The Algorithm and the Org Chart: How Algorithms Can Conflict with Organizational Structures

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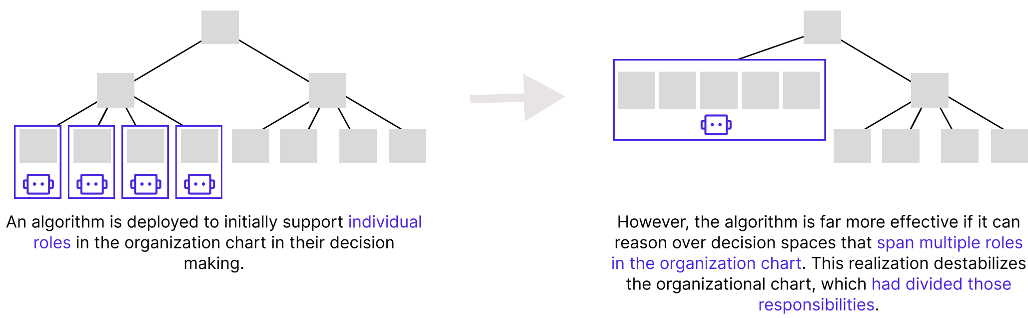

Fig. 1. A theory of the algorithm and the organization chart: while algorithms are often thought of as impacting individual workers' jobs, they can also come into tension with the core decision-making structures of an organization. This change may arise when the decision spaces that produce the best algorithmic recommendations are in tension with the human decision spaces articulated in the existing organization chart.

Algorithms are introducing changes to individuals' jobs, but do algorithms also lead to changes in the structures of organizations themselves? Organizational structures, as often formalized into organization (org) charts, are meant to facilitate coordinated decision-making. Yet our 10-month ethnographic study of a large online retail company reveals why the organizational structures that facilitate effective decision-making by humans may be in tension with the organizational structures that facilitate effective decision-making using algorithms. Our findings show that the human decision-makers needed small, divided-up sets of decisions, and they had previously accomplished this through how they structured individuals' roles and teams in the org chart. In contrast, when data scientists developed a new algorithm and first deployed it within organizational structures meant to support human decision-making, they realized that these small divided-up decision spaces were arbitrarily constraining the algorithm's search space. When not constrained in this manner, the algorithm could identify and recommend better solutions, but those optimal solutions did not always align with the structure of roles and teams in the org chart. This study suggests that as algorithms are integrated into

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ACM 2573-0142/2024/11-ART364
https://doi.org/10.1145/3686903

the workplace, organization designs may begin to more explicitly reflect the contours of those algorithms' behaviors.

CCS Concepts: • **Human-centered computing** → **Computer supported cooperative work**; **Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: algorithms, automation, planning, hierarchy, organizational structure, ethnography

ACM Reference Format:
Melissa A. Valentine, Amanda L. Pratt,, Rebecca Hinds, and Michael S. Bernstein. 2024. The Algorithm and the Org Chart: How Algorithms Can Conflict with Organizational Structures. *Proc. ACM Hum.-Comput. Interact.* 8, CSCW2, Article 364 (November 2024), 31 pages. https://doi.org/10.1145/3686903

1 Introduction

Algorithms, defined as "encoded procedures for transforming input data into a desired output, based on specified calculations" [29], are introducing profound changes to individuals' jobs, including their expertise, skills, and task boundaries, and to their managers' attempts at organizational control [e.g., 18, 26, 37, 38, 80]. The introduction of previous technologies, such as novel medical imaging modalities [5] and the global, digital communications systems [59, 72], affected individuals' roles and, in turn, changed organizational structures [3].

Given this history, could algorithms also lead to broader changes in the structures of the organization? And if so, why?

Most prior research focuses on the effects of algorithms on individual workers' decision-making: algorithms are configured to take on decisions and judgments typically considered knowledge work, or skilled work that is based on experts' critical thinking and decision-making [23]. This prior research focuses on experts making decisions within the purview of their individual jobs and has explored how and why they respond to new algorithms, given that algorithms may draw on different inputs, use different analytical processes, and sometimes produce different results and recommendations than the experts. As examples, prior studies have characterized changes to the individual decision-making of police officers, journalists, HR recruiters, radiologists, investment bankers, and retail fashion buyers [e.g., 2, 19, 22, 39, 71, 77, 78].

Yet key technology change theories predict that "transformative" technologies change more than just individual work practices within jobs – these technologies also impact broader organizational structures, including the ways that expert roles interact (i.e., their role structures) and their organizational hierarchies [3, 6, 7], both of which are central topics of interest to CSCW [e.g., 4, 8, 36, 64]. Roles, role structures, and organizational hierarchies are often codified in the organization chart, known colloquially as the "org chart." Changes to individual decision-makers' roles may easily ripple out to changing the organization chart as well. However, to date, there exists a gap in our understanding of how algorithms result in changes to broader organizational structures and, in turn, to the collaborative decision-making those structures are intended to coordinate.

