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

With growing attention toward on–demand labor — ranging from the "sharing economy" to information work — scholars have made connections to various frameworks and mechanisms such as worker advocacy, empowerment, and Taylorism, to make sense of our observations of on–demand work and the workers that power this movement. We argue that the literature surrounding "piecework" informs and even predicts both the contributions that have been made toward the development of on–demand labor and crowd work as well as the fallout among workers and researchers with regard to the disillusionment and alienation of work.

After evaluating this framing through a series of case studies, we look to the future to identify worthwhile questions and points of inquiry, such as the movement toward factories, that researchers in social computing should consider as we attempt to anticipate and perhaps shape the future of work.

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 where the statuses of workers have become so fleeting that these workers (known colloquially as "Turkers") have been described as "transient" [25, 43, 35]. The realization that tasks can be accomplished by directing and managing this crowd 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, seemingly ephemeral labor force. Researchers in particular have taken to the space in earnest, finding opportunities to enable new forms of work as well as using Turkers as representative populations of the public [3, 64, 50].

The many sites of work replicating and extending on the general style of labor popularized by AMT have predominantly involved work done on a computer or involving the human processing of data, leading many to call this "information work" [24, 60, 22, 49]. Howe defined "crowdsourcing" in 2008 as "taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call" [18].

In the years since, scholars have generated taxonomies for the work done by many distributed workers in an attempt to better categorize and reason about the many forms of work done on information work platforms such as AMT, oDesk, etc... [77, 14, 51]. We add that, under Howe's constraints, even *more* new forms of work fall squarely under the metaphorical umbrella we collectively call "crowdsourcing".

Indeed, this on–demand workforce has sparked interest across industries ranging livery (driving for hire, for example Uber), house–cleaning (Handy), and generalized services (TaskRabbit) [71, 17, 65]. Today, a rapidly growing transient workforce is forming, itself assembling piece–by–piece as industries and researchers find yet more unexpected ways to benefit from a latent pool of previously vetted workers [62].

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 [55, 61]. Some of this research has been motivated by the realization of the sociality of gig work, and the frustration and disenfranchisement that these systems embody [24, 57]. Other work has focused on the outcomes of work, reflecting on the resistance workers express against digitally mediated labor markets [37].

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 of scholarship:

1. What are the limits of crowdsourcing? Perhaps more tightly constrained, what can and cannot be done by crowd workers? [52, 63, 28, 76, 75, 31, 45, 16];

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

2. What forms of work design, and worker management and arrangement, are viable? [3, 7, 41, 32, 36, 6, 8, 46]; and
3. What will work and the place of work look like for the workers? [24, 23, 57, 15, 5, 42]

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, 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 Kittur et al. referenced crowd work as "piecework" briefly as a loose analogy to the form of work emerging at the time [30].

But more than this, the framing of on–demand labor as piecework (re–instantiated) allows us to attempt to make sense of the broader research on this new form of work by evaluating this work through a much more refined lens. 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...

MAJOR RESEARCH QUESTIONS

[al2: 4 paragraphs on what happened in the above contexts; 2 paragraphs on best/worst outcomes & why; ??? paragraphs on predictions for crowdsourcing]

What are the limits of crowdsourcing?

Research in crowdsourcing has spent the better part of a decade exploring ways of growing the limits of crowdsourcing and finding the boundaries of crowd work and microtasks; identifying challenges to this form of labor, overcoming them through novel designs of work–flows and processes, and repeating the process [3]. 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) Decomposition, 2) Work Abstraction, and 3) Flexibility. As we'll discuss these dimensions, exploring 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.

[al2: At this point I'm trying to retain as much of the old content as possible, but if the next few sections seem like I'm trying too hard to be lazy, say so and I'll do a rewrite rather than refactoring.]

Decomposition

Crowdsourcing has explored the decomposition of work for the better part of a decade; Kittur et al. specifically drive at this goal by addressing the possibility of crowdsourcing complex work [29]. 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 [10].

