Examining Crowd Work Through The Historical Lens of Piecework

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ABSTRACT

The Internet is enabling the rise of crowd work, gig work, and other forms of on–demand labor. A large and growing body of scholarship has attempted to predict the socio–technical outcomes of this shift, especially along three threads: 1) What are the complexity limits of crowd work? 2) How far can work be decomposed into smaller microtasks? and 3) What will work and the place of work look like for workers? In this paper, we look to the historical scholarship on piecework — a similar trend of work decomposition, distribution, and payment that was popular at the turn of the 20th century — to understand how these questions might play out with modern crowd work. To do so, we identify the mechanisms that enabled and limited piecework historically, and identify whether crowd work faces the same pitfalls or might differentiate itself. This approach introduces theoretical grounding that can help address some of the most pernicious questions in crowd work, and suggests design interventions that learn from history rather than repeat it.

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INTRODUCTION

The past decade has seen a flourishing of *on–demand work*, largely driven by the reformulation of work as the constituent parts of larger tasks. This framing of work into de–contextualized, modular blocks enables computation to hire workers at scale through open calls on the Internet [63, 15, 78]. Distributed paid participants then engage in the work whenever their schedules allow, with little to no awareness of the broader context of the work, and with (often) fleeting identities and associations [100, 91]. In this paper, we use the term on–demand work to join a pair of related phenomena: 1) *crowd work*, on platforms such as Amazon Mechanical Turk (AMT) and other sites of (predominantly) information work; and 2) *gig work*, typically involving platforms for one–off jobs, like driving, courier services, or administrative support. The realization that complex tasks can be accomplished by directing and managing these crowds of workers spurred industry to flock to sites of labor like AMT and Uber to explore the limits of this distributed, on–demand workforce. Researchers have also taken to the space in earnest, developing systems and designs that enable new forms of production (e.g., [12, 16, 114]).

As on–demand work has grown far beyond the domain of information work from which it first sprang, it has given rise to an increasingly complicated and conflicted culture amongst both the workers who enable it and the researchers who empower it. Originally, Howe described crowdsourcing in general terms as "outsourcing [work] to an undefined, generally large group of people in the form of an open call". However, for years its instantiation was limited to the utilization of human intelligence to process data, participate in scientific studies, and perform information work [76, 154, 161, 47, 115]. More recently, crowdsourcing of physically embodied work — driving and cleaning, for instance — has become a focus for on–demand labor markets [91, 141, 62, 137]. This growth prompted increasing efforts to understand the workers who gravitate toward these platforms [122, 131]. Some of this research has been motivated by the identification of the sociality of gig work, and the frustration and disenfranchisement that these systems embody [67, 100, 102]. Other work has focused on the *outcomes* of this frustration, reflecting on the resistance workers express against digitally mediated labor markets [91, 126].

This body of research has sought to answer one central question: What does the future hold for on–demand work and those that do it? Researchers have offered their input on this open question along three major threads:

1. What are the complexity limits of crowd work? Specifically, (a) How complex are the goals that crowd work can accomplish?, and (b) What kinds of goals and industries may eventually utilize it? [117, 135, 73, 160, 158, 107, 54];
2. How far can work be decomposed into smaller microtasks? [79, 12, 25, 96, 80, 89, 22, 27, 108]; and
3. What will work and the place of work look like for workers? [67, 66, 126, 50, 19, 102]

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This research literature has largely sought to answer these questions by examining the present phenomenon. So far, it has not offered a framing for holistically explaining the developments in worker processes that researchers have developed, or the emergent phenomena in social environments; nor has any research, to our knowledge, gone as far as predict future developments.

Piecework as a lens to understand crowdsourcing

In this paper, we offer a framing for on–demand work as a contemporary instantiation of *piecework*: a work and payment structure which breaks tasks down into standalone contracts, wherein payment is made for *work output*, rather than for *time*. Piecework as a metaphor for crowd work is not new. Indeed, Kittur et al. in 2013 referenced crowd work as "piecework" briefly as a loose analogy to the form of work emerging at the time [78]. But more than this, the framing of on–demand labor as a re–instantiation of piecework gives us years of historical material to make sense of the broader research on this new form of work, and allows us to reflect on–demand work through a mature theoretical lens, informed by decades of rigorous, empirically based research.

More concretely, by looking at on–demand work as an instantiation (or even a continuation) of piecework, and by looking for patterns of behavior that the corresponding literature predicts on this basis, we can 1) make sense of the phenomena so far as part of a much larger series of interrelated events; 2) reflect on similarities in the ongoing work among workers, system–designers, and researchers in this space; and finally, 3) to the extent that history repeats itself, offer predictions of what on–demand work researchers, and workers themselves, should expect to see on the horizon. For example, we will draw on the piecework literature such as case studies of the Santa Fe Railway to understand the historical complexity limits in piecework, and leverage that understanding to suggest which modern complexity limits in crowd work [78] may be fundamental and which may be overcome.

We organize this paper as follows: we first review the literature on piecework to lay groundwork and make clear the analogy to on–demand work. Then, we interrogate the three major research questions above from a piecework frame. We will identify similarities and differences between piecework as historically understood and on–demand work as we experience it today. Finally, we will make predictions of future developments based on how those similarities and differences influenced piecework. Finally, we will offer design implications for researchers and practitioners based on our results.

A REVIEW OF PIECEWORK

The HCI community has used the term "piecework" to describe myriad instantiations of on–demand labor, but this reference has generally been offered in passing. As this paper principally traces a relationship between the historical piecework and the contemporary crowd work (or on–demand labor more generally), this casual familiarity with piecework may prove insufficient. We'll more carefully discuss piecework in this section in order to inform the the rest of the argument. Specifically, we will 1) define "piecework" as researchers in the topic understood it; 2) trace the rise of piecework at a very high level, identifying key figures and ideas during this time; and finally 3) look at the fall of piecework, such as it was, considering in particular the factors that may have led to piecework's eventual demise in the American and European labor markets.

