Reexamining Crowd Work: A Historical Framing of On–Demand Labor as Piecework

Leave Authors Anonymous
for Submission
City, Country
e-mail address

Leave Authors Anonymous
for Submission
City, Country
e-mail address

Leave Authors Anonymous
for Submission
City, Country
e-mail address

ABSTRACT

Networked computation is enabling the rise of crowdwork, gig work, and other forms of on–demand labor. A large and growing body of scholarship has sought to predict the socio–technical outcomes of this shift, especially finding crowdwork's limits how complex and interdependent crowdwork's tasks can be, the decomposition of work how thinly crowdwork can be sliced and modularized, and the relationships of workers what the collective outcomes will be for crowdworkers. In this paper, we look to the historical scholarship on piecework — a strikingly 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 crowdwork. To do so, we identify the mechanisms that limited piecework historically, and identify whether crowdwork faces the same mechanism limits or might differentiate itself.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous; See http://acm.org/about/class/1998/ for the full list of ACM classifiers. This section is required.

Author Keywords

Crowdsourcing

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 abstract blocks has allowed people to engage in work despite limited time, little to no awareness of the broader context of the work, and (often) fleeting identities and associations [55, 82, 69]. The realization that complex tasks can be accomplished by directing and managing crowds of workers has spurred the research and and industry communities to flock to sites of labor like Amazon's Mechanical Turk (AMT) to explore the limits of this distributed, fleeting workforce. Researchers in particular have taken to the space in earnest, finding opportunities to enable new forms of work using this population of "Turkers" [6, 113, 89].

This form of work has grown considerably in size, far beyond the domain of "information work" from which it first sprang. While Howe described crowdsourcing as "outsourcing [work] to an undefined, generally large group of people in the form of an open call", for years the instantiation of this work was limited to the utilization of human intelligence to process data and act on information [60, 133, 137, 32, 91]. More recently, crowdsourcing of embodied work — driving, cleaning, for instance — has become a focus of on–demand labor markets [71, 121, 44, 114]. Today, on–demand work promises to become a .

For all the growth we've observed in this labor market, we have also seen a complicated and conflicted culture emerge among its constituent workers. Researchers have made efforts to understand the people that have gravitated toward crowdsourcing platforms since its emergence and popularization, but as the form of work has grown and changed, so too have the demographics of workers [98, 107]. 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 [52, 101]. Other work has focused on the *outcomes* of this frustration, reflecting on the resistance workers express against digitally mediated labor markets [71].

The extant body of work has ostensibly sought to answer one underlying question: What does the future hold for work and those that do it? Researchers have offered their input on this open question along three major threads:

1. What are the limits of crowdsourcing? Specifically, 1) how complex can crowd work get? and 2) how far will crowd work reach into the everyday lives of people? [93, 112, 58, 136, 135, 84, 37];
2. To what extent can we decompose work (especially into micro–tasks)? [63, 6, 15, 76, 64, 70, 13, 17, 85]; and
3. What will work and the place of work look like for the workers? [52, 51, 101, 35, 9, 80] [al2: is this about collective action? yes; also, career growth? education? governance? sociality? wages?]

Piecework as a lens to understand crowdsourcing

This large and growing body of research has conversed to varying degrees with labor scholarship, but has not offered a persuasive framing for holistically explaining the developments in worker processes that researchers have developer,

ACM ISBN 978-1-4503-2138-9.
DOI: 10.1145/1235

or the phenomena in social environments we have observed; nor has any research, to our knowledge, gone as far as predict future developments.

We offer a framing for crowd work spanning the aforementioned industries collectively as a contemporary instantiation of "piecework". Piecework as a metaphor for the type of work at hand 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 [62]. But more than this, the framing of on–demand labor as a re–instantiation of piecework gives us more material to make sense of the broader research on this new form of work by evaluating this work through a much more refined theoretical lens, informed by decades of rigorous, empirically based research.

More concretely, by looking at task–based or "gig" 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) bring into focus the ongoing work among workers, system–designers, and researchers in this space; and finally, 3) offer predictions of what social computing researchers, and workers themselves, should expect to see on the horizon of on–demand work.

We'll look at a broad range of cases under a number of major themes we propose as broadly describing the types of research being done in crowd work and more generally in what we argue is contemporary piecework. After validating this lens as a way of reasoning about on–demand labor, we'll attempt to use this perspective to suggest areas of research worth anticipating, and developments we should expect to see in the maturation of digitally mediated work. Finally, we will offer design implications based on this research.

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 crowdwork (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 subsequent sections — and indeed, the entire 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.

What was piecework?

While "piecework" has proven difficult to concretize from the literature, we can trace a constellation of characteristics of piece work that recur throughout the literature. We'll follow the history of research, collecting descriptions, examples, and provided definitions of piecework, trying to trace the outline of a working understanding of *what piecework is*.

One of the earliest definitions of piecework, in 1847, also proves to be the most circumspect in its wording. 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]" [92]. This description offers the first rudimentary definition of piecework from which the practice will grow for more than a century; piece work, as Raynbird offers, "depend[s] on the quantity of work done".

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…[16]. 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 [28, 128, 129, 41].

It's worth acknowledging that — as Hart and Roberts point out — "this distinction [between piece–rates and time–rates] was not completely clear–cut" [39]. The "Rowan premium system", which essentially paid workers a base rate for time with the opportunity for additional pay associated with 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 [99]. Nevertheless, this work offers us an intuition for what piecework is, if not a bright–line rule.

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 piece workcrop 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 [92, 99].

We see this sense of independence regardless of the time, locale, and industry. Satre offers us 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 reputation "… for generosity, independence, and protectiveness, but also for brashness, irregularity, low morality, and little education" [102]. J. Hagan documents piecework from 1850–1930 in Australia, finding similar assertions of the freedom compositors of newspapers experienced as piece workers: "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" [53]. 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 locus otherwise unknown to workers.

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 [39].

Consolidating what we've learned from these sources about piecework, we might be able to arrive at a working definition that will suffice for our needs. Those needs being that the definition be 1) faithful to the historical cases of piecework that we see in the scholarship; and 2) relevant and informative to potential cases of piecework today. We offer the following: that piecework is the paradigm of renumeration that is largely made compelling for its use of "payment for results", leading to and leveraging narrower skill sets required for narrowly defined tasks, and affording workers some amount of freedom to complete tasks (and consequently earn money) at at whatever rate and in whichever manner they wish.

What was piecework's historical arc?

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 [36]. While this approach didn't become an economic powerhouse as later examples would prove, Airy and others arguably found the kernel of insight that we pursue throughout this discussion: determining the extent to which work can be decomposed, and finding the limits of complexity of that decomposed work. That is, Airy found that he could train youths in elementary mathematics to complete the majority of the calculations he would otherwise have had to solve on his own, and that the greater body of work could ultimately be completed sooner if he arranged his work appropriately.

Piecework took a circuitous path in its rise to the mainstream, each time finding additional ways to leverage the advantages of piecework. First applied to farm work, as Raynbird and others illustrate, the practice remained relatively obscure until it was brought to the textile industry [92]. At the turn of the 20th century, when Riis was documenting abhorrent working & living conditions of pieceworkers in New York City, Norton was providing substantive guidance on various wage regimes, describing piecework comprehensively [95, 87]. Soon after, we saw the application of piecework systems in textile mills on the realization that "[pieceworkers in Italy] will work as many hours as it is possible for him to stand" [21]. Best practices regarding the measurement and management of piecework rates, and of workers in the engineering industry, were beginning to take shape [12].

Researchers have since struggled to understand the mechanisms and characteristics in piecework which fueled its rise to popularity during this time. Graves argued 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 [34]. This argument is certainly compelling; it would seem to make the concurrent upswing of scientific management and Fordism through the first two–thirds of the 20th century alongside piecework not only understandable, but predictable [39]. 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) [11].

As increasing attention revealed problems in piecework as it related to workers, workers themselves began to speak out about their frustration with this new regime. It began, arguably, with Riis's photo–documentary work, but this led to industry organizations representing railway workers, mechanical engineers, and others contributing their myriad perspectives [65, 94, 95]. Nevertheless, piecework continued to permeate low–skilled labor.

Piecework became an important contributor to the war effort in the Second World War, cementing its role not only in American factories, but in industrial work around the world. While piecework began to catch on at the turn of the 20th century, 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.

Despite the intense growth of the piecework approach to renumeration, this time was not without turmoil. As previously discussed, a number of worker organizations weighed in on (or, more precisely, against) piecework and the myriad oversights it made in valuing workers' time [65, 94]. Satre describes worker resistance among a largely disempowered community — young women employed by piecework [102].

While many workers participated in piecework, worker sentiment toward the practice was — by all accounts — mostly negative. The match girls strikes which Satre describes were just one early — albeit critical — case study in this space; the national coal strike of 1912 led to an overwhelming vote among federated coal miner pieceworkers to strike for an individual minimum wage, among other demands [96]. Emmet documents a series of efforts among women in the garment industries in Philadelphia to negotiate collective bargaining rights and recognition of their own labor union [27]. The adoption of piecework time–study and other principles associated with Taylor and scientific management itself reliably precipitated strikes and more generally gave workers a clear enemy against which to rally [54].

Piecework's popularity in the United States and Europe plummeted almost as quickly as it had climbed just a few decades earlier. 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. We summarize some of the salient suggestions here: 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; 3) the quality of "multidimensional" work becoming too difficult to evaluate. [39].

Why is piecework relevant to crowdwork?

Using the definition of piecework that we came up with earlier, we argue that crowdwork 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 crowdwork 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.