In this paper, we report findings from a 10-month ethnographic study of a large online retail company where we encountered this issue. During our study, data scientists developed a novel inventory planning algorithm for the company's fashion buyers. Fashion buyers plan and purchase the large volumes of clothing inventory that a company stocks to sell to customers. The new algorithm was developed to recommend inventory plans to buyers based on historical sales data. It recommends a set of styles intended to optimize buyers' assigned performance metrics. The algorithm was configured for the individual buyers' use but quickly came into tension with the entire organization chart of the Merchandising Department.

Previously, the organization chart had coordinated the work of planning the entire inventory by dividing up decisions among product segments that aligned with organizational teams (e.g., the Plus Women's buying team, the Men's buying team) and sub-segments that aligned with roles on each team (e.g., the Plus Women's Denim buyer, the Men's Denim buyer). This style of organizing, as visualized by such organization charts, has been used in retail companies for over a hundred years and optimizes for clear management and decision-making structures. However, as the buyers began to use the algorithm to recommend inventory plans for their sub-segments, they realized several issues with dividing the inventory decisions into segments and sub-segments. Specifically, they saw that the algorithm would recommend different inventory plans depending on the decision space given to the algorithm (i.e., it would recommend a different plan if configured to recommend plans for the whole buying team vs. each individual buyer). And, the algorithm could predict which plan would be more effective on a given set of performance metrics, relative to existing inventory plan metrics. These better-performing inventory plans were possible because the algorithm could identify styles that were missed when the decisions were segmented (e.g., masculine-styled clothes for women-identified customers), could recommend complementary styles that had previously been isolated within different roles, and could recommend more flexible changes in style distributions. However, the organization chart had disallowed such inventory plans because the organization chart segmented those decisions across roles – a segmentation that the organization began to reflect on and evolve in response to the algorithm's results.

Our findings analyze these tensions to contribute to a theory of algorithms and the organization chart: we show that the decision spaces which produce the best algorithmic recommendations may be in tension with the human decision spaces outlined in organization charts. This tension occurs because their objectives differ: an organization chart is designed to support human decision-making given humans' limited information processing and coordination capacities, whereas an algorithm is designed to maximize its objective regardless of those information processing and coordination needs – for better or for worse. Though we study the Merchandising Department of a retail company, this finding may extend to other companies where organization charts repeatedly divide targets and subsequent decision-making into human-sized decision spaces, including segmenting engineering departments around product lines, sales departments around geographies, and client services around industry targets. We suggest that there are two possible high-level outcomes from these tensions. One, detailed in prior work [11, 39, 40], involves workers undercutting, delegitimizing, or otherwise minimizing the impact of the algorithm in order to maintain the existing order. The other approach, as suggested by our ethnography, involves changing the organization chart to accommodate the algorithm's decision space: an integration of both algorithmic and human information processing.

2 Related Work

In this section, we motivate why algorithms may come into tension with organizational structures by linking literatures on algorithms' impacts on individual decision-making, coordinated decision-making, and organizational structures.

2.1 Algorithms: Tools for Individual Decision-Making

Most studies of algorithms in the workplace have focused on the impact of algorithms on an individual's decision-making processes, or, at most, the processes of small teams. The primary thrust of much of this literature is to understand how humans and algorithms can best work together. Topics cover how advice generated by algorithms affects decision-making [e.g., 17, 27, 30], how the presence of algorithmic-agents affects perceptions of team attributes [e.g., 21, 49, 62, 63], what and how information provided to human decision-makers changes algorithm-supported decisions [e.g., 15, 34], and techniques for enabling algorithm-supported decision-makers to overcome barriers to superior human-algorithm performance [e.g., 14, 35, 48], such as aversion, overreliance [e.g., 13, 16, 75], and anchoring [e.g., 58].

Findings around how humans and algorithms best work together highlight mechanisms that decision-makers' use to simplify decision-making and thus accommodate humans' limited processing capacities [65]. For example, Cai et al. [15] explore how medical experts' existing mental models created specific information needs within individual decision-makers when being trained to use clinical decision-support tools. With respect to overcoming decision-makers' overreliance, aversion, and anchoring, theorists often focus on the cognitive shortcuts which may underlie these behaviors. Rastogi et al. hypothesize that decision-makers anchor on the output of algorithms as a rational choice between time and accuracy and show that, in fact, increased cognitive resources in the form of more decision-making time does result in less anchoring [58]. Buçinca et al. [13] hypothesized that decision-makers over-rely on algorithms because decision-makers form heuristics about an algorithm's performance overall, rather than engaging with each prediction from the algorithm. Buçinca et al. go on to show that forcing functions, meant to disrupt heuristics-based thinking, do reduce overreliance [13]. Vasconcelos et al. [75] also show how human overreliance on algorithms is a result of rational decision-making under conditions of limited cognitive capacity or satisficing and that humans are less likely to over-rely on AI when the cost of checking the AI's output is low and the reward is high.

