of the same challenges as organizations, and we use the assumption that organisms function near optimal to discover a baseline expectation for optimal performance. More specifically, we focus on the connection between function and regulation. The smallest and simplest bacterial cells still have about 500 distinct functions, each coming from a unique gene, and these functions must be appropriately managed as the cell both undergoes routine processes and responds to diverse environmental conditions. The quantity of management or regulation can be measured in several ways: as both the number of unique regulatory genes (genes who only function is to regulate which other genes are “on" or “off") and the expression level of those regulatory genes (the number of protein copies free floating in the cell that are generated from a regulatory gene).

We take a scaling perspective, and ask how the quantity of total functions and regulatory function changes with the size of the bacterial cell (measured both as cell volume or genome size which are interrelated). We will first show that regulatory function follows consistent scaling laws across the diversity of bacterial cells (Fig. 1). We will then introduce a mathematical model for the optimal amount of regulatory function that explains these scaling relationships. We will then show that these scaling relationships breakdown at a critical size implying a transition in regulatory architecture, which we will then compare to other cell types beyond bacteria. Finally, we will show how this mathematical model is applicable to human organizations and comment of optimal management structure in human organizations.

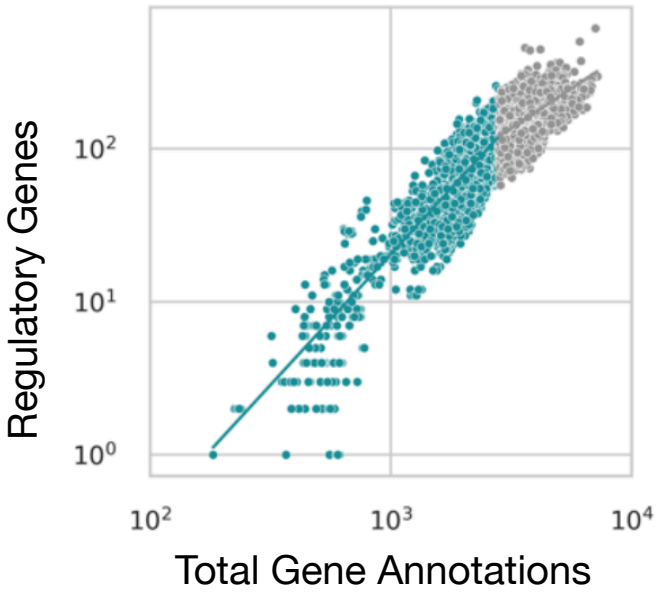


Fig. 1 The scaling of regulatory function across the range of bacterial sizes (Gondhalekar et al., 2023)

Unifying regulatory costs across complex adaptive systems

Vicky Chuqiao Yang*, Chris Kempes, Sid Redner, Geoffrey West, and Hyejin Youn

What do cells and companies have in common? Despite their apparent differences, both these systems, irrespective of their size, organizational structure, and composition, necessitate dedicated components for regulation and mediating interactions among their components. In cellular contexts, regulatory genes control the activation of other genes, while in companies, managers coordinate interactions among employees. These regulatory functions, essential across various systems, are not without significant costs. For instance, administrative spending in U.S. colleges has matched instructional spending, reaching $122.3 billion in the 2014-15 school year. Such increasing costs of regulatory functions pose crucial challenges for the 21st century, demanding an understanding of which aspects are fundamental and which can be modified through changes in structure, culture, or procedure.

We aim to provide a foundational understanding of the mechanisms underlying regulatory functions in a range of systems, comparing diverse systems from well-mixed to segregated/modular in structure. For instance, bacterial cells, characterized by a well-mixed cellular environment, face unique regulatory challenges in protein expression. In contrast, companies typically adopt hierarchical and modular structures as they grow. By comparing these systems, we develop an overarching framework for regulatory functions, contributing to a more quantitative and predictive understanding of these functions in both living organisms and human socioeconomic systems.

We define regulatory costs as the resources dedicated to the oversight and control of the functioning of other components. We collected data on regulatory genes in biological systems and the number of managers in various socioeconomic entities. Scaling analysis was used to

quantify shifts in regulatory costs with changes in entity size within each class of systems. See Fig. 1. for a summary of the scaling statistics. We observed that in biological systems, such as bacteria and unicellular eukaryotes, the number of regulatory genes scales superlinearly with the genome size. In socioeconomic systems, the scaling of regulatory functions is typically linear to sublinear and varies by system type.

Our empirical analysis shows that regulatory functions vary with system size and depend on the system's structure. Systems with centralized structures, such as companies and federal agencies, exhibit sublinear scaling in regulatory functions. In contrast, decentralized systems like bacterial genes show superlinear scaling relationships.

Regulatory functions can be proactive, creating and maintaining structures and processes, or reactive, responding to unforeseen interactions. Our findings suggest that biological systems engage more in reactive regulation, while socioeconomic systems lean towards proactive regulation. However, this does not imply that biological systems are less efficient, as creating compartmentalization in biology is costly, while in social systems, it is relatively cheaper.

We further understand how the interaction structure relates to regulatory costs by developing a mathematical model, where organisms optimize under the costs of adding regulators, creating and maintaining compartments, and dealing with adverse interactions. We derive conditions under which it makes sense to create structure and have sublinear scaling of regulators, and when it makes sense carry more regulators and avoid creating compartments.

In conclusion, our study provides a first step toward a unified understanding of regulatory functions across different systems. Future research should focus on the cost of regulatory compliance in organizations and the temporal changes in regulatory costs, especially in the face of increasing societal complexity and function diversity.

Systems	Regulatory function	Size	Exponent	95%CI	obs
Bacteria genomes	Regulatory genes	# genes in genome	1.84	[1.75, 1.95]	64
Unicellular eukaryotes genomes	Regulatory genes	# genes in genome	1.26		
Cities (US)	Police	Working population	0.97	[0.94, 0.99]	422
Federal agencies (US)	Managers	Employees	0.94	[0.90, 0.96]	121
Companies (Norway)	Managers	Employees	0.91	[0.88, 0.93]	802
All universities baccalaureate level & above (US)	Managers	Employees	0.85	[0.83, 0.88]	1344
Doctoral/research universities (US)	Managers	Employees	0.82	[0.74, 0.86]	256
Associate colleges (US)	Managers	Employees	0.81	[0.77, 0.86]	1058
Liberal arts colleges (US)	Managers	Employees	0.79	[0.70, 0.87]	215
Wikipedia articles	Administrators	Contributors	0.78	[0.77, 0.79]	
Companies (S. Korea)	Managers	Employees	0.72	[0.70, 0.78]	2759

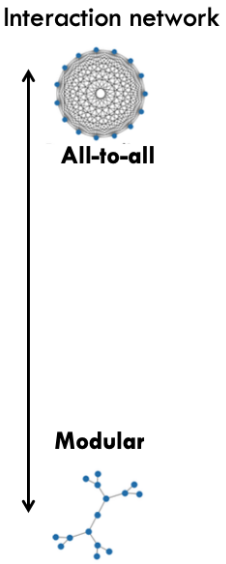


Fig. 1: Summary of the scaling exponents of regulatory functions across biological and social systems.

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