MAJOR RESEARCH QUESTIONS

We look at lots of papers that use the term "crowdsourcing" or "crowdwork" 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.

What are the limits of crowdsourcing?

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. 6, 93, 61]. 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) finding crowdwork's limits, 2) the decomposition of work, and 3) the relationships of 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.

Achieving greater complexity

Crowdwork's perspective. Crowdsourcing research has spent the better part of a decade attempting to prove the viability of crowdsourcing in increasingly complex work. Kittur et al. map the discussion toward this goal in their work on crowdsourcing complex work [61]. The broader body of work has varied significantly in type — providing conversational assistants, interpreting medical data, and telling coherent and compelling stories, to name a few examples [67, 79, 58].

This body of research has involved similar approaches to problems, often involving insights made in Computer Science and applied to human work–flows. The crowdwork literature typically identifies target milestones in CS that have presented significant challenges for researchers, leverages some of the approaches and insights that Computer Science researchers have already made (for example, MapReduce in the case of Kittur et al.'s *CrowdForge*), and arranges humans as computational black boxes within those approaches and processes [61, 93, and others]. This approach has proven a compelling one because it leverages the in–built advantages that technology and digital media afford. *Foundry*'s tools for managing and arranging expert groups into a cohort allow researchers to convincingly argue that expert teams can be rapidly formed, just like non–expert teams [93].

Piecework's perspective. The research into piecework makes the case that piecework has been limited principally by the challenges of human management and oversight. Graves describes a case study in Santa Fe Railway, which deployed scientific management and a piecework regime in an attempt to stymie rising repair costs [34]. Returning to Hart's reflections on piecework's limitations, we recall the multidimensional problem — tasks comprising of numerous, sometimes conflicting, goals [40]. It would be reasonable, then, to infer that work like this — reasonably highly skilled work where quality is difficult to assess — would be unsuitable for piecework.

Hart and Graves, without acknowledging one another, seemingly corroborate one another's conclusions at different levels of observation. Graves enumerates some of the roles required to facilitate piecework in the early 20th century: "… piecework clerks, inspectors, and 'experts'…" [40, 34]. Graves and Hart may seem to be making differing claims about the limitations of piecework, but we argue that Graves is simply making a more concrete observation illustrating the insight that Hart later makes. Graves recognizes that it's necessary for a successful piecework shop to employ clerks, inspectors, and other experts to properly design and evaluate complex work. Hart argues an ultimate limit to how far this can go; at some point, evaluating multidimensional work output for quality (rather than for quantity) becomes infeasible.

This isn't to say that complex work is outside of the realm of piecework; indeed, we've discussed complex applications of crowdwork already. As Hart and Roberts described, the 1930s saw a flourishing of clever piecework job design out of necessity due to the fact that it was infeasible to provide new workers with the comprehensive education that was familiar to men [39]. This constraint led to much more tightly scoped work, and (perhaps surprisingly at the time) more efficient

allocations of workers, who could now specialize in extremely narrowly defined roles. The same could be said of Airy and his *computers* — young boys whose preparations consisted principally of a relatively specific mathematics curriculum [36].

Piecework researchers also make claims regarding the organizations that benefit from piecework in the first place. Brown discusses the factors necessary for piecework to thrive: "... incentive pay is less likely in jobs with a variety of duties than in jobs with a narrow set of routinized duties" [11]. Graves adds further, that successful cases of piecework owed themselves in part to the fact that "... only [the largest and most wealthy railroads] had the resources to ... pay the overhead involved in installing work reorganization" [34]. Together, Graves and Brown make a persuasive argument that piecework is limited in complexity by managerial overhead and the fixed cost of adopting a piecework payment regime.

There are other characteristics to effective complex piecework institutions, such as appropriately designed management practices. Boal and Pencavel describe the role of the foreman in West Virginia coal mines under the piecework model: "The foreman had the power to hire and fire workers and allocate workplaces, but then left the face–worker largely free to his own efforts so that often he went all day without seeing the foreman" [8]. The general approach adopted by these West Virginia mines was, as in other factories with active foremen, to let the foreman be the intermediary between management and the worker. Specifically, foremen were responsible for allocating resources and understanding when and how to modify work as necessary [132].

What's different about crowdwork. Digital media have expanded the scope of viable piecework by pushing drastically on the limits cited by piecework researchers. 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 [11]. 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 for two reasons: 1) Technology make it much easier to do complex work aided by computers; and 2) The Internet allows us to leverage the benefits of "economies of scale" at very little cost to the system–designer [72, 81].

Technology has made it possible for non–experts to do work that was once considered within the domain of experts. Yuan et al. builds on the work of others (*Voyant* and, more relevantly, *CrowdCrit*) to design workflows that yield "expert–level feedback" [136, 134, 75]. This body of work identifies ways to transform a variety of duties comprising complex tasks and distills them into "a narrow set of routinized duties", informed in part by researchers — acting as inspectors — and experts [quotations from 34] Where Graves would call additionally for the identification of crowdsourcing's version of "piecework clerks", we point out that today algorithms manage workers as pieceworkers once did [71, 34].

Furthermore, technology more directly facilitates the subversion of expertise requirements by giving non–experts access to information that would otherwise be unavailable. Taxi drivers in London endure rigorous training to pass a test known as "The Knowledge" — a demonstration of the driver's comprehensive familiarity. Researchers have identified significant growth of the hippocampal regions of the brains in veteran drivers, generally understood to be responsible for spatial functions such as navigation [78, 77, 109, 110, 131, 130]. Services such as Google Maps & Waze make it possible for people entirely unfamiliar with a city to know more about a city even than experts through the collective data generated by other users ranging topics such as police activity, congestion, construction, etc... [108, 42].

Implications for crowdwork research. The piecework literature gives us a template for pushing the boundaries of complexity in piecework, but it also signals some of the ultimate limitations of crowdwork and piecework in general. While the threshold preventing task requesters from utilizing piecework has dropped thanks to affordances of the Internet, the ceiling on task complexity hasn't moved significantly. If we're to make use of Brown's prescriptions, we would benefit from finding ways to decompose varied tasks into homogeneous microtasks.

We should also consider exploring the limitations that algorithmic management bring along more carefully. While research has touched on this subject, we've yet to make out the bigger picture of this theme [71]. If we can resolve the tension between workers and perilously antagonistic managers, as Boal and Pencavel suggest, then we may be able to break a toxic cycle of mistrustful requesters [for example 30] and develop more considerate platforms as McInnis et al. advocate [80].

Finally, and perhaps most importantly, we need to replicate the success of narrowly slicing education and training for expert work as Hart and Roberts and Grier described in their piecework examples [39, 36]. That is, we need to identify new ways to train crowdworkers for uniquely narrowly defined work. To some extent, an argument can be made that MOOCs and other online education resources provide crowdworkers 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 [1]. If we can overcome this obstacle, we might be able to empower crowdworkers to do complex work such as engineering and metalworking, rather than doom them to match girl reputations: "brash, irregular, immoral, and uneducated" [102].

The Decomposition of Work

Crowdwork's perspective. The crowdsourcing research into work decomposition has largely focused on minimizing the additional context necessary to do tasks, and making it easier to do tasks with less time. This first thread is perhaps best described by Verroios and Bernstein as making crowd workers "... able to act with global understanding when each contributor only has access to local views" [124]. With the exception of a few cases (specifically, Kinnaird, Dabbish, and Kiesler's work which finds that greater work context fosters more reliably

high–quality work), the micro task paradigm has emerged as the overwhelming favorite [116, 117, 19, 59].

As the additional context necessary to complete a task diminishes, the marginal cost of finding and *doing* tasks has increasingly become the focus of research. Chilton et al. illustrate the challenges on AMT, and some work has gone into ameliorating the problems specific to this work site (*ReLauncher*), while other work designs tasks around gap time (*Twitch Crowdsourcing* & *Wait–Learning*) [20, 64, 123, 14]. Yet more work looks at the general framing of tasks, chaining and arranging them to maximally exploit the attention and stress threshold of workers [13]. Rather than attempt to minimize the error rates in micro–tasks, as Kinnaird, Dabbish, and Kiesler suggested, we as a community have leaned *into* the peril of low–context work, "embracing error" in crowdsourcing [63].

Not all of the work toward optimizing crowd work–flows has gone toward minimizing the creative input of crowd workers; a thriving body of literature adopts practices such as pipelining to allow experts to participate in crowd work [93].

Piecework's perspective. 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 17th 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, by hand, astronomical phenomena [36]. These workers became the first *computers*.

The work Airy solicited was interesting 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.

The insight of breaking tasks down into smaller components didn't find its audience until the early 20th century, with the rise of Fordism and scientific management (or Taylorism). From scientific management, we found that we could 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 — and certainly in Airy's time — highly instrumented, automatic measurement of workers was all but impossible. As a result, the distillation of work into smaller chunks ultimately reached a limit of usefulness.

What's different about crowdwork. A number of factors in crowdwork are different from piecework, chief among them being the relative ease with which the metaphorical "assembly line" can be changed. Computers make it possible to switch from one task to another unlike any arbitrary manufacturing factory possibly could; a worker could do any number of different *types* of tasks in the span of just a few minutes [68]. This 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 measure consistently as few as 20 years ago [19, 18, 63].

Further, we've sliced work to such small scales that the marginal activities — things like finding work, cognitive task switching, etc. . . — have become relatively large compared to the tasks themselves [20]. 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 [39].

