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

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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.

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INTRODUCTION

The past decade has seen a flourishing of on–demand work, motivated by the framing of work as contextually abstract and therefore interchangeable and modular. The statuses of many of these workers (known colloquially as "Turkers") have become so fleeting that they have been described as "transient" [28, 47, 38]. 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, 63, 52].

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" [27, 59, 25, 51]. 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" [20].

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... [76, 15, 53]. We add that, under Howe's constraints, even *more* new forms of work fall squarely under the metaphorical umbrella we collectively call "crowdsourcing".

This matters because... Indeed, this on–demand workforce has sparked interest across industries ranging driving for hire (for example Uber), house–cleaning (Handy), and generalized services (TaskRabbit) [70, 19, 64]. 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 [61].

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 [56, 60]. 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 [27, 57]. Other work has focused on the outcomes of work, reflecting on the resistance workers express against digitally mediated labor markets [40].

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:

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1. What are the limits of crowdsourcing? Perhaps more tightly constrained, what can and cannot be done by crowd workers? [54, 62, 30, 75, 74, 33, 49, 18];
2. What forms of work design, and worker management and arrangement, are viable? [3, 8, 44, 34, 39, 7, 9, 50]; and
3. What will work and the place of work look like for the workers? [27, 26, 57, 17, 5, 46]

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 2013 referenced crowd work as "piecework" briefly as a loose analogy to the form of work emerging at the time [32]. 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.

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. 3, 54, 31]. 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) Achieving greater complexity , 2) Slicing work smaller , and 3) Volatile quality and availability? How much can you deal with?. 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

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 [31]. 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 [36, 45, 30].

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 [31, 54, 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 [54].

The research into piecework makes the case that piecework has been limited principally by the challenges of human management and oversight. Graves, who describes piecework as "... based on examination of various shop jobs, which included calculation of the standard time and compensation for each task", argues that piecework must be rigorously evaluated at a time that demands *other people* perform the evaluation. Graves later enumerates some of the roles required to facilitate

piecework in the early 20th century: "... piecework clerks, inspectors, and "experts"..." [16]. This criterion strictly limits the extent to which piecework can grow in complexity; it must, for instance, be quickly evaluable by another person.

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" [6]. 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" [16]. 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.

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. Given the flourishing of on–demand labor platforms such as Uber, Amazon Mechanical Turk, 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 [41].

topic sentence here. Teevan, Liebling, and Lasecki push the boundaries of decomposed work, exploring "selfsourcing", and further this work with Teevan et al. [66, 67]. While some of this work doesn't strictly fall under "crowdsourcing", the [scientific] management of the self as a worker (of sorts) will prove relevant as we trace the literature surrounding piecework.

Slicing work smaller

Decomposition allows requesters to assign parallelized tasks without undue concern for the broader context of the work. The earlier example of transcribed audio is admittedly a carefully curated one — used to illustrate the ability to parallelize work across as many workers as there are tasks — but even in this case problems arise; breaking an hour–long interview into 3,600 1–second–long tasks would seem to make it impossible to do the tasks for lack of *context*, but the other extreme (one hour–long block) offers no performance improvement over conventionally sourced work.

The question, then, becomes about how to break tasks down as much as possible (as discussed in the previous section) without losing the necessary context to do a task. Stated another way, how can we design work so that as little context as possible is provided, without leaving out context or information necessary to complete the task? As Verroios and Bernstein frame it, "the crowd must be able to act with global understanding when each contributor only has access to local views" [72].

While some research has attempted to increase workers' awareness of the work they do in apparent efforts to yield higher quality work, others have turned this constraint of crowdwork into a feature — the abstraction from the work itself appears to allow requesters to engage workers in work with — for instance — sensitive, confidential or otherwise personally identifying information. We will discuss these and other avenues of research here.

Cascade demonstrated that it's possible to break certain classes of tasks apart in such a way that they yield taxonomies of various subjects, a task generally thought to be sufficiently complex that only expert workers with top–down awareness of the task — in this case, with awareness of all the constituent colors — could complete the task [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 [72].

Volatile quality and availability? How much can you deal with?

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 [14, 23]. [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 [10]. 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 [24, 37, 71]. 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 [10, 37, 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 [33]. 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 [8].

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) [14], 2) Designing tasks with break points to facilitate the on–boarding and off–boarding that happens anyway [10], and 3) Expecting certain levels of attrition and incorrectness and using that variability to their advantage [33].

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" [69].

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

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 [21]. 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" [68].

Broken down in this way, work could grow to unprecedented scales, but the quality of the work would remain relatively variable [48]. 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 [73].

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 [43]. 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 [65]. 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 [37]. Perhaps more important, however, was that the breaking down of work into tasks has made it more practical to evaluate work at each stage [55].

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:

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 [22, 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 [27, 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" [42]. 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, 29]. 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 [41]. 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, 35].

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] 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.

[7] 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.

[8] 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.

[9] 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.

[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] 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.

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

[16] 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.

[17] 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.

[18] 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.

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

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

[21] 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.

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

[23] 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.

[24] 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.

[25] 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.

[26] 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.

[27] 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.

[28] 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.

[29] 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.

[30] 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.

[31] 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.

[32] 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.

[33] 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.

[34] 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.

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

[36] 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.

[37] 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.

[38] 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.

[39] 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.

[40] 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.

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

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

[43] 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.

[44] 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.

[45] 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.

[46] 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.

[47] 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.

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

[49] 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.

[50] 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.

[51] 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.

[52] 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.

[53] 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.

[54] 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.

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

[56] 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.

[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] 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.

[60] 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.

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

[62] 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.

[63] 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.

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

[65] 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.

[66] 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.

[67] 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.

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

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

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

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

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

[73] 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.

[74] 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.

[75] 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.

[76] 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.