What is piecework?

Aligning on–demand work with piecework requires an understanding of what piecework is. While "piecework" has had multiple definitions over time, we can trace a constellation of characteristics that recur throughout the literature. We will follow this history of research, collecting descriptions, examples, and provided definitions of piecework, trying to trace the outline of a working understanding of *what piecework is*.

Raynbird offers a concise definition of piecework — which he variously also calls "measure work", "grate work", and "task work" — by contrasting the "task–labourer" with the "day–labourer": "…the chief difference lies between the day–labourer, who receives a certain some of money… for his day's work, and the task–labourer, whose earnings depend on the *quantity* of work done [emphasis added]" [116]. Chadwick gives a more illustrative definition of piecework, offering examples: "… payment is made for each hectare which is pronounced to be well ploughed … for each living foal got from a mare; … for each living calf got … " etc…[26]. This framing perhaps makes the most intuitive sense; "payment for results", as Chadwick calls it, is not only common in practice, but well–studied in labor economics as well [43, 146, 147, 59].

It's worth acknowledging that "this distinction [between piece–rates and time–rates] was not completely clear–cut" [56]. Indeed, we see work that adopts piece–rate compensation in some aspects and time–rate compensation in others. The "Rowan premium system", which essentially paid workers a base rate for time plus (the potential for) an additional pay dependent on output, was just one of several alternatives to stricter time– and piece–rate renumeration paradigms, which muddies the waters for us later as we attempt to categorize cases of piecework [123]. As Rowan's premium system guaranteed an hourly rate regardless of the worker's productive output *as well as* an additional compensation tied to performance, workers under this regime were in some senses "task–labourers", and in other senses (more conventional) "day–labourers".

It may be worth thinking about piecework through the lens of its *emergent* properties to help understand it. Returning to Raynbird, several arguments for the merits of piecework crop up; he points out that…"piece work holds out to the labourer an increase of wages as a reward for his skill and exertion…he knows that all depends on his own diligence and perseverance… [and] so long as he performs his work to the satisfaction of his master, he is not under that control to which the day–labourer is always subject." Raynbird (and others, as we will see) highlight the freedom from control that "task–labourers" enjoy [116, 123].

We see this sense of independence regardless of the time, locale, and industry. Satre offers a look into the lives and culture of "match girls" — young women paid by piecework to assemble matchsticks generally in the late 19th century. Of particular interest was their independent nature, via their reputation "… for generosity, independence, and protectiveness, but also for brashness, irregularity, low morality, and little education" [127]. J. Hagan documents piecework from 1850–1930 in Australia, finding similar assertions of the freedom compositors of newspapers experienced as pieceworkers: "If a piece–work compositor who held a 'frame' decided that he did not want to work on a particular day or night, the management recognised his right to put a 'substitute' or 'grass' compositor in his place" [68]. From these accounts we should be able to identify a sense of independence that resonates across decades, industries, and locales where piecework is found. We'll problematize this supposed advantage as we trace the history of piecework, but for now we can say that piecework affords independence and some sense of autonomy new to people in the working class.

Hart and Roberts offer another series of compelling insights toward the question of the features that sprout from piecework. In their reflection on the features endemic to piecework in the 1930s, which they describe as the "heyday" of piecework's prominence; among them were the following: 1) "female workers who generally had less training" had to be trained in narrower subsets of the general body of skills that conventional (male) apprentices would undertake, and 2) workers with specific slices of skills could be more appropriately matched to suitable tasks [56]. Piecework thus opened the door for people who previously couldn't participate in the labor market — either for lack of training or for other reasons — to do so, and to acquire job skills incrementally. Workers without conventional training — like women, who had no such opportunities to engage in engineering and metalworking apprenticeships as men did — could be trained very narrowly on a very tightly constrained task, demonstrate proficiency, and become experts in their own ways.

In summary, piecework:

1. paid workers for quantity of work done, rather than time done, but occasionally mixed the two payment models;
2. afforded workers freedom in when and how much to work; and
3. structured tasks such that people who didn't have the training to engage in the traditional labor force could still participate.

A Primer of Piecework

In this section we will offer a brief overview of the history of piecework; this should not be mistaken for a comprehensive or especially rigorous background. Instead, this section will attempt to provide a sense of orientation when thinking about piecework. In other words, framing piecework in the contexts of the early days of the industrial revolution, through the political and economic turmoil of the early and mid–20th century, and into the 21st century. While the previous section provided a *definition* of piecework, this section attempts to shine a light on the *zeitgeist* of piecework.

Piecework's history traces back further perhaps than most would expect. Grier describes the process astronomers adopted of hiring young boys to calculate equations in order to better–predict the trajectories of various celestial bodies in the 19th century [51]. George Airy was perhaps the first to rigorously apply piecework–style decomposition of tasks to work; by breaking complex calculations into constituent parts, and training young men to solve simple algebraic problems, Airy could distribute work to many more people than could otherwise complete the full calculations.

Piecework may have started in the intellectual domain of astronomical calculations and projections, but it found its foothold in manual labor. Piecework took off on in farm work [116], in textiles [10, 119], on railroads [20], and elsewhere in manufacturing [127]. This proliferation of manual piecework led to discussion surrounding how best to manage these workers [110, 34], which seemed to lead to frustration among workers over their poor working and living conditions (famously documented by Riis) [119]. This led to industry organizations representing railway workers, mechanical engineers, and others contributing their myriad perspectives [82, 118].

Fordism and scientific management thrust piecework into higher gear, especially as mass manufacturing and a depleted wartime workforce forced industry to find new ways to eke out more production capacity. Hart and Roberts point out that the Second World War, which called millions of Americans to military service, necessitated the rapid training and employment of a labor pool that hadn't historically been utilized in industrial labor: women [56].