Rather than fall into the trap that Irani warns of, — one which where crowdworkers are rendered as "modular, protocol–defined computational services" — we may yield better results from crowdwork if we think of workers as similar to specialized, repurposable tools [50]. [al2: feeling meh about this argument. . .]

Finally, instrumentation has reached a sufficiently advanced and ubiquitous point that the dream of scientific management and Taylorism — to measure every motion at every point throughout the workday and beyond — is not only doable, but trivial [127]. One of the major challenges Graves cites as preventing scientific management from being fully utilized, the difficulty of tracking work & workers, no longer exists [34].

Implications for crowdwork research. Crowdwork research today is on the right track to investigate pipelining and meta–task design. That is, investigating better work discovery methods, producing tools for workers to make more informed decisions [see, for example, 52]. It's not clear how much benefit there is in the further decomposition of work, given that we've hit bottlenecks with the cognitive stresses of switching between tasks as Lasecki et al. highlight [68].

The Relationships of Workers to Work, Peers, and Others

Crowdwork's perspective. A number of ethical questions surrounding the increasing complexity of crowdwork and the hazards have increasingly arisen. Silberman, Irani, and Ross bring some of these issues at stake — working for increasing amounts of time on tasks of growing complexity, only to discover that requesters are not willing to pay, for instance — but these and other dangers range an enormous landscape [62, 106, 86, 101].

[al2: TODO:

1. Crowdwork's perspective.
2. Piecework's perspective.
3. What's different about crowdwork.

]

IMPLICATIONS FOR RESEARCH

[al2: todolidos]

References

[1] J Ignacio Aguaded-Gómez. "The MOOC Revolution: A new form of education from the technological paradigm". In: *Comunicar* 41.21 (2013), pp. 7–8.

[2] George A Akerlof. “The market for" lemons": Quality uncertainty and the market mechanism”. In: *The quarterly journal of economics* (1970), pp. 488–500.

[3] Andy Baio. *The Faces of Mechanical Turk*. Nov. 2008. URL: http://waxy.org/2008/11/the_faces_of_mechanical_turk/.

[4] Peter Baker. “Production restructuring in the textiles and clothing industries”. In: *New Technology, Work and Employment* 8.1 (1993), pp. 43–55. ISSN: 1468–005X. DOI: 10.1111/j.1468--005X.1993.tb00033.x. URL: http://dx.doi.org/10.1111/j.1468-005X.1993.tb00033.x.

[5] John Perry Barlow. *A Declaration of the Independence of Cyberspace*. Feb. 1996. URL: https://projects.eff.org/~barlow/Declaration-Final.html.

[6] Michael S. Bernstein et al. “Soylent: A Word Processor with a Crowd Inside”. In: UIST ’10 (2010), pp. 313–322. DOI: 10.1145/1866029.1866078. URL: http://doi.acm.org/10.1145/1866029.1866078.

[7] Ivan Beschastnikh, Travis Kriplean, and David W McDonald. “Wikipedian Self–Governance in Action: Motivating the Policy Lens.” In: *ICWSM*. 2008.

[8] William M. Boal and John Pencavel. “The Effects of Labor Unions on Employment, Wages, and Days of Operation: Coal Mining in West Virginia”. In: *The Quarterly Journal of Economics* 109.1 (1994), pp. 267–298. ISSN: 00335533, 15314650. URL: http://www.jstor.org/stable/2118435.

[9] Robin Brewer, Meredith Ringel Morris, and Anne Marie Piper. “"Why Would Anybody Do This?": Understanding Older Adults’ Motivations and Challenges in Crowd Work”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 2246–2257. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858198. URL: http://doi.acm.org/10.1145/2858036.2858198.

[10] Chantal Brisson et al. “Effect of duration of employment in piecework on severe disability among female garment workers”. In: *Scandinavian journal of work, environment & health* (1989), pp. 329–334.

[11] Charles Brown. “Firms’ Choice of Method of Pay”. In: *Industrial & Labor Relations Review* 43.3 (1990), 165S–182S. DOI: 10.1177/001979399004300311. eprint: http://ilr.sagepub.com/content/43/3/165S.full.pdf+html. URL: http://ilr.sagepub.com/content/43/3/165S.abstract.

[12] Francis G Burton. *The Commercial Management of Engineering Works*. Scientific Publishing Company, 1899.

[13] Carrie J. Cai, Shamsi T. Iqbal, and Jaime Teevan. “Chain Reactions: The Impact of Order on Microtask Chains”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 3143–3154. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858237. URL: http://doi.acm.org/10.1145/2858036.2858237.

[14] Carrie J. Cai et al. “Wait-Learning: Leveraging Wait Time for Second Language Education”. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI ’15. Seoul, Republic of Korea: ACM, 2015, pp. 3701–3710. ISBN: 978-1-4503-3145-6. DOI: 10.1145/2702123.2702267. URL: http://doi.acm.org/10.1145/2702123.2702267.

[15] L. Elisa Celis et al. “Assignment Techniques for Crowdsourcing Sensitive Tasks”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 836–847. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2835202. URL: http://doi.acm.org/10.1145/2818048.2835202.

[16] Edwin Chadwick. “Opening Address of the President of the Department of Economy and Trade, at the Meeting of the National Association for the Promotion of Social Science, held at York, in September, 1864”. In: *Journal of the Statistical Society of London* 28.1 (1865), pp. 1–33. ISSN: 09595341. URL: http://www.jstor.org/stable/2338394.

[17] Joseph Chee Chang, Aniket Kittur, and Nathan Hahn. “Alloy: Clustering with Crowds and Computation”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 3180–3191. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858411. URL: http://doi.acm.org/10.1145/2858036.2858411.

[18] Justin Cheng, Jaime Teevan, and Michael S. Bernstein. “Measuring Crowdsourcing Effort with Error–Time Curves”. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI ’15. New York, NY, USA: ACM, 2015, pp. 1365–1374. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702145. URL: http://doi.acm.org/10.1145/2702123.2702145.

[19] Justin Cheng et al. “Break it down: A comparison of macro–and microtasks”. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. ACM. 2015, pp. 4061–4064.

[20] Lydia B. Chilton et al. “Task Search in a Human Computation Market”. In: *Proceedings of the ACM SIGKDD Workshop on Human Computation*. HCOMP ’10. New York, NY, USA: ACM, 2010, pp. 1–9. ISBN: 978–1-4503–0222–7. DOI: 10.1145/1837885.1837889. URL: http://doi.acm.org/10.1145/1837885.1837889.

[21] William Alexander Graham Clark. *Cotton Textile Trade in Turkish Empire, Greece, and Italy*. Vol. 10. US Government Printing Office, 1908.

[22] Dan Cosley et al. "SuggestBot: Using Intelligent Task Routing to Help People Find Work in Wikipedia". In: *Proceedings of the 12th International Conference on Intelligent User Interfaces*. IUI '07. Honolulu, Hawaii, USA: ACM, 2007, pp. 32–41. ISBN: 1-59593-481-2. DOI: 10.1145/1216295.1216309. URL: http://doi.acm.org/10.1145/1216295.1216309.

[23] Ben Craig and John Pencavel. "The behavior of worker cooperatives: The plywood companies of the Pacific Northwest". In: *The American Economic Review* (1992), pp. 1083–1105.

[24] Ellen Cushing. *Dawn of the Digital Sweatshop*. Aug. 2012. URL: http://www.eastbayexpress.com/oakland/dawn-of-the-digital-sweatshop/Content?oid=3301022.

[25] Steven Dow et al. "Shepherding the Crowd Yields Better Work". In: *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work*. CSCW '12. New York, NY, USA: ACM, 2012, pp. 1013–1022. ISBN: 978-1-4503-1086-4. DOI: 10.1145/2145204.2145355. URL: http://doi.acm.org/10.1145/2145204.2145355.

[26] Bernhard Ebbinghaus and Jelle Visser. "When institutions matter: Union growth and decline in Western Europe, 1950—1995". In: *European Sociological Review* 15.2 (1999), pp. 135–158.

[27] Boris Emmet. "Trade Agreements In The Women's Clothing Industries Of Philadelphia". In: *Monthly Review of the U.S. Bureau of Labor Statistics* 6.1 (1918), pp. 27–39. ISSN: 23291354, 23291362. URL: http://www.jstor.org/stable/41829256.

[28] David N. Figlio and Lawrence W. Kenny. "Individual teacher incentives and student performance". In: *Journal of Public Economics* 91.5–6 (2007), pp. 901 –914. ISSN: 0047-2727. DOI: http://dx.doi.org/10.1016/j.jpubeco.2006.10.001. URL: http://www.sciencedirect.com/science/article/pii/S004727270600140X.

[29] Karën Fort, Gilles Adda, and K Bretonnel Cohen. "Amazon mechanical turk: Gold mine or coal mine?" In: *Computational Linguistics* 37.2 (2011), pp. 413–420.

[30] Ujwal Gadiraju et al. "Understanding Malicious Behavior in Crowdsourcing Platforms: The Case of Online Surveys". In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI '15. New York, NY, USA: ACM, 2015, pp. 1631–1640. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702443. URL: http://doi.acm.org/10.1145/2702123.2702443.

[31] Henry Laurence Gantt. *Work, wages, and profits*. Engineering Magazine Co., 1913.

[32] David Geiger et al. "Managing the Crowd: Towards a Taxonomy of Crowdsourcing Processes." In: *AMCIS*. 2011.

[33] Alan Gevins and Michael E Smith. "Neurophysiological measures of cognitive workload during human–computer interaction". In: *Theoretical Issues in Ergonomics Science* 4.1–2 (2003), pp. 113–131.