Organizations and their structures are also mechanisms that support decision-making by reducing information processing requirements and thus, the cost of making decisions [67]. And as such, organizations are also likely to be impacted by changes in algorithm use, given changes in decision-making at the individual level [e.g., 76]. But to date, organizations enter the literature on algorithms largely as mechanisms that constrain the development or use of algorithmic decision-making [e.g., 25, 52, 57]. For example, Rakova et al. [57] found that organizational contexts constrained the success of responsible AI initiatives.

However, little research directly studies how algorithms are impacting role structures and organizational hierarchies more generally, even though theories of technology change predict such effects are likely to unfold [7]. Surprisingly, this lack of research is not limited to the CSCW literatures, but extends into the domains of Organization Theory and Management of Information Systems.[1] The lack of research may reflect the moment in time: typically individual work practices change before changes in role structures and organizational networks emerge [7, Figure 2.1]. Individuals' practices are often slow to evolve, relative to formal mandates to change, and changes to role structures and organizational hierarchies may occur even more slowly, after the close of many ethnographies, or may only be emerging within organizations more recently. The goal of this paper is to initiate development of this needed understanding. Because of its focus on the structure of organizations and use of organization charts, we draw on organizational theory as a useful explanatory literature to explore how algorithms may be informing such changes. We start with a review of how organization charts are used to structure coordinated decision-making among large groups of employees.

2.2 The Organization Chart: Organizations and Coordinated Decision-Making

According to organizational theorists, organizations are infrastructures for helping large groups process information and coordinate decision-making. Organization charts, as the visualization of this infrastructure, facilitate this function by dividing up large sets of decisions into human

[1]Based on a literature review conducted during June 2023 of top Management/Organization Theory journals (Administrative Science Quarterly, Organization Science, Management Science, Academy of Management Journal, and Academy of Management Annals) and Information Systems journals (MIS Quarterly and Information Systems Research)

manageable and interpretable domains (i.e., roles or jobs) and nesting them into organizational hierarchies that help coordinate across those domains [e.g., 4, 36, 64, 67]. Organizational structures facilitate coordinated decision-making among the large number of employees who comprise an organization in at least three ways.

First, organizational structures provide the blueprint by which decisions get divided into human-manageable quantities. These divisions are necessary because of the "bounded rationality of both humans and computers" [67, pgs. 240-241]. From an information processing perspective, an organizational hierarchy can be conceptualized as a series of "boxes-within-boxes" [68, p. 128] which factorizes decisions into sub-decisions. The most granular boxes in this decision hierarchy contain a number and size of decisions "reduced to manageable proportions" [67, p. 241]. The decisions in these boxes – along with related tasks – define a job or role within the organization that is achievable by a single human [9, 31, 43, 67]. According to functionalist theories of organizational design, the way that these roles are grouped within the organization hierarchy – both horizontally in teams and vertically in layers – informs and is informed by the level of coordination necessary between roles and signals appropriate lines of accountability [28, 31, 43, 66, 67, 70, 79].

Second, organizational structures provide contextual information that guides human decision-making and reduces the number of alternatives a decision-maker considers. Specifically, the social context of any role defines a "decision premise" that guides appropriate actions of the role [65, p. 201]. "Roles tell organization members how to reason about the problems and decisions that face them: where to look for appropriate and legitimate informational premises and goal (evaluative) premises, and what techniques to use in processing these premises" [66, pgs. 126-127]. In this way, organizational structures provide a certain environmental context for individuals, reducing the alternatives individuals consider in their decision-making and decreasing the information processing necessary when enacting a role.

Finally, organizational structures outline repeated patterns of activity between and among group members. According to Galbraith, "the ability of an organization to coordinate interdependent tasks depends on its ability to compute meaningful subgoals to guide subunit action" [28, p. 29]. Mintzberg argues that the definitions, decision-premises, delineations, organizational position, and coordinating mechanisms of and between roles, all of which are necessary to compute such goals, change relatively infrequently [45, p. 86] and become "givens" [43, 67]. These "givens" are patterns of activity inside organizations. Because of these patterns of activity, planners may consider fewer alternatives during their planning activities, effectively reducing the information processing required to compute subunit goals.

2.3 The Potential Implications of Algorithms for Organization Charts

Theories of organizational structures, as discussed in the previous section, highlight that, historically, organizational structures have been defined by individual human information processing capacity (based on individuals' existing technology use). With increased information processing capacity, the decision domain of individual jobs may shift and impact organizational structures.

In general, scholars have predicted and found that changes in information processing and communications technology do change organizational structures, paying particular attention to effects on decentralization [e.g., 1, 10, 46, 47, 56, 81]. The evolution of digital communications and technologies also enables novel organizational structures, such as flash teams and flash organizations – temporary crowdsourced organizations complete with roles and hierarchies [59, 72]. Some theorists have predicted that current technological trends, in particular algorithms, are likely to impact decision-making and lead to changes in organizational structures [e.g., 76]. Yet researchers have not yet explored how these changes unfold or how the resulting tensions might be resolved. Moreover, little attention has been paid to how the current technological trends of "Big Data" and