Piecework's popularity in the United States and Europe plummeted almost as quickly as it had climbed. Hart and Roberts's work substantively explores the precipitous decline of piecework in the last third of the 20th century. In their work, Hart and Roberts offer a number of explanations for the sudden vanishing of piecework. The salient suggestions include: 1) the emergence of more effective, more nuanced incentive models — rewarding teams for complex achievements, for instance; 2) the shifting of these industries (manufacturing, clothing, etc…) to other countries; and 3) the quality of "multidimensional" work becoming too difficult to evaluate [56].

Why is piecework relevant to crowd work?

Using the definition of piecework that we came up with earlier, we argue that crowd work is fundamentally an instantiation of piecework, and that we can more precisely anticipate the answers to the open research questions we discussed earlier. We'll show that the dimensions of crowd work that the broader HCI community has been studying align with the history of piecework, and that this can greatly inform predictions about the future of crowd work.

From piecework to on–demand work

Crowd work and gig work are fundamentally an instantion of piecework. First, workers on platforms such as Mechanical Turk and Uber are generally incentivized by unit of work, even if some may be offered an hourly base salary as well. Second, workers are attracted to these platforms by the freedom they offer to pick the time and place of work [100, 19]. Third, system developers as on Mechanical Turk typically assume no professional skills in transcription or other areas, and attempt to build that expertise into the workflow [109, 12].

Given this alignment, many of the same properties of piecework historically will apply to on–demand work as well. In the next section, we perform this application to three of the major questions in crowd work and gig work, identifying similarities and differences between historical piecework and modern on–demand work.

RESEARCH QUESTIONS

We look at lots of papers that use the term "crowdsourcing" or "crowd work" in the abstracts and titles of their papers, especially the papers that we cited earlier, to try to answer the questions that we posed in the introduction. Then we look to the piecework literature to see whether and to what extent piecework answers the questions we, crowdsourcing researchers, have asked. We then see whether and how crowdsourcing as we know it has differed from piecework, and how that affects the predictions and conclusions made in the piecework literature.

Research in crowdsourcing has spent the better part of a decade exploring how to grow the limits of crowdsourcing and find the boundaries of crowd work and microtasks. This has largely involved identifying challenges to this form of labor, overcoming them through novel designs of work–flows and processes, and repeating the process [e.g. 12, 117, 77]. The question that has emerged among these researchers and through the work that they have produced then has been driving at *whether* there are limits to crowdsourcing (and, if so, what factors determine those limits). Through this lens, we can point to a number of contributions to the field that have extended the boundaries of crowd work.

The exploration of crowdsourcing's potential and limits has principally looked at manipulating and extending along three dimensions: 1) What are the complexity limits of crowd work, 2) How far can work be decomposed into smaller microtasks, and 3) What will work and the place of work look like for workers. We'll explore these aspects of crowdsourcing, discussing the extents to which work can be decomposed, contextually abstracted, and made more resilient to attrition of various forms. We'll also point to corresponding piecework literature addressing these aspects. Finally, we'll discuss how these elements will serve to constrain the upper and lower bounds of crowdsourcing as it relates to the question of the furthest limits of crowdsourcing.

Identifying the Complexity Limits of Crowd Work

A key question to the future of crowd work is *what* precisely will become part of this economy. Paid crowdsourcing began with simple microtasks on platforms such as Amazon Mechanical Turk, but microtasks are only helpful if they build up to a larger whole. So, our first question: how complex can the work outcomes from crowd work be?

Crowd work's perspective

Crowdsourcing research has spent the better part of a decade proving the viability of crowdsourcing in complex work. Unless crowdsourcing can demonstrate viability for meaningfully complex tasks, the argument runs, it will be incapable of ensuring a pro–social outcome for work and workers [78]. Kittur et al. first opened the question of whether crowdsourcing could be used for goals that are not simple parallel tasks [77]. Their work demonstrated proof–of–concept crowdsourcing of a simple encyclopedia article and news summary — tasks which could be verified or repeated with reasonable expectations of similar outcomes. Seeking to raise the complexity ceiling [106], researchers have since created additional proof–of–concept applications and techniques, including conversational assistants [84], medical data interpreters [84], and idea generation [158, 156, 157], to name a few examples.

To achieve complex work, this body of research has often applied ideas from Computer Science to design new crowdsourcing workflows. Beginning with a goal that has presented significant challenges for computers, the researcher leverages an insight from Computer Science (for example, MapReduce [77] or sequence alignment algorithms [83]) and arranges humans as computational black boxes within those approaches. This approach has proven a compelling one because it leverages the in–built advantages of scale, automation, and programmability that software affords.

It is now clear that this approach works with focused complex tasks, but the broader wicked problem that each complex goal represents remains unsolved [120]. As a first example, idea generation shows promise [158, 156, 157], but there is as yet no general crowdsourced solution for the broader goal of invention and innovation [45]. Second, focused writing tasks are now feasible [74, 12, 107, 138, 2], but there is no general solution to create a cross-domain, high–quality crowd–powered author. Third, data analysis tasks such as clustering [32], categorization [7], and outlining [95] are possible, but there is no general solution for sensemaking. It is not yet clear what insights would be required to enable crowdsourced solutions for these broader wicked problems.

Restricting attention to non–expert, microtask workers proved limiting. So, Retelny et al. introduced the idea of crowdsourcing with online paid *experts* from platforms such as Upwork. Expert crowdsourcing enables access to a much broader set of workers, for example designers and programmers. The same ideas can then be applied to expert "macro-tasks" [31, 53], enabling the crowdsourcing of goals such as user–centered design [117], programming [88, 42, 28], and mentorship [135]. However, there remains the open question of how complex the work outcomes from expert crowds can be.