[34] Carl Graves. "Applying Scientific Management Principles to Railroad Repair Shops — the Santa Fe Experience, 1904-18". In: *Business and Economic History* 10 (1981), pp. 124–136. ISSN: 08946825. URL: http://www.jstor.org/stable/23702539.

[35] Mary L. Gray et al. "The Crowd is a Collaborative Network". In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW '16. New York, NY, USA: ACM, 2016, pp. 134–147. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2819942. URL: http://doi.acm.org/10.1145/2818048.2819942.

[36] David Alan Grier. *When computers were human*. Princeton University Press, 2013.

[37] Nathan Hahn et al. "The Knowledge Accelerator: Big Picture Thinking in Small Pieces". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 2258–2270. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858364. URL: http://doi.acm.org/10.1145/2858036.2858364.

[38] Russell Hardin. *Collective action*. Resources for the Future, 1982.

[39] Robert A Hart and J Elizabeth Roberts. "The rise and fall of piecework–timework wage differentials: market volatility, labor heterogeneity, and output pricing". In: (2013).

[40] Robert A Hart et al. "the rise and fall of piecework". In: *IZA World of Labor* (2016).

[41] John S. Heywood, W. S. Siebert, and Xiangdong Wei. "Payment by Results Systems: British Evidence". In: *British Journal of Industrial Relations* 35.1 (1997), pp. 1–22. ISSN: 1467-8543. DOI: 10.1111/1467-8543.00038. URL: http://dx.doi.org/10.1111/1467-8543.00038.

[42] Sam Hind and Alex Gekker. "'Outsmarting Traffic, Together': Driving as Social Navigation". In: *Exchanges: the Warwick Research Journal* 1.2 (2014), pp. 165–180.

[43] John Joseph Horton and Lydia B. Chilton. "The Labor Economics of Paid Crowdsourcing". In: *Proceedings of the 11th ACM Conference on Electronic Commerce*. EC '10. New York, NY, USA: ACM, 2010, pp. 209–218. ISBN: 978–1-60558–822–3. DOI: 10.1145/1807342.1807376. URL: http://doi.acm.org/10.1145/1807342.1807376.

[44] *House Cleaning, Handyman, Lawn Care Services in Austin, Denver, Kansas City, Minneapolis and San Francisco —- Zaarly*. Sept. 2015. URL: https://www.zaarly.com/.

[45] Jeff Howe. *Crowdsourcing: How the power of the crowd is driving the future of business*. Random House, 2008.

[46] Te C Hu. “Parallel Sequencing and Assembly Line Problems”. In: *Operations Research* 9.6 (1961), pp. 841–848. DOI: 10.1287/opre.9.6.841. eprint: http://dx.doi.org/10.1287/opre.9.6.841. URL: http://dx.doi.org/10.1287/opre.9.6.841.

[47] *Infoscout: Using Mechanical Turk to Mine Reciepts 7–23–2013*. July 2013. URL: https://www.youtube.com/watch?v=N3T6FyymsCw.

[48] Panagiotis G. Ipeirotis, Foster Provost, and Jing Wang. “Quality Management on Amazon Mechanical Turk”. In: *Proceedings of the ACM SIGKDD Workshop on Human Computation*. HCOMP ’10. Washington DC: ACM, 2010, pp. 64–67. ISBN: 978-1-4503-0222-7. DOI: 10.1145/1837885.1837906. URL: http://doi.acm.org/10.1145/1837885.1837906.

[49] Shamsi T. Iqbal and Brian P. Bailey. “Effects of Intelligent Notification Management on Users and Their Tasks”. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI ’08. New York, NY, USA: ACM, 2008, pp. 93–102. ISBN: 978–1-60558–011–1. DOI: 10.1145/1357054.1357070. URL: http://doi.acm.org/10.1145/1357054.1357070.

[50] Lilly Irani. “The cultural work of microwork”. In: *New Media & Society* 17.5 (2015), pp. 720–739.

[51] Lilly C. Irani and M. Six Silberman. “Stories We Tell About Labor: Turkopticon and the Trouble with "Design"”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 4573–4586. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858592. URL: http://doi.acm.org/10.1145/2858036.2858592.

[52] Lilly C. Irani and M. Six Silberman. “Turkopticon: Interrupting Worker Invisibility in Amazon Mechanical Turk”. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI ’13. New York, NY, USA: ACM, 2013, pp. 611–620. ISBN: 978–1-4503–1899–0. DOI: 10.1145/2470654.2470742. URL: http://doi.acm.org/10.1145/2470654.2470742.

[53] C. Fisher J. Hagan. “Piece Work and Some of Its Consequences in the Printing and Coal Mining Industries in Australia, 1850-1930”. In: *Labour History* 25 (1973), pp. 19–39. ISSN: 00236942. URL: http://www.jstor.org/stable/27508091.

[54] Sanford M Jacoby. “Union–management cooperation in the United States: Lessons from the 1920s”. In: *Industrial & Labor Relations Review* 37.1 (1983), pp. 18–33.

[55] David R. Karger, Sewoong Oh, and Devavrat Shah. “Iterative Learning for Reliable Crowdsourcing Systems”. In: *Advances in Neural Information Processing Systems 24*. Ed. by J. Shawe-Taylor et al. Curran Associates, Inc., 2011, pp. 1953–1961. URL: http://papers.nips.cc/paper/4396-iterative-learning-for-reliable-crowdsourcing-systems.pdf.

[56] Nicolas Kaufmann, Thimo Schulze, and Daniel Veit. “More than fun and money. Worker Motivation in Crowdsourcing–A Study on Mechanical Turk.” In: *AMCIS*. Vol. 11. 2011, pp. 1–11.

[57] Brian Keegan and Darren Gergle. “Egalitarians at the gate: One–sided gatekeeping practices in social media”. In: *Proceedings of the 2010 ACM conference on Computer supported cooperative work*. ACM. 2010, pp. 131–134.

[58] Joy Kim and Andrés Monroy-Hernández. “Storia: Summarizing Social Media Content Based on Narrative Theory Using Crowdsourcing”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 1018–1027. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2820072. URL: http://doi.acm.org/10.1145/2818048.2820072.

[59] Peter Kinnaird, Laura Dabbish, and Sara Kiesler. “Workflow Transparency in a Microtask Marketplace”. In: *Proceedings of the 17th ACM International Conference on Supporting Group Work*. GROUP ’12. Sanibel Island, Florida, USA: ACM, 2012, pp. 281–284. ISBN: 978-1-4503-1486-2. DOI: 10.1145/2389176.2389219. URL: http://doi.acm.org/10.1145/2389176.2389219.

[60] Aniket Kittur, Ed H. Chi, and Bongwon Suh. “Crowdsourcing User Studies with Mechanical Turk”. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI ’08. New York, NY, USA: ACM, 2008, pp. 453–456. ISBN: 978–1-60558–011–1. DOI: 10.1145/1357054.1357127. URL: http://doi.acm.org/10.1145/1357054.1357127.

[61] Aniket Kittur et al. “CrowdForge: Crowdsourcing Complex Work”. In: *Proceedings of the 24th Annual ACM Symposium on User Interface Software and Technology*. UIST ’11. New York, NY, USA: ACM, 2011, pp. 43–52. ISBN: 978–1-4503–0716–1. DOI: 10.1145/2047196.2047202. URL: http://doi.acm.org/10.1145/2047196.2047202.

[62] Aniket Kittur et al. “The Future of Crowd Work”. In: *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*. CSCW ’13. New York, NY, USA: ACM, 2013, pp. 1301–1318. ISBN: 978–1-4503–1331–5. DOI: 10.1145/2441776.2441923. URL: http://doi.acm.org/10.1145/2441776.2441923.

[63] Ranjay A. Krishna et al. “Embracing Error to Enable Rapid Crowdsourcing”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 3167–3179. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858115. URL: http://doi.acm.org/10.1145/2858036.2858115.

[64] Pavel Kucherbaev et al. “ReLauncher: Crowdsourcing Micro–Tasks Runtime Controller”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 1609–1614. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2820005. URL: http://doi.acm.org/10.1145/2818048.2820005.

[65] American Federation of Labor. Railway Employees Dept and United States Railroad Labor Board. *The problem of piece work*. The Problem of Piece Work nos. 1-16. Bronson Canode Print. Co., 1921. URL: https://books.google.com/books?id=NN5NAQAAIAAJ.

[66] Jaron Lanier. *Who owns the future?* Simon and Schuster, 2014.

[67] Walter S. Lasecki et al. "Chorus: A Crowd-powered Conversational Assistant". In: *Proceedings of the 26th Annual ACM Symposium on User Interface Software and Technology*. UIST '13. St. Andrews, Scotland, United Kingdom: ACM, 2013, pp. 151–162. ISBN: 978-1-4503-2268-3. DOI: 10.1145/2501988.2502057. URL: http://doi.acm.org/10.1145/2501988.2502057.

[68] Walter S. Lasecki et al. "The Effects of Sequence and Delay on Crowd Work". In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI '15. New York, NY, USA: ACM, 2015, pp. 1375–1378. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702594. URL: http://doi.acm.org/10.1145/2702123.2702594.

[69] Thomas D LaToza et al. "Crowd development". In: *Cooperative and Human Aspects of Software Engineering (CHASE), 2013 6th International Workshop on*. Citeseer. 2013, pp. 85–88.

[70] Edith Law et al. "Curiosity Killed the Cat, but Makes Crowdwork Better". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 4098–4110. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858144. URL: http://doi.acm.org/10.1145/2858036.2858144.