Much of the research in the space of designing crowd work has sought to illustrate the potential to take highly creative or skilled work and generate high–quality results. Perhaps the most notable case study here can be found in Retelny et al.'s *Foundry*, which employed "flash teams" to achieve expert–level outcomes via thoughtful decomposition of work as "modular tasks" [52].

Research exploring the decomposition of work more generally — that is, without the constraint of an employer/requester directing workers — has since emerged as well. Teevan, Liebling, and Lasecki further push the boundaries of decomposed work, exploring "selfsourcing", and further this work with Teevan et al. [67, 68]. While some of this work doesn't strictly fall under "crowdsourcing", the topicality of this broader body of work will become more apparent as we trace the parallels of crowdsourcing with piecework.

The work described thus far has illustrated myriad ways that we can manage workers for the purpose of accomplishing complex tasks with rapidly sourced workers from across the world. Critically, the work's defining characteristic involves the use of the Internet as a medium both to coordinate workers, as well as to do the work itself. But research into the "decomposition" of work more generally illustrates the same concepts of work that "Taylorism" and scientific management sought to embody — Silberman, Irani, and Ross in particular foresaw this danger and warned of it in 2010 [30, 60, 47]. In both the historical and contemporary cases of decomposed work, work was, at least initially, distributed in the form of tasks to the homes of workers; Riis captured this in in 1901 [53].

Following this thread of work, it may be said that much of the work in crowdsourcing has found ways of "vertically slicing" work such that each person is responsible for as small a task as can be made reasonable — taking a minute of audio, for instance, and transcribing just that. The aforementioned research has found many novel ways to slice work, communicate different amounts of context of work from one worker to the next, etc... but fundamentally they follow similar patterns. It's through this lens that we see the echoes of piecework.

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" [69].

Broken down in this way, work could grow to unprecedented scales, but the quality of the work would remain relatively variable [44]. 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 [74].

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 [1]. 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 [40]. By the mid–20th century, Schoenberger writes, "... the intensification of the labor process is argued to have hit mental, physical, and social limits." [58].

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 [66]. 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 [34]. Perhaps more important, however, was that the breaking down of work into tasks has made it more practical to evaluate work at each stage [54].

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:

Work Abstraction

Decomposition allows requesters to assign tasks without concern for the broader context. While we'll discuss this aspect of crowd work more critically later, it's worth pointing out that discrete blocks of work containing all the relevant context for a worker allows workers to engage with virtually any component of work without worrying that their lack of higher–level awareness of the goals of the requester might negatively affect their work.

Chilton et al. perhaps best illustrated this with *Cascade* by demonstrating that it's possible to break certain classes of tasks apart in such a way that they yield taxonomies of various subjects, a task previously thought to be safely within the domain of expert workers with top–down awareness of the context of the work as a whole [11]. Verroios and Bernstein further illustrate this potential by forming a task one might consider highly contextually dependent — summarizing the contents of a movie — in such a way that crowd workers could contribute small pieces of work without needing to know the content of the rest of the project [73].

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 [19]. 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.

Flexibility

Earlier we discussed Cheng et al.'s work measuring the impact that interruption has on worker performance. This work both points to and embodies a broader sentiment in both the study and practice of crowd work that microtasks should be designed resiliently against the variability of workers, fully exploiting the abstracted nature of each piece of work [21, 34, 72]. That is to say, micro–tasks should be designed such that a single worker's poor performance, or a good worker's sudden departure, would not significantly impact the agenda of the work as a whole. While Cheng et al. identified 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.

Given the importance of consistent work results, one might intuit that requesters would prefer high–quality workers who can be relied upon to be available (even for contextually independent tasks), which would appear to contradict the benefits of

flexibility already discussed; requesters have thus made significant headway toward "embracing error" to allow requesters to maximize the benefits of a flexible, even transient, workforce.