Piecework's perspective

Grier gives early accounts of a piecework strategy in Airy's creation of the British Nautical Almanac [51]. Airy's goal was complex — mathematical calculations to produce tables that would allow sailors to locate themselves by starlight from sea. Many of his contributors did not have high–level mathematical training, so Airy broke down the task into simpler calculations and distributed them by mail, accomplishing the complex goal through piecework tasks that paid little.

However, when piecework entered the American economy, it was not used for complex work. One reason for low complexity was workers' skills: it was infeasible to provide new pieceworkers with the comprehensive education that apprenticeships imparted [56]. So, initially piecework arose for farm work, and as Raynbird and others discuss, the practice remained relatively obscure until it blossomed in the textile industry [116]. Complexity levels remained low at the turn of the 20th century as piecework saturated New York City [119]. However, writers of the time focused their attention on wage [21] and management regimes [110] rather than training.

Measurement also limited the complexity of piecework: only tasks that could be measured and priced could be completed via piecework. When Brown investigated what limited the adoption of piecework in industries that otherwise gravitated toward it (e.g., railway engineers), the homogeneity of tasks arose as a major contributing factor [20]. Graves concurs via a case study of the Santa Fe Railway, which used "efficiency experts" to develop a "standard time" to determine pay for each task at the company informed by "thousands of individual operations" [48]. One might conclude from Graves's observations that complex, creative work — which is inherently heterogeneous and difficult to routinize — would be unsuitable for piecework.

Piecework was limited to tasks that could be clearly evaluated. For example, the roles required to facilitate piecework in the early 20th century included "piecework clerks, inspectors, and 'experts"' [48]. Hart argues that evaluation causes an ultimate complexity limit: at some point, evaluating multidimensional work for quality (rather than for quantity) becomes infeasible. In his words, "if the quality of the output is more difficult to measure than the quantity [. . .] then a piecework system is likely to encourage an over–emphasis on quantity produced and an under-emphasis on quality" [57]. Complex work, which is often subjective to evaluate, falls victim to this criteria.

This focus on measurement and tracking had consequences. Graves suggests that the first sparks of scientific management could be found in piecework: the approach of paying workers for each piece of output necessitated the rigorous tracking, measurement, and training of workers for which scientific management became famous [48]. If true, the concurrent upswing of scientific management and Fordism through the first two–thirds of the 20th century alongside piecework was not only understandable, but predictable [56].

Piecework researchers also argue that, in addition to constraints on the kind of *work* that's amenable to piecework, only certain kinds of *organizations* were amenable to piecework. Researchers detail three organizational criteria. First, Brown argues that piecework "is less likely in jobs with a variety of duties than in jobs with a narrow set of routinized duties" [20]. Agell points out the phenomenon here as a market effect: "in an environment with multi–tasking, pay schemes based on tightly specified performance may induce workers to neglect tasks that are less easy to measure" [3]. Second, complexity was limited by access to capital to create the necessary infrastructure. As Graves reports, only the largest and most wealthy railroads had the resources necessary [48]. Third, organizations required capable managers in charge of the pieceworkers. The West Virginia mines, for example, hired foremen to be the intermediary between upper management and the workers [17]. These foremen were responsible for allocating resources and understanding when and how to modify work as necessary [153]. So, in sum, organizations historically could only take advantage of piecework if they had homogeneous work to be done, access to capital to purchase the necessary equipment, and the ability to hire people who could serve as intermediaries between pieceworkers and management.

The research seems to suggest that it was difficult to apply piecework to more skilled work, particularly because maximizing the advantages of piecework seemed to reward smaller, more constrained, more narrowly-trained tasks, and only in organizations that could pay for the equipment and people to enable it. For most of the 19th century, piecework was applied almost exclusively to farm and textile work. Work was simple and widely understood — farm workers didn't need to be trained on how to plow fields, or birth foals; seamstresses knew how to sew together denim [26, 119].

Comparing the phenomena

The research on piecework tells us that we should expect piecework to thrive in industries where the nature of the work is limited in complexity [20]. Given the flourishing of on–demand labor platforms such as Uber, AMT, and others, we ask ourselves what — if anything — has changed. We argue that the Internet has trivialized the costs and challenges of the earlier limiting factors because technology makes it easier 1) for workers to do complex work without training, 2) to manage workers in doing complex work, and 3) to create the infrastructure necessary to manage the workers.

Technology increases non–experts' levels of expertise by giving access to information that would otherwise be unavailable. For example, taxi drivers in London endure rigorous training to pass a test known as "The Knowledge" — a demonstration of the driver's comprehensive familiarity with the city's roads. This test is so challenging that veteran drivers exhibit significantly larger the regions of the brain associated with spatial functions such as navigation [98, 97, 133, 134, 152, 151]. In contrast, with on–demand platforms such as Uber, services such as Google Maps & Waze make it possible for people entirely unfamiliar with a city to operate profesionally [132, 60]. Other examples include search engines enabling information retrieval, and word processors enabling spelling and grammar checking. By augmentating the human intellect [41], computing has shifted the complexity of work that is possible without training.

Algorithms have automated some tasks that previously fell to management. Computational systems hire workers [94, 148], as well as direct their activities [91], and act as "piecework clerks" [48] to inspect, modify and combine work [67, 102]. In many cases, the intermediary function has been removed as well, leading workers to need to directly email requesters for clarification and feedback [100]. These algorithms, however, are less able than human managers to manage contingencies that were not programmed into them.

Finally, the organizational limit on infrastructure creation is somewhat lessened. Writing web scripts takes fewer people and fewer hours than creating physical equipment for piecework. Little et al.'s vision was that any user with basic programming skills could tap into on–demand human intelligence. As better toolkits lower this threshold [106] and computational thinking diffuses, a broader population will be able to use crowd work.