[71] Min Kyung Lee et al. "Working with Machines: The Impact of Algorithmic and Data–Driven Management on Human Workers". In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI '15. New York, NY, USA: ACM, 2015, pp. 1603–1612. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702548. URL: http://doi.acm.org/10.1145/2702123.2702548.

[72] Lawrence Lessig. *Code*. Lawrence Lessig, 2006.

[73] Margaret Levi et al. "Union democracy reexamined". In: *Politics & Society* 37.2 (2009), pp. 203–228.

[74] Alain Lipietz. "Towards Global Fordism?" In: *New Left Review* 0.132 (Mar. 1982). Last updated — 2013–02–24, p. 33. URL: http://search.proquest.com/docview/1301937328?accountid=14026.

[75] Kurt Luther et al. "CrowdCrit: Crowdsourcing and Aggregating Visual Design Critique". In: *Proceedings of the Companion Publication of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*. CSCW Companion '14. Baltimore, Maryland, USA: ACM, 2014, pp. 21–24. ISBN: 978-1-4503-2541-7. DOI: 10.1145/2556420.2556788. URL: http://doi.acm.org/10.1145/2556420.2556788.

[76] Ioanna Lykourentzou et al. "Personality Matters: Balancing for Personality Types Leads to Better Outcomes for Crowd Teams". In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW '16. New York, NY, USA: ACM, 2016, pp. 260–273. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2819979. URL: http://doi.acm.org/10.1145/2818048.2819979.

[77] Eleanor A. Maguire, Rory Nannery, and Hugo J. Spiers. "Navigation around London by a taxi driver with bilateral hippocampal lesions". In: *Brain* 129.11 (2006), pp. 2894–2907. ISSN: 0006-8950. DOI: 10.1093/brain/awl286. eprint: http://brain.oxfordjournals.org/content/129/11/2894.full.pdf. URL: http://brain.oxfordjournals.org/content/129/11/2894.

[78] Eleanor A. Maguire et al. "Navigation-related structural change in the hippocampi of taxi drivers". In: *Proceedings of the National Academy of Sciences* 97.8 (2000), pp. 4398–4403. DOI: 10.1073/pnas.070039597. eprint: http://www.pnas.org/content/97/8/4398.full.pdf. URL: http://www.pnas.org/content/97/8/4398.abstract.

[79] Sam Mavandadi et al. "Distributed medical image analysis and diagnosis through crowd-sourced games: a malaria case study". In: *PloS one* 7.5 (2012), e37245.

[80] Brian McInnis et al. "Taking a HIT: Designing Around Rejection, Mistrust, Risk, and Workers' Experiences in Amazon Mechanical Turk". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 2271–2282. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858539. URL: http://doi.acm.org/10.1145/2858036.2858539.

[81] Vincent Miller. *Understanding digital culture*. Sage Publications, 2011.

[82] Tanushree Mitra, C.J. Hutto, and Eric Gilbert. "Comparing Person- and Process–centric Strategies for Obtaining Quality Data on Amazon Mechanical Turk". In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI '15. New York, NY, USA: ACM, 2015, pp. 1345–1354. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702553. URL: http://doi.acm.org/10.1145/2702123.2702553.

[83] Fergus Murray. "The decentralisation of production—the decline of the mass–collective worker?" In: *Capital & Class* 7.1 (1983), pp. 74–99.

[84] Michael Nebeling et al. "WearWrite: Crowd–Assisted Writing from Smartwatches". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 3834–3846. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858169. URL: http://doi.acm.org/10.1145/2858036.2858169.

[85] Edward Newell and Derek Ruths. "How One Microtask Affects Another". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI '16. New York, NY, USA: ACM, 2016, pp. 3155–3166. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858490. URL: http://doi.acm.org/10.1145/2858036.2858490.

[86] Jeffrey V Nickerson. "Crowd work and collective learning". In: *Technology–Enhanced Professional Learning: Routledge, Forthcoming* (2013).

[87] George Pepler Norton. *Textile Manufacturers' Bookkeeping for the Counting House, Mill and Warehouse: Being a Practical Treatise, Specially Designed for the Woollen and Worsted and Allied Trades*. Simpkin, Marshall, Hamilton, Kent & Company, 1900.

[88] Oded Nov. "What Motivates Wikipedians?" In: *Commun. ACM* 50.11 (Nov. 2007), pp. 60–64. ISSN: 0001–0782. DOI: 10.1145/1297797.1297798. URL: http://doi.acm.org/10.1145/1297797.1297798.

[89] Gabriele Paolacci, Jesse Chandler, and Panagiotis G Ipeirotis. "Running experiments on amazon mechanical turk". In: *Judgment and Decision making* 5.5 (2010), pp. 411–419.

[90] Sidney Pollard. "Factory Discipline in the Industrial Revolution. 1". In: *The Economic History Review* 16.2 (1963), pp. 254–271.

[91] Alexander J. Quinn and Benjamin B. Bederson. "Human Computation: A Survey and Taxonomy of a Growing Field". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. CHI '11. New York, NY, USA: ACM, 2011, pp. 1403–1412. ISBN: 978–1-4503–0228–9. DOI: 10.1145/1978942.1979148. URL: http://doi.acm.org/10.1145/1978942.1979148.

[92] Hugh Raynbird. *Essay on Measure Work, locally known as task, piece, job, or grate work (in its application to agricultural labour)*. 1847.

[93] Daniela Retelny et al. "Expert Crowdsourcing with Flash Teams". In: *Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology*. UIST '14. New York, NY, USA: ACM, 2014, pp. 75–85. ISBN: 978–1-4503–3069–5. DOI: 10.1145/2642918.2647409. URL: http://doi.acm.org/10.1145/2642918.2647409.

[94] Frank Richards. "Is Anything the Matter with Piecework". In: ASME. 1904.

[95] Jacob August Riis. *How the other half lives: Studies among the tenements of New York*. Penguin, 1901.

[96] D. H. Robertson. "A Narrative of the Coal Strike". In: *The Economic Journal* 22.87 (1912), pp. 365–387. ISSN: 00130133, 14680297. URL: http://www.jstor.org/stable/2221944.

[97] Jakob Rogstadius et al. "An Assessment of Intrinsic and Extrinsic Motivation on Task Performance in Crowdsourcing Markets." In: *ICWSM* 11 (2011), pp. 17–21.

[98] Joel Ross et al. "Who Are the Crowdworkers?: Shifting Demographics in Mechanical Turk". In: *CHI '10 Extended Abstracts on Human Factors in Computing Systems*. CHI EA '10. New York, NY, USA: ACM, 2010, pp. 2863–2872. ISBN: 978–1-60558–930–5. DOI: 10.1145/1753846.1753873. URL: http://doi.acm.org/10.1145/1753846.1753873.

[99] James Rowan. "A Premium System of Remunerating Labour". In: *Proceedings of the Institution of Mechanical Engineers* 61.1 (1901), pp. 865–882.

[100] Donald F Roy. "Work satisfaction and social reward in quota achievement: An analysis of piecework incentive". In: *American Sociological Review* 18.5 (1953), pp. 507–514.

[101] Niloufar Salehi et al. "We Are Dynamo: Overcoming Stalling and Friction in Collective Action for Crowd Workers". In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. CHI '15. New York, NY, USA: ACM, 2015, pp. 1621–1630. ISBN: 978–1-4503–3145–6. DOI: 10.1145/2702123.2702508. URL: http://doi.acm.org/10.1145/2702123.2702508.

[102] Lowell J. Satre. "After the Match Girls' Strike: Bryant and May in the 1890s". In: *Victorian Studies* 26.1 (1982), pp. 7–31. ISSN: 00425222, 15272052. URL: http://www.jstor.org/stable/3827491.

[103] Erica Schoenberger. In: *Environment and Planning D: Society and Space* 6.3 (1988), pp. 245–262.

[104] W Douglas Seymour. "Manual skills and industrial productivity". In: *Production Engineers Journal, Institution of* 33.4 (1954), pp. 240–248.

[105] Aaron D. Shaw, John J. Horton, and Daniel L. Chen. "Designing Incentives for Inexpert Human Raters". In: *Proceedings of the ACM 2011 Conference on Computer Supported Cooperative Work*. CSCW '11. New York, NY, USA: ACM, 2011, pp. 275–284. ISBN: 978–1-4503–0556–3. DOI: 10.1145/1958824.1958865. URL: http://doi.acm.org/10.1145/1958824.1958865.

[106] M. Six Silberman, Lilly Irani, and Joel Ross. "Ethics and Tactics of Professional Crowdwork". In: *XRDS* 17.2 (Dec. 2010), pp. 39–43. ISSN: 1528–4972. DOI: 10.1145/1869086.1869100. URL: http://doi.acm.org/10.1145/1869086.1869100.

[107] Six Silberman. *Stop citing Ross et al. 2010, "Who are the crowdworkers?"*. Mar. 2015. URL: https://medium.com/@silberman/stop-citing-ross-et-al-2010-who-are-the-crowdworkers-b3b9b1e8d300.

[108] Thiago H Silva et al. "Traffic condition is more than colored lines on a map: characterization of waze alerts". In: *International Conference on Social Informatics*. Springer. 2013, pp. 309–318.

[109] Walter Skok. “Knowledge Management: London Taxi Cabs Case Study”. In: *Proceedings of the 1999 ACM SIGCPR Conference on Computer Personnel Research*. SIGCPR ’99. New Orleans, Louisiana, USA: ACM, 1999, pp. 94–101. ISBN: 1-58113-063-5. DOI: 10.1145/299513.299625. URL: http://doi.acm.org/10.1145/299513.299625.