Krishna et al. offer orders–of–magnitude improvements in various binary classification tasks on the principle that diverse workers complete these tasks in order to accurately inform the model on the variety of delays in response times. And rather than building tasks to *tolerate* worker drop–off and attrition, some researchers have designed work predicated on the expectation of this phenomenon: 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 [7].

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" [70].

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

Points to make:

- Blossoming of piecework
  - high point: consultants?
  - most cases: auto workers/etc...
  - worst case: sweatshops (especially in developing nations)
- what led to these outcomes?
  - "consultant" work came out well because the work was complex; this made it difficult to turn into a mass market commodity. We see consultants ranging skill levels like oDesk (implementing modules) to Accenture (on–demand teams of consultants).
  - auto workers, working in settings where capital couldn't be moved as easily found themselves in the same workspace as a direct — if multi–stepped — result to the benefits of putting people in the same place to consolidate resources. Moreover, workers had leverage over factory owners as a result of that consolidated capital; operating equipment required training.
  - sweatshop workers fared the worst, for reasons that may seem obvious with hindsight. Source materials for textiles are easier to ship than mechanical components such as engines, making it easier for factories to relocate to developing nations (where cost–of–living, and consequently wages, would be lower). As wages, CoLAs, and QoL rise, workers begin asking for (and later demanding) higher wages and better conditions. But where the auto workers have leverage, textile workers find only a precarious economic balance now tipped by their collective action, spurring manufacturers to move to a new locale

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) [9].
- we've also seen people "embrace error" [31].
- 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 [59].
- Researchers have even asked the age old question of *what motivates* pieceworkers (echoing similar research on Wikipedia and Mechanical Turk) [56, 48, 26]

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 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 [20, 12]. 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 [13]. Incidents broadly describing this dynamic can be found in research on AMT [24, 57]. 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" [39]. 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 [4, 27]. 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 [38]. 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 [2, 33].

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.

References

[1] 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.

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

[3] 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.

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

[5] 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.

[6] 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.

[7] 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.

[8] 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.

[9] 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.

[10] 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.

[11] Lydia B Chilton et al. “Cascade: Crowdsourcing taxonomy creation”. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM. 2013, pp. 1999–2008.

[12] 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.

[13] 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.

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

[15] 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.

[16] 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.

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

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

[19] 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.

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

[21] 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.

[22] Lilly Irani and M. Six Silberman. “From Critical Design to Critical Infrastructure: Lessons from Turkopticon”. In: *interactions* 21.4 (July 2014), pp. 32–35. ISSN: 1072–5520. DOI: 10.1145/2627392. URL: http://doi.acm.org/10.1145/2627392.

[23] 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.

[24] 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.

[25] 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.

[26] 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.

[27] 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.

[28] Joy Kim and Andres Monroy-Hernandez. "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.

[29] 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.

[30] 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.

[31] 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.

[32] 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.

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

[34] 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.

[35] 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.

[36] 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.

[37] 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.

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

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

[40] 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.

[41] 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.

[42] 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.

[43] 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.

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

[45] 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.

[46] 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.

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

[48] 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.

[49] Judith S. Olson and Gary M. Olson. "How to Make Distance Work Work". In: *interactions* 21.2 (Mar. 2014), pp. 28–35. ISSN: 1072–5520. DOI: 10.1145/2567788. URL: http://doi.acm.org/10.1145/2567788.

[50] 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.

[51] 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.

[52] 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.

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

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

[55] 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.

[56] 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.

[57] 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.

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

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

[60] 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.

[61] 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.

[62] Aaron Smith. *Shared, Collaborative, and On Demand: The New Digital Economy*. May 2016.

[63] 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.

[64] 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.

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

[66] 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.

[67] 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.

[68] 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.

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

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

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

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

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

[74] 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.

[75] 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.

[76] 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.

[77] 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.