Implications for crowd work

Technology's ability to support human cognition will enable stronger assumptions about workers' abilities, increasing the complexity of crowd work outcomes. Just as the shift to expert crowdsourcing increased complexity, so too will workers with better tools increase the set of tasks possible. Beyond this, further improvements would most likely come from replicating the success of narrowly-slicing education for expert work as Hart and Roberts and Grier described in their piecework examples of human computation [51] and drastically reformulating macro–tasks given the constraints of piecework [56]. To some extent, an argument can be made that MOOCs and other online education resources provide crowd workers with the resources that they need, but it remains to be seen whether that work will be appropriately valued, let alone properly interpreted by task solicitors [4]. If we can overcome this obstacle, we might be able to empower more crowd workers to do complex work such as engineering and metalworking, rather than doom them to "uneducated" match girl reputations [127]. However, many such experts are already available on platforms such as Upwork, so training may not directly increase the complexity accessible to crowd work unless it makes common expertise more broadly available.

Will the shift from human managers to Turing-complete algorithms raise the complexity ceiling? By the Turing test, the algorithms would be at best indistinguishable from human piecework clerks and foremen. So in terms of enabling coordination, algorithmic management is unlikely to directly raise the ceiling beyond what piecework could achieve. However, as a resource constraint, algorithms are a fixed cost and not a per-person cost like human managers. So in terms of accessibility, algorithms will allow a broader class of organizations and individuals to afford crowd work. This shift may enable complex goals that were not cost-effective before to become feasible. However, because algorithms remain far from replicating all of the foremen's responsibilities, most likely is a middle ground in which crowd work re-introduces the human element to management in a more targeted way (e.g., [53, 81, 150]). This move will require resolving the tension between workers and perilously antagonistic managers, as Boal and Pencavel suggest, to break a toxic cycle of mistrustful requesters [46].

Finally, the cost of creating piecework infrastructure has dropped. Expensive manufacturing equipment has been largely replaced by computer code [92]. As with lowered costs of management, lowered infrastructure costs will make crowd work accessible to a broader set of people and organizations. This in and of itself does not raise the complexity ceiling, but by broadening the potential market for crowd work, it may enable a new set of goals and needs take part.

Decomposing Work

At its core, on–demand work has been enabled by decomposition of large goals into many small tasks. As such, one of the central questions in the literature is how to design these microtasks, and which kinds of tasks are amenable to decomposition. In this section, we place these questions in the context of piecework's Tayloristic evolution.

Crowd work's perspective

Many contributions to the design and engineering of crowd work consist of creative methods for decomposing goals. Even when tasks such as writing and editing cannot be reliably performed by individual workers, researchers demonstrated that decompositions of these tasks into workflows can succeed [77, 12, 138, 107]. These decompositions typically take the form of workflows, which are algorithmic sequences of tasks that manage interdependencies [15]. Workflows often utilize a first sequence of tasks to identify an area of focus (e.g., a paragraph topic [77], an error [12], or a concept [157, 159] and a second sequence of tasks to execute work on that area. This decomposition style has been successfully applied across many areas, including food labeling [109], brainstorming [130, 156], and accessibility [85, 83, 86].

If decomposition is key to success in crowd work, the question arises: what can, and can't, be decomposed? Moreover, how thinly can work be sliced and subdivided into smaller and smaller tasks? The general trend has been that smaller is better, and the microtask paradigm has emerged as the overwhelming favorite [139, 140]. This work illustrates a broader sentiment in both the study and practice of crowd work, that microtasks should be designed resiliently against the variability of workers, preventing a single errant submission from impacting the agenda of the work as a whole [65, 87, 142]. In this sense, finer decompositions are seen as more robust — both to interruptions and errors [31] — even if they incur a fixed time cost. At the extreme, recent work has attempted demonstrated microtasks that take seconds [143, 23] or even tenths of a second [79]. However, workers perform better when similar tasks are strung together [87], or chained and arranged to maximize the attention threshold of workers [22]. Despite this, we as a community have leaned *into* the peril of low–context work, "embracing error" in crowdsourcing [79].

The general lesson has been that the more micro the task, and the more fine the decomposition, the greater the risk that workers lose context necessary to perform the work well. For example, workers edit adjacent paragraphs in inconsistent ways [12, 74], interpret tasks in different ways [70], and exhibit lower motivation [75] without sufficient context. Research has sought to ameliorate this issue by designing workflows help workers "act with global understanding when each contributor only has access to local views" [144], typically by automatically or manually generating higher-level representations for the workers to reflect on [32, 144, 74].

As the additional context necessary to complete a task diminishes, the invisible labor of *finding* tasks [100] has arisen as a major issue. Chilton et al. illustrate the task search challenges on AMT.Workers seek out good requesters [100] and then "streak" to perform many tasks of that same type [33].

Researchers have reacted by designing task recommendation systems (e.g., [35]) and others focused on minimizing the amount of time that people need to spend doing anything other than the work for which they are paid [24].

Piecework's perspective

Brown inquired from another direction, asking what limited the adoption of piecework in industries that otherwise gravitated toward it (in the case studies he examined, this mostly focused on railway engineers), ultimately arguing that factors such as the nature of the work design (specifically, the homogeneity of tasks) and the costs associated with adopting a piecework model were the major contributing factors that determined the use of piecework [20].

Piecework became an important factor in the war effort for the Second World War, cementing its role not only in American factories, but in industrial work around the world. The 1930s represented a boom for piecework on an unprecedented scale, especially among engineering and metalworking industries. As discussed earlier, Hart and Roberts characterize the 1930s — and more broadly the first half of the 20th century — as the "heyday" of the use of piecework. He attributes this to the shortage of male workers, who would have gone through a conventional apprenticeship process affording them more comprehensive knowledge of the total scope of work. One might reflect on the observation that "Rosie the Riveter" — an icon of mid–20th century America who represented empowerment and opportunity for women [61] — was herself a pieceworker [37].