[110] Walter Skok. “Managing knowledge within the London taxi cab service”. In: *Knowledge and Process Management* 7.4 (2000), p. 224.

[111] Yongqiang Sun, Nan Wang, and Zeyu Peng. “Working for one penny: Understanding why people would like to participate in online tasks with low payment”. In: *Computers in Human Behavior* 27.2 (2011). Web 2.0 in Travel and Tourism: Empowering and Changing the Role of Travelers, pp. 1033 –1041. ISSN: 0747–5632. DOI: http://dx.doi.org/10.1016/j.chb.2010.12.007. URL: http://www.sciencedirect.com/science/article/pii/S0747563210003742.

[112] Ryo Suzuki et al. “Atelier: Repurposing Expert Crowdsourcing Tasks As Micro–internships”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 2645–2656. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858121. URL: http://doi.acm.org/10.1145/2858036.2858121.

[113] John C. Tang et al. “Reflecting on the DARPA Red Balloon Challenge”. In: *Commun. ACM* 54.4 (Apr. 2011), pp. 78–85. ISSN: 0001–0782. DOI: 10.1145/1924421.1924441. URL: http://doi.acm.org/10.1145/1924421.1924441.

[114] *TaskRabbit connects you to safe and reliable help in your neighborhood*. Sept. 2015. URL: https://www.taskrabbit.com/.

[115] Jaime Teevan, Shamsi T. Iqbal, and Curtis von Veh. “Supporting Collaborative Writing with Microtasks”. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. CHI ’16. New York, NY, USA: ACM, 2016, pp. 2657–2668. ISBN: 978–1-4503–3362–7. DOI: 10.1145/2858036.2858108. URL: http://doi.acm.org/10.1145/2858036.2858108.

[116] Jaime Teevan, Daniel J. Liebling, and Walter S. Lasecki. “Selfsourcing Personal Tasks”. In: *CHI ’14 Extended Abstracts on Human Factors in Computing Systems*. CHI EA ’14. New York, NY, USA: ACM, 2014, pp. 2527–2532. ISBN: 978–1-4503–2474–8. DOI: 10.1145/2559206.2581181. URL: http://doi.acm.org/10.1145/2559206.2581181.

[117] Jaime Teevan et al. “Productivity Decomposed: Getting Big Things Done with Little Microtasks”. In: *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. CHI EA ’16. New York, NY, USA: ACM, 2016, pp. 3500–3507. ISBN: 978–1-4503–4082–3. DOI: 10.1145/2851581.2856480. URL: http://doi.acm.org/10.1145/2851581.2856480.

[118] Sanford E Thompson. “Time–Study and Task Work”. In: *The Journal of Political Economy* (1913), pp. 377–387.

[119] Steven Tolliday and Jonathan Zeitlin. *Between fordism and flexibility*. Oxford, 1986.

[120] HA Turner. “Trade unions, differentials and the levelling of wages”. In: *The Manchester School* 20.3 (1952), pp. 227–282.

[121] *Uber*. Sept. 2015. URL: https://www.uber.com/.

[122] Rajan Vaish et al. “Low Effort Crowdsourcing: Leveraging Peripheral Attention for Crowd Work”. In: *Second AAAI Conference on Human Computation and Crowdsourcing*. 2014.

[123] Rajan Vaish et al. “Twitch Crowdsourcing: Crowd Contributions in Short Bursts of Time”. In: *Proceedings of the 32Nd Annual ACM Conference on Human Factors in Computing Systems*. CHI ’14. Toronto, Ontario, Canada: ACM, 2014, pp. 3645–3654. ISBN: 978-1-4503-2473-1. DOI: 10.1145/2556288.2556996. URL: http://doi.acm.org/10.1145/2556288.2556996.

[124] Vasilis Verroios and Michael S Bernstein. “Context trees: Crowdsourcing global understanding from local views”. In: *Second AAAI Conference on Human Computation and Crowdsourcing*. 2014.

[125] Nicole Vezina, Daniel Tierney, and Karen Messing. “When is light work heavy? Components of the physical workload of sewing machine operators working at piecework rates”. In: *Applied Ergonomics* 23.4 (1992), pp. 268–276.

[126] Roger D Waldinger et al. “Helots no more: A case study of the Justice for Janitors campaign in Los Angeles”. In: *The Ralph and Goldy Lewis Center for Regional Policy Studies* (1996).

[127] Emily Waltz. “How I quantified myself”. In: *Spectrum, IEEE* 49.9 (2012), pp. 42–47.

[128] Martin L Weitzman. “The new Soviet incentive model”. In: *The Bell Journal of Economics* (1976), pp. 251–257.

[129] Martin L. Weitzman. “The "Ratchet Principle" and Performance Incentives”. In: *The Bell Journal of Economics* 11.1 (1980), pp. 302–308. ISSN: 0361915X. URL: http://www.jstor.org/stable/3003414.

[130] Katherine Woollett and Eleanor A Maguire. “Acquiring “the Knowledge” of London’s layout drives structural brain changes”. In: *Current biology* 21.24 (2011), pp. 2109–2114.

[131] Katherine Woollett, Hugo J. Spiers, and Eleanor A. Maguire. “Talent in the taxi: a model system for exploring expertise”. In: *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 364.1522 (2009), pp. 1407–1416. ISSN: 0962-8436. DOI: 10.1098/rstb.2008.0288. eprint: http://rstb.royalsocietypublishing.org/content/364/1522/1407.full.pdf. URL: http://rstb.royalsocietypublishing.org/content/364/1522/1407.

[132] Donald E Wray. “Marginal men of industry: The foremen”. In: *American Journal of Sociology* (1949), pp. 298–301.

[133] Shao-Yu Wu, Ruck Thawonmas, and Kuan-Ta Chen. “Video Summarization via Crowdsourcing”. In: *CHI ’11 Extended Abstracts on Human Factors in Computing Systems*. CHI EA ’11. New York, NY, USA: ACM, 2011, pp. 1531–1536. ISBN: 978–1-4503–0268–5. DOI: 10.1145/1979742.1979803. URL: http://doi.acm.org/10.1145/1979742.1979803.

[134] Anbang Xu, Shih-Wen Huang, and Brian Bailey. “Voyant: Generating Structured Feedback on Visual Designs Using a Crowd of Non-experts”. In: *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*. CSCW ’14. Baltimore, Maryland, USA: ACM, 2014, pp. 1433–1444. ISBN: 978-1-4503-2540-0. DOI: 10.1145/2531602.2531604. URL: http://doi.acm.org/10.1145/2531602.2531604.

[135] Lixiu Yu, Aniket Kittur, and Robert E. Kraut. “Encouraging “Outside–The–Box” Thinking in Crowd Innovation Through Identifying Domains of Expertise”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 1214–1222. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2820025. URL: http://doi.acm.org/10.1145/2818048.2820025.

[136] Alvin Yuan et al. “Almost an Expert: The Effects of Rubrics and Expertise on Perceived Value of Crowdsourced Design Critiques”. In: *Proceedings of the 19th ACM Conference on Computer–Supported Cooperative Work & Social Computing*. CSCW ’16. New York, NY, USA: ACM, 2016, pp. 1005–1017. ISBN: 978–1-4503–3592–8. DOI: 10.1145/2818048.2819953. URL: http://doi.acm.org/10.1145/2818048.2819953.

[137] M. C. Yuen, I. King, and K. S. Leung. “A Survey of Crowdsourcing Systems”. In: *Privacy, Security, Risk and Trust (PASSAT) and 2011 IEEE Third Inernational Conference on Social Computing (SocialCom), 2011 IEEE Third International Conference on*. Oct. 2011, pp. 766–773. DOI: 10.1109/PASSAT/SocialCom.2011.203.

Graveyard of old paragraphs

0

One of the emergent properties of micro–tasks has been the relative cost of *finding* worthwhile tasks. The research community has documented and to some extent attempted to intervene in the discovery of worthwhile tasks [20]. Cosley et al. attempts to address this by directing workers to tasks through "intelligent task routing" [22]. Much of this work and the work at the periphery of this space, then, has focused on minimizing the amount of time that people need to spend doing anything other than the work for which they are paid.

What we take away from this and the previous set of work is that the value of adopting crowdsourcing for any particular task seems to be mediated by two questions: 1) How long does it take to train workers to do the work in question? and 2) How long does it take for the worker to do the work? Minimizing these criteria has become the overarching motivation of the crowdsourcing work design community [19, 85]

0

FLEXIBILITY NOTES

A number of researchers have identified worker attrition, variability of worker performance, and uncertainty about good versus bad–faith actors as open questions of crowdwork [30, 48]. [al2: We can and should discuss the distinction between presumably "bad faith" workers & workers who are merely responding in kind to bad requesters — and the broader questions surrounding the roles that requesters as well as workers should play — but let it suffice to say that requesters have been trying to understand and manage what appears to them as inconsistent work. Their ways of responding to that variance in work quality has largely involved making the work more flexible and resilient to work (although some work has gone into investigating the causes, rather than treating the symptoms)]

Earlier we discussed Cheng et al.'s work measuring the impact that interruption has on worker performance [19]. This work illustrates a broader sentiment in both the study and practice of crowdwork, that microtasks should be designed resiliently against the variability of workers, fully exploiting the abstracted nature of each piece of work [49, 68, 122]. That is to say, micro–tasks should be designed such that a single worker's poor performance, or a good worker's sudden departure, does not significantly impact the agenda of the work as a whole. While Cheng et al. found costs with breaking tasks into smaller components in the form of higher cumulative time to complete (albeit much shorter real time to complete, owing to parallelization), Lasecki et al. found that at least *some* performance can be recouped by stringing similar tasks together [19, 68, respectively].

Krishna et al. take a different approach; by "embracing error" and forming models describing the latency of workers in classifying objects at rapid speeds, the authors offer orders–of–magnitude improvements in various binary classification tasks [63]. And rather than building tasks to *tolerate* worker drop–off and attrition, some researchers have designed work predicated on the expectation of it instead: Celis et al. describe ways of assigning tasks in such a way that crowd workers would never be given enough information to piece together sensitive information about any single topic [15].

The work thus far seems to attempt to maximize the quality of work among workers through various means: 1) Identifying "bad" workers (fraught with problems as this characterization is) [30], 2) Designing tasks with break points to facilitate the on–boarding and off–boarding that happens anyway [19], and 3) Expecting certain levels of attrition and incorrectness and using that variability to their advantage [63].

Flexibility has been explored through the lens of Fordism, perhaps best illustrated by Tolliday and Zeitlin's treatment describing turnover rates rising above 300% in the decade leading to the introduction of the assembly line in 1913. Specifically, the utilization of "... 'semi–special' machine tools which could be adapted [and] ... added flexibility through seasonal layoffs for production workers and the use of piece rates ... rather than a day wage system" [119].

In the field of piecework, the research covering this topic has both explored a breadth of tasks that might be rendered doable by piecemeal workers *as well as* longitudinally documented the success of these approaches. Here, we [al2: ...?]

[0] Here, Hu's work, saying of assembly line work that "it is assumed that men are of equal ability and every man can do any of the *n* jobs", parallels the approach that dominated early research into crowd work — namely, using non–expert crowds for complex work [46]. This mindset in Hu's analysis, and indeed the study of factory and mass manufacturing labor through the 20th century, substantively owes its existence to scientific management and the rigorous decomposition of work into tasks, discussed earlier, and persists to this day as it colors researchers' goals and objectives in the study and design of crowd work.

Piecework's influence on the abstraction of work into tasks, described above, is more than just caused by the decomposition of work; work abstraction itself makes it possible for workers to come and go flexibly, prompting work requesters to consider ways to design these now discrete tasks in ways that maximize flexibility, both by allowing (and even anticipating) some inconsistency in worker availability *and* allowing and anticipating some inconsistency in the quality of the work output itself. It's to this area that we now turn our attention.

Piecework has seen work along this dimension spanning decades; Thompson investigate some of the ways that construction can benefit from the principles of scientific management. Thompson's thesis asserts that task work is predicated on the accurate scientific management of work, including the "miscellaneous tasks". Thompson argues — as early as 1913 — that "...one may be challenged to find any class of work involving labor either indoors or out–of–doors where tasks cannot be fixed by proper time–study" [118].

Broken down in this way, work could grow to unprecedented scales, but the quality of the work would remain relatively variable [83]. Textile work being a salient example, it took time for workers to acquire sufficient skill to do every

aspect of the work so that the garment would be accepted by the company soliciting that work [125].

A compelling solution emerged in the early 20th century to break tasks down into discrete, manageable routines that could be taught relatively easily, and whose work output could be evaluated in abstraction from the rest of the work [4]. In Ford's assembly line, this meant that workers were not responsible for building a whole car, but a single very narrowly defined action that needed to be done on every car [74]. By the mid–20th century, Schoenberger writes, "... the intensification of the labor process is argued to have hit mental, physical, and social limits." [103].

This approach, "Fordism" (and its better–known contemporary "Taylorism" of similar ethos), can be seen today in crowd work and on–demand labor through the application of micro–tasks. Teevan, Iqbal, and Veh highlight some of the advantages of breaking work into pieces, facilitating evaluation and parallelization [115]. By decomposing and recomposing tasks, and in particular by assigning similarly natured work to the same workers, workers could become "experts" in a small aspect of the work that they did, speeding their work dramatically [68]. Perhaps more important, however, was that the breaking down of work into tasks has made it more practical to evaluate work at each stage [97].

So how does this affect crowdwork?

The work we've seen so far

- worst case: assembling iPhones (extant)
- average case: railroad workers and assembly lines
- high (complexity) case:

0

CASES NOTES

Cheng et al. found that microtasks — though not necessarily *faster* than "macrotasks" — yield higher quality work, particularly when that work is susceptible to frequent interruptions [19].

What forms of work design and worker management are viable?

- researchers have looked at how to increase worker productivity (e.g. finding the maximal speed at which gig workers can be expected to work before making errors) [18].
- we've also seen people "embrace error" [63].
- still other research has looked into ways to sandbox workers from the context of their work
- but scholarship looking into the design and management of work and workers isn't new; lots of research into getting pieceworkers to do work more quickly [104].
- Researchers have even asked the age old question of *what motivates* pieceworkers (echoing similar research on Wikipedia and Mechanical Turk) [100, 88, 56]

What will work and the place of work look like for workers?

The metaphorical mechanics of these dynamics are still at play; workers and managers continue to interact in adversarial manners, despite substantive work into aligning the motivations of workers and requesters

The existing body of research has shed light on on–demand labor from various perspectives, and revealed a number of topics that, through our framing, are clearly situated together. Those topics are, at a high level, as follows:

1. the **processes** involved in making work into tasks, or discretization;
2. the outcomes (and indeed the **fallout**) of that discretization, both on the work itself as well as the workers; and finally
3. the **relationships** between workers and requesters of the work — both *cooperative* and *adversarial* cases.

The Fallout of Crowd Work

, Irani and Silberman point out the disillusion that companies such as Amazon foster on platforms for work like AMT (see also Salehi et al.'s work continuing in the spirit of this observation to generate collective action to improve worker conditions) [52, 101]. Lee et al. find similarly that workers on gig work platforms are frustrated by the systems on which they work, to say little of the policies which these systems enforce [71].

We discussed the benefits of flexibility (both in the sense of having arbitrary workers perform tasks and in the sense that we can design tasks to be more resilient to poor work) in the previous section. It's from that point in the literature that we turn our attention to the perhaps unintended effects of crowd work and the affordances for transience that we build into this mode of work. We'll address two major areas of work under this subject: 1) **??**; and 2) **??**.

Low Pay

Horton and Chilton identified problems with crowd work wages relatively early on, attempting to address this imbalance from a behavioral economic perspective — that is, identifying and presenting a model that describes a worker's "*reservation wage*" [43]. This work has largely informed much of the research into and practice of estimating crowd work compensation [105, 89].

But we turn to Irani and Silberman's discussion of "*Turkopticon*", a system they designed to interrogate worker invisibility and to promote better wages across several dimensions [52]. Of particular relevance here, Irani and Silberman call to attention that "Turkers" are ultimately vulnerable to wage theft and pay rates that translate to well under minimum wage. Returning to Horton and Chilton, we find that the median "reservation wage" in 2010 was $1.38, while the mean was $3.63 [43].

Understanding workers' motivations given these conditions has thus become a goal for some researchers [9]. Sun, Wang, and Peng conclude that "... solvers participate in online tasks not only for money but also for enjoyment or the sense of self–worth" [111]. This might have rung true in 2011, and certainly corroborates Ross et al.'s findings after investigating "who are the crowdworkers", but as Silberman points out "we [have since] learned that most tasks on AMT are done by a small group of professional Turkers..." [98, 107].

Now, Irani and Silberman and later Salehi et al. cite insufficient pay as a central point of frustration among workers, via Irani and Cushing's contributions in this space [101, 50, 24, 52].

On–demand workers were not the first to be exploited along the dimension of low pay rates. Frustration over low (and declining) pay was one of the chief grievances among then nascent British labor unions in the early 20th century [120]. This, Ebbinghaus and Visser argued, fueled the rocketing union membership rates through the mid–20th century until 1980 (to which we'll return when we discuss Levi et al.'s reexamination of labor unions) [26, 73]. This realization has similarly fueled a body of research into the various incentive structures available to piecework employers [100].

The parallels between the complaints of low pay among crowd workers and other on–demand workers and the pieceworkers and later factory workers in the 20th century are inescapable. We argue further that the *causes* here — work decomposition, work abstraction, and flexibility — lead inexorably to low and declining pay for workers. Moreover, we point out that low pay leads to other negative outcomes both in on–demand work as well as in piecework and on assembly lines.

Variable quality work

Researchers have struggled with what we might generously call work of "variable quality" along two dimensions. The first, to use the characterization of one of these contributions, we can call "understanding malicious behavior" [30]. While some work has cast workers as "malicious" or at least adversarial parties, the evidence thus far suggests that workers behave in unexpected ways as they attempt to assert some control over their interaction with the system (a topic of discussion to which we'll return later) [71]. The second dimension of research in this space generally attempts to eke out the highest quality work possible from workers given the apparent difficulty in predicting work outcomes [63].

The effect low wages have had on piece work and factory workers is well–known; Gantt discuss this exact mechanism in his book on "... where there is no union, the class wage is practically gauged by the wages the poor workman will accept, and the good workman soon becomes discouraged and *sets his pace by that of his less efficient neighbor*, with the result that the general tone of the shop is lowered" (emphasis added) [31].

This research is similar to, but subtly different from, the notion of the "market for 'lemons"' which Fort, Adda, and Cohen discuss; specifically, Akerlof's writing of a "market for 'lemons"' describes a marketplace where the quality of the product or service is unknown to the buyer [29, 2]. The effect of this *perceived* uncertainty is that the *actual* trustworthiness drops precipitously as all of the consistent, reliable, high–quality workers capable of leaving these markets do so, leaving only the ones who cannot or will not establish their trustworthiness.