The research community relating to piecework and labor has been wrestling with the decomposition of work for centuries. The beginnings of systematic task decomposition stretch back as far as the 19th century, when Airy employed young boys at the Greenwich Observatory who "possessed the basic skills of mathematics, including 'Arithmetic, the use of Logarithms, and Elementary Algebra' " to compute astronomical phenomena [51].

The work that Airy solicited resonates with modern crowd work for several reasons. First, work output was quickly verifiable; Airy could assign variably skilled workers to compute values, and have other workers check their work. Second, tasks were discrete — that is, independent from one another. Finally, knowledge of the full scope of the project — indeed, knowledge of anything more than the problem set at hand — was unnecessary.

This approach found its audience in the early 20th century with the rise of Fordism and scientific management (or Taylorism). Scientific management suggested that it was possible to measure work at unprecedented resolution and precision. As Brown points out, piecework most greatly benefits the instrumented measurement of workers, but certainly in Ford and Taylor's time, highly instrumented, automatic measurement of workers was all but impossible [20]. As a result, the distillation of work into smaller units ultimately bottomed out with tasks as small as could be usefully measured [48].

Piecework researchers enumerate a number of problems with the decomposition of work, and the conflicting pressures managers and workers put forth. Bewley in particular points out that the approach of paying workers by the piece is "… not practical for workers doing many tasks, because of the cost of establishing the rates and because piecework does not compensate workers for time spent switching tasks". Ultimately, Bewley argues that "[piecework is] infeasible, because … total output is the joint product of varying groups of people" [13].

Comparing the phenomena

Where measurement and instrumentation were limiting factors for historical piecework, computation has changed the situation so that a dream of scientific management and Taylorism — to measure every motion at every point throughout the workday and beyond — is not only doable, but trivial [145]. Where Graves directly implicates measurement as preventing scientific management from being fully utilized, modern crowd work is measuring and modeling every click, scroll, and keyboard event [125, 124]. The result is that on–demand work can articulate and track far more carefully than piecework historically could.

A second shift is the relative ease with which the metaphorical "assembly line" can be changed. Historical manufacturing equipment could not quickly be assembled, edited, and redeployed. In contrast, today system–designers can share, modify, and instantiate environments like sites of labor in a few lines of code [92, 94]. This opportunity has spurred an entire body of work investigating the effects of ordering, pacing, interruptions, and other factors in piecework that would have been all but impossible to manipulate as few as 20 years ago [36, 22, 31, 30, 79].

Third, modern crowd work has sliced work to such small scales that the marginal activities — things like finding work and cognitive task switching — have become relatively large compared to the tasks themselves [33]. In the historical case of piecework, moving metallurgical tools, mining equipment, or other industry materials would have been prohibitively difficult and slow; workers were encouraged to specialize in a single set of tasks, allowing pieceworkers to sequence their tasks optimally on their own [56]. The result is that crowd workers are more free agents than historically was the case. However, because they spend significant time searching for tasks, the piece rate is less a good estimate of take-home earnings than before.

Implications for crowd work

If measurement precision limited the depth of decomposition for piecework historically, as Graves argues, then modern on–demand work stands to become far more finely-sliced and highly decomposed than ever before. Online tools make measurement and validation so easy [125] that these aspects of piecework are solved, or near enough that they no longer limit task decomposition. Now, not just tasks, but entire workers' histories [58], can be collected and analyzed in detail.

However, decomposition has hit a second bottleneck: cognition. Task switching costs and other cognitive costs make it difficult to work tasks so far decontextualized from their original intention [87]. There will of course be tasks that can be decomposed without much context, and these will form the most fine-grained of microtasks. However, other tasks cannot be freed from context — for example, logo design requires a deep understanding of the client and their goals. In part due to this limitation, 99designs workers often recycle old designs rather than make new ones for each client [9].

So, ultimately, the levels of decomposition are likely to follow the contours of context required. Low-context work will be extremely highly decomposed. High-context work will continue to be limited.

The Relationships of Workers to Work, Peers, and Others

HCI and CSCW have largely framed themselves around supporting work rather than becoming an infrastructural layer enabling it. While all artifacts have politics, this shift into computational labor systems has directly impacted the lives and livelihood of workers. So, it is important to understand: what will the future look like for the workers who use these systems?

Crowd work's perspective

One of the initial questions that researchers asked was, who are the crowd workers and what draws them to crowd work? Early literature emphasized motivations like fun and spare change, but this narrative soon shifted to emphasize that many workers use platforms such as Amazon Mechanical Turk as a primary source of income [71, 64, 8]. Despite this, Mechanical Turk is a low-wage affair for most workers in the United States [64, 100, 52]. Thus, those who choose to opt out of the traditional labor force and spend significant time on Mechanical Turk are especially motivated by the opportunity for autonomy and skill variety [71]. Due to valuing autonomy, it is tempting to ascribe attitudes of "pity the workers" to Turkers, but this frame is increasingly rejected by workers and designers as patronizing [66].

Workers' relationships with requesters are fraught. Workers are often blamed for any low-quality work, regardless of whether they are responsible [100, 102]. Some research is extremely open about this position, blaming unpredictable work on "malicious" workers [46] or those with "a lack of expertise, dedication [or] interest" [129]. Workers resent this position — for good reason. Irani and Silberman highlighted the information asymmetry between workers and requesters on AMT, leading to the creation of *Turkopticon*, a site which allows Turkers to rate and review requesters [67]. Dynamo then took this critique on information asymmetry and power imbalances a step further, designing a platform to facilitate Turkers acting collectively to bring about changes to their circumstances [126]. This unbridled power that requesters have over workers and the resultant stress and frustration that this generates has been part of the undercurrent of research into the tense relationships between workers and requesters [49, 126].

Researchers have also begun to appreciate the sociality of crowd workers. Because the platforms do not typically include social spaces, workers instead congregate off-platform in forums and mailing lists. There, Turkers exchange advice on high-paying work, talk about their earnings, build social connections, and discuss requesters [100]. Many crowd workers know each other through offline and online connections, coordinating behind-the-scenes despite the platforms encouraging independent work [50, 155]. However, the frustration and mistrust that workers experience with requesters does occasionally boil over on the forums. This behavior has come to be known as "mega–drama" amongst such workers [126]. Still, the study of these communities is made challenging because most of these platforms do not themselves include social affordances for workers [105].

Piecework's perspective

Early observers believed that workers were strongly motivated by the piecework model. Clark observed textile mill pieceworkers and reported, "When he works by the day the Italian operative wishes to leave before the whistle blows, but if he works by the piece he will work as many hours as it is possible for him to stand." Workers' situations were quite dire: Riis documented abhorrent working and living conditions of pieceworkers in New York City [119].

Workers' relationships with employers quickly soured. The match–girls strike of 1888 was one of the earliest and most famous successful worker strikes and perhaps the beginning of "militant trade unionism" [127]. As Weyer, Webb, and Webb described, "the match–girls' victory turned a new leaf in Trade Union annals" [149]: in the 30 years after the match–girls strike, the Trade Union Movement enrollment grew from 20% of eligible workers to over 60%. This strike was followed by others, including women in the garment industry in Philadelphia who established collective bargaining rights [40] and national coal miners who effected an individual minimum wage in 1912 [121]. The adoption of piecework's time–studies and other Taylorist and scientific management approaches reliably precipitated strikes and more generally gave workers a clear enemy against which to rally [69].

Soon, many worker organizations were weighing in on (or, more precisely, against) piecework and the myriad oversights it made in valuing workers' time [82, 118]. As mounting attention increasingly revealed problems in piecework's treatment of workers, theworkers themselves began to speak out about their frustration with this new regime. Organizations representing railway workers, mechanical engineers, and others began to mount advocacy in defense of workers [82, 118].

Pieceworkers' relationships with their employers eventually developed a pattern of using laborer advocacy groups [93, 5, 101, 69]. Collective action grew to become a central component of negotiating with managers [55, 112].

Less is known about how pieceworkers related to each other. For one thing, the research methods we typically associate with the exploratory study of cultures — Anthropology, and namely participant–observation, ethnography, etc. . . — didn't exist quite as we know them at the turn of the 20th century, and wouldn't for several more decades. Primary sources indicate that labor organizations wished for workers to identify as a collective group, "not only as railroad employees but also as members of the larger life of the community" [82]. Doing this, Ostrom and others argued, would facilitate collective action and perhaps collective governance [113, 55, 112]. Riis also contributed to this sense of shared struggle and endurance by documenting pieceworkers in their home–workplaces, literally bringing to light the grim circumstances in which pieceworkers lived and worked [119].

Comparing the phenomena

While historical pieceworkers could be looked down on, as the match-stick girls were characterized by "brashness, irregularity, low morality, and little education", there was generally less written about quality concerns for historical pieceworkers than there is in modern crowd work. Why the difference? One possibility is that, through writing web scripts and applying them to many tasks, it is possible for a small number of spammers have an outsized influence. Historically, it was much harder for such workers to move and get new jobs — today, they can simply accept a different task on Mechanical Turk. Another possibility: online anonymity breeds distrust [44], and where pieceworkers could be directly observed by foremen, online workers are known by little more than an account ID.

The relationship between workers and employers has also shifted: while historically the management of workers had to be done through a foreman (who necessarily had an intuitive — perhaps sympathetic — relationship with workers), the foreman of the 20th century has largely been replaced by algorithms of the 21st century [91]. The result of this change is that the agents managing work are now cold, logical, and unforgiving. Where a person might recognize that the "attention check" questions proposed by Le et al. ensure that malicious and inattentive workers are stopped, some implementations of these approaches only seem to antagonize workers. More than 30 years ago, Anderson and Schmittlein wrote: "When performance is difficult to evaluate, imperfect input measures and a manager's subjective judgment are preferable to defective (simple, observable) output measures" [6]. This frustration has only grown as requesters have had to rely on automatic management mechanisms. Only a few use the equivalent of human foremen [53, 81].

Relative to the mature state of collective action for pieceworkers offline, crowd workers have struggled to make their voices heard [126, 66, 67]. Both pieceworkers and crowd workers have struggled at times to form a collective identity necessary to organize. With workers joining and leaving the crowd labor force continuously, and with many part-time members, it is extremely difficult to corral the group to make a collective decision [126]. However, even when they can: whereas pieceworkers could physically block access to a site of production, online labor markets provide no facilities for workers to change the experience of other workers. This is a key limitation — without it, workers cannot enforce a strike.

Implications for crowd work

The decentralization and anonymization of crowd work will continue to make many of its social relationships a struggle. While some workers get to know each other well on forums [100, 50], many never engage in these social spaces. Without intervention, worker relationships and collectivism are likely to be inhibited by this decentralized design. One option is to build worker centralizing points into the platform, for example asking workers to vote on each others' reputation or allowing groups of workers to collectively reject a task from the platform [150].

The history of piecework further suggests that relationships between workers and employers might be improved if employers engaged in more human management styles. Instead of delegating as many management tasks as possible to an algorithm, it might be possible to build dashboards and other information tools that empower modern crowd work foremen [81]. If the literature on piecework is to be believed, more considerate *human* management may resolve many of the tensions we've discovered among among crowd workers.