Relationships Between Workers and Managers

Suffice it to say that poor pay and poor work are linked, and that we should not be surprised to find this relationship play out online as strongly as it does offline. But the poor treatment of workers by managers — both human and algorithmic — do more than affect the economic relationships between workers and employers. Here, then, we turn to examine this facet of on–demand work and how these dynamics strikingly replicate the relationships researchers in labor advocacy encountered in the study of piecework and factory work.

This topic can be condensed into two major areas: 1) external (scientific) management, and the evaluation of workers as functional modules; and 2) the consequential resistance workers express due to their perceived alienation and distance from managing forces.

External Management

We discussed Fordism and Taylorism earlier in our discussions of **??** and **??**, but here the core of these paradigmatic views — the scientific management of work — becomes relevant. We use "external" here instead of "scientific", however, to more broadly capture the disconnect between managers and workers. By describing it as thus, we can touch on the relationship that workers have with *researchers*, as well, even though that work is not strictly — or just not exclusively — of the same nature as the management and experience as when interacting with requesters.

First, intuitively, the variable–quality work we discussed previously has led to a large and growing body of research attempting to evaluate workers' performance and error rates across numerous dimensions; for example, Cheng, Teevan, and Bernstein explore the error rates of workers by operating on a sliding scale giving workers varying amounts of time to accomplish micro–tasks [18]. Irani and Silberman describe the treatment of workers as sorts of "human APIs" that can, importantly, be rigorously evaluated [51]. Gevins and Smith began to explore the neurophysiological effects of cognitively demanding tasks on workers, informing crowdsourcing research by suggesting the use of cognitive load assessments such as NASA Task Load Index surveys to evaluate workers pre and post–tasks [63, 18].

External management comes in other forms than scientific, as previously mentioned. Researchers in particular have noticed that their relationships with on–demand workers are, at the least, complex. Irani and Silberman point out that their relationships with Turkers are highly complex; specifically, their interactions with field sites in which they work as designers and mediators of change influence the relationships they have with Turkers [51].

The scientific management of pieceworkers has been well–studied under the umbrella of assembly line research, and even physiological study of pieceworkers closely resembles the research into cognitive loads and stress levels that we discussed among on–demand crowd workers [46, 10]. Even the complicated relationships between observers and workers themselves are not necessarily new; Riis's photodocumentary of pieceworkers has even been re–examined through an exercise

asking crowd workers to photograph themselves for similar purposes as Riis's — to document and humanize an otherwise abstracted, invisible workforce [3, 52, 95].

Similarly, Pollard's words on the punishment factory workers faced — for example, that "unsatisfactory work was punished ... by fines or by dismissal" — seems especially relevant given the fears we now know to be ubiquitous on platforms such as AMT, Uber, and other on–demand markets [90, 71, 101, 52, 80].

Resistance

It shouldn't surprise us, then, that workers have resisted the management imposed on them both by other people and their systems, often without recourse or opportunity for feedback, let alone substantive input. Indeed, Lee et al. discover of Uber drivers that many toggle their availability to avoid being dispatched to more distant locations, resisting the intent of the designers of the systems and their "algorithmic and data–driven management" [71].

Resistance has sometimes been more coordinated, as well; we see this in Irani and Silberman's coverage on *Turkopticon* as workers collectively accumulated information about requesters, and in Salehi et al.'s work on *Dynamo*, which generated "Guidelines for Academic Requesters" written by crowd workers [52, 101].

Resistance against managers in piecework and factory labor settings are deeply well–explored, but perhaps the most relevant case study to draw on here is to be found in Waldinger et al.'s case study of "Justice for Janitors", where marginalized workers managed to raise awareness for their plight and secure support for badly needed reforms [126]. The achievements of labor advocacy groups such as labor unions as resistant, even adversarial organizations counter–balancing the management is somewhat well–understood [38, 23]. We argue that these threads of resistance against management in various forms are in fact one.

0

THE BLEAK FUTURE OF CROWD WORK

We've traced a path from piecework itself through the processes that describe the design and implementation of piece work and crowd work as part of the same thread; in tracing this process, we touched on the relationships between decomposition, work & worker abstraction, flexibility, and followed through both the general fallout of crowd work in the research community as well as the fallout between workers and the managers and other external parties — including researchers.

Throughout these case studies, we have pointed out the parallels between the contemporary research in on–demand labor and the much larger body of research constituting our understanding of topics such as piecework, factory work, and laborer relations. If we agree that this framing is useful and informative, then several topics emerge as relatively open questions in the study of crowd work and on–demand labor. Two of the most pressing questions are 1) the beginnings of factories, and 2) the decline of relevance of worker advocacy organizations. We will discuss those questions here.

The beginnings of factories

We established earlier that abstracted work and low wages tend to result in variable outcomes, which presents problems for employers. Historically, this is what led to factories; by employing a cohort of known workers, we can be reasonably assured that the quality of the work will be better than random. Furthermore, we can invest more resources in training workers and get workers to do more complex work with more context.

Some research already looks at research such as investing in workers, and informally, we know that this happens among industry requesters [47, 25]. AMT, meanwhile, offers requesters the ability to create tasks which are not just hidden from unqualified workers by default, but completely. Requesters have taken to using lists of worker IDs which reference workers who have proven their reliability, representing a sort of proto–organization of loosely connected workers.

This, then, suggests that the beginning of the regularization of workforces — a sort of coalescence of factories — is already happening. If our framing of on–demand labor is accurately describing an underlying relationship with piecework, then we should watch for the emergence and popularization of persistent teams of workers.

The decline of advocacy organizations

The rise of labor unions in the 20th century seems to have been precipitated by severely unjust conditions imposed on workers in factories and elsewhere [26]. Incidents broadly describing this dynamic can be found in research on AMT [52, 101]. If these are prototypical labor advocacy organizations of contemporary on–demand work, the next question we should look to is if — and indeed *how* — these institutions might face challenges in the future.

For insight on this, we return to 2009's study of labor unions, and identify that "Scholars who evaluate union governance by procedural criteria generally find that oligarchy tends to arise and persist even when democratic procedures are in place" [73]. Indeed, Levi et al. writes about the general perception that labor unions were either This perception already appears to be emerging in digitally mediated peer–governed organizations, as Keegan and Gergle and others have illustratively documented [7, 57]. If these organizations and others are to avoid the same fate that labor unions faced, they should take care to study this phenomenon and attempt to avoid it.

IMPLICATIONS FOR DESIGN

If it's agreed that the major topics we've discussed thus far are related and — at least to *some* extent — precipitated in the fashion we argue, then we have a rare opportunity as researchers, and as agents of change in the communities we study, to affect change on the dynamics of crowd and on–demand work as they continue to develop.

Without claiming to have easy, cut–and–dry solutions to these problems, we can nevertheless bring to attention a number of critical opportunities to learn from historical parallels in piecework and factory labor, and make informed decisions regarding whether (or indeed how) we may want to influence outcomes. The challenges we bring to attention here are as

follows: 1) codifying investment toward collective goods into the designs of systems; 2) (re–)decentralizing the internet; and 3) enabling reputation transferral.

Codify the common good

As Lessig points out in his book, digital media give designers the opportunity to design and build into the systems policies and practices to contribute to the collective benefit of the people therein [72]. Historically, the confluence of forces Lessig describes would ultimately result in outcomes such as benefits for workers, funds for sick leave and vacation, and other conveniences. The transient nature of on–demand work would seem to problematize this arrangement, but we can discuss and explore the viability of building into systems the mechanisms necessary to save a portion of payment from every gig, record taxable income, or myriad other generally administrative tasks automatically.

Decentralize the internet — again

Digitally mediated on–demand labor markets have historically been insular and incompatible with one another, forcing workers either to choose one or juggle participation in these markets with great difficulty. An "API" for on–demand labor markets could make it possible for any person or organization to instantiate their own marketplace and inter–operate with. This can be changed, and indeed must, if we are to realize the hopes of early researchers who advocated the democratizing nature and power of the internet [5, 66].

Deal with reputation

Reputation systems in on–demand labor markets are fundamentally broken. To say nothing of the fact that information workers (such as those on AMT) can't transfer their reputations to qualitatively different forms of labor like driving–for–hire (e.g. Uber), even within the same industry it's currently not feasible for workers to transfer their reputations or other information from one place to another. This affects more than the reputation and trustworthiness of workers; accounting for things such as taxes, benefits, etc. . . is all but left to the individual workers, who struggle with myriad bureaucratic obstacles. We can design systems that facilitate the aggregation and, more importantly, the transferral of reputation, income, and other features of work.

DISCUSSION

We've discussed a number of aspects of on–demand work that offer parallels with historical piecework. Perhaps more importantly, we've hopefully demonstrated that the dynamics we observe in on–demand work are interrelated and follow from one another just as necessarily as they did in the development and maturation of piecework and factory work through the 20th century. This framing on on–demand work should, we hope, provide us with the necessary historical context to make better–informed design decisions about how we want "the future of crowd work" to look.

CONCLUSION

Kittur et al. discussed many of the challenges and problems in crowd work in 2013, but didn't necessarily situate the notion of crowd work in a broader context. This paper attempts to fill that gap, and in doing so hopes to give the research community theoretical grounding to work with and within on–demand labor more successfully. But more than that, we hope to have addressed important questions to inform how we actually might make crowd work a career in which we want our children to work.