Reciprocally, crowd work may be able to inform piecework research. There exists far less literature about pieceworkers' relationships than there does today about crowd workers' relationships. Crowd work research benefits from both the accessibility of digital platforms, as well as the firmer theoretical basis of Anthropology than existed at the turn of the 20th century, when piecework began to emerge. Malinowski, Boas, Mead and Boas and other luminaries throughout the first half of the 20th century effectively defined Cultural Anthropology as we know it today; *participant–observation*, the *etic* and the *emic* understanding of culture, and *reflexivity* didn't take even a resemblance of their contemporary forms until these works [99, 18, 104]. Modern crowd work may give us an opportunity to revisit open questions in piecework with a more refined lens.

DISCUSSION

Having taken a comprehensive look toward crowd work through the piecework lens, we can't help but take a step back to consider a number of meta–issues that arose in our analysis. Stated briefly, these issues are 1) the hazards of predicting the future, 2) polarizing tendencies, and 3) determining our research agenda. We will attempt to grapple with these questions here based on what we brought up in the earlier case studies.

The Hazards of Predicting the Future

The past can't be a perfect predictor for the future; as [128] points out, "it would be wrong to conclude that in the realm of digital labor there is nothing new under the sun" [128]. Many of the challenges that *Dynamo* overcame — determining trustworthiness, ensuring anonymity, etc. . . [126] — were relatively unique challenges precipitated by the affordances of the Internet, specifically that people could (and often do) contribute to communities in a one–off manner [103]. The Internet seemed to make this kind of loose affiliation feasible where before it wasn't [29, 126].

But this does not mean that attempting to draw meaningfully from historical scholarship would be folly; as we have shown in the preceding sections, enough of piecework can and does inform crowdsourcing that we should take this as a cue to look first for historical framings on phenomena that we encounter, as this work can outline both the mechanisms that we should expect to play out as well as one of the (perhaps many) possible futures.

In particular, the predictions that have emerged surrounding crowd work have run the spectrum from deep pessimism to exuberant optimism. In the next section, we will use the piecework foundation which informed our case studies to trace out possible Dystopian and Utopian futures for crowd work.

Polarizing Tendencies

It would be easy to think about the future of crowd work and end up at one of two extremes. On one hand, crowd work researchers imagine the application of crowdsourcing as a potentially bright future that enables the achievement of near–impossible goals [136, 78, 16]; on the other hand, researchers warn against crowd work as potentially exploitative sites of dispossession [128], a site of racial discrimination [39], and invisible, deeply frustrated workers [67, 14].

A uniquely challenging facet of this topic of inquiry is the public attention that this domain has attracted. Activists have described speculative work as having "essentially been turned into modern–day slaves" [11]. Meanwhile, advocates describe it as "a project of sharing aimed at providing ordinary people with more economic opportunities and improving their lives. . . " [38].

There is evidence to support the claim that a Dystopian world awaits us at the end of the tunnel. The arbitrary nature of on–demand work may permeate our lives, inducing us "to neglect tasks that are less easy to measure" [3] rewarding us not for creativity but predictability; payment for this work may ultimately be determined by an algorithm that fundamentally doesn't understand us; the layers between us and our managers might increasingly become "defective (simple, observable)" algorithms [6], just like those which already frustrate on–demand workers [91, 126, 67].

On the other hand, there is some evidence that offers hope. Yes, piecework's nascent years were arguably grim, but they precipitated a century of the strongest labor advocacy the world has ever seen [56, 101]. Even today, the geist that came out of the labor union revolution inspires collective action and worker empowerment around the world: in India, workers across the nation engaged in the largest labor strike in human history — perhaps as many as 150 million [1]. If labor advocacy groups can find ways to permeate on–demand labor markets, as some have called for [72], then the future of crowd work may follow the same trajectory of worker empowerment that piecework *later* found.

Perhaps the most pressing question is this: is the future of crowd work going to look more *Dystopian* or *Utopian*? If we have learn nothing, crowd work will probably end up somewhere in the middle. It's possible that the difficulties of enforcing laws on multinational corporations is tipping the balance of power in the direction of corporations, in which case things will get worse; but arguably we can affect change on the trajectory of crowd work, benefiting from everything piecework scholars have learned about collective action and governance among workers, while also avoiding some of the perils they faced.

Determining our Research Agenda

Taking a step back from the work that's been done so far and thinking about where the body of crowd work research is attempting to go may help us identify areas of research on which we should be pushing forward on. We return to the three questions that motivated this paper: 1) "what are the complexity limits of crowd work?" 2) "how far can work be decomposed into smaller microtasks?" and 3) "what will work and the place of work look like for workers?".

While we have arguably outpaced piecework with regard to the limits on the complexity of work, we have yet to find insurmountable limits to crowdsourcing. Still, we can learn from the piecework literature as it relates to the stymieing effect that mismanagement has on workers; research into the complexity limits should emphasize on finding new ways to manage workers, in particular using humans — perhaps other crowd workers — to act as modern foremen.

Piecework researchers looking into decomposition pointed out long ago that piecework is saddled by a lower limit on decomposition: "piecework does not compensate workers for time spent switching tasks" [13]. We've since studied this phenomenon in crowd work to great length both observationally [33] and experimentally [87]. We should consider whether this remains a worthwhile area to explore; unless the work we put forth directly affects the costs of task–switching — for instance, the cost of suboptimal task search, or the cognitive burden of changing tasks — we may only make incremental advances in micro–task decomposition.

Finally, we turn to the relationships of crowd workers. The crowd work literature here can convincingly speak back to the piecework scholarship perhaps more than in the other sections. The tools that are available to us today — not just technical, but *methodological* — make it possible to discover, study, and empower crowd workers in ways that were unimaginable to piecework researchers. A professor engages in crowd work [14] not just because it's possible, but because our community (of mostly computer scientists) appreciates the importance of approaches such as participant–observation and ethnography as a whole [111].

CONCLUSION

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