

A REVIEW OF PIECEWORK

The HCI community has used the term “piecework” to describe myriad instantiations of on-demand labor, but researchers have generally made this allusion in passing. Since this paper traces a much stronger parallel between (historical) piecework and (contemporary) crowd work (and, more generally, on-demand labor), a more comprehensive background on piecework will be useful. We will more carefully discuss piecework in this section to help make our observations and arguments with better familiarity with the topic. Specifically, first, we’ll define “piecework” as researchers in its field understand it; and second, we’ll trace the rise and fall of piecework at a high level, identifying key figures and ideas during this time. This section is not intended to be comprehensive: instead, it sets up the scaffolding necessary for our later investigations of crowd work’s three questions: complexity limits, task decomposition, and worker relationships.

What is piecework? A Primer and Timeline

Aligning on-demand work with piecework requires an understanding of what piecework is. While it has had several definitions over the years, we can trace a constellation of characteristics that recur throughout the literature. We’ll follow this research, collecting descriptions, examples, and definitions, tracing an outline of *what piecework is* alongside piecework’s contemporary developments in practice.

Piecework’s history traces back further perhaps than most would expect. Grier describes the process astronomers adopted of hiring young boys to calculate equations in order to better-predict the trajectories of various celestial bodies in the 1830s [12]. George Airy was perhaps the first to rigorously apply piecework-style decomposition of tasks to work; by breaking complex calculations into constituent parts, and training young men to solve simple algebraic problems, Airy could distribute work to many more people than could otherwise complete the full calculations.

Piecework may have started in the intellectual domain of astronomical calculations and projections, but it found its foothold in manual labor. Piecework took hold in farm work [24], in textiles [1, 25], on railroads [5], and elsewhere in manufacturing [27]. Fordism and scientific management thrust piecework into higher gear, especially as mass manufacturing and a depleted wartime workforce forced industry to find new ways to eke out more production capacity. [MSB: I think a sentence here to characterize the height of piecework would be helpful — how big a deal was it at its peak?] [al2: I’m not sure; I’ll look for some data.]

update: hard to find anything saying “piecework represented eleven billion dollars of the U.S. economy”, which is what I’d like to say, but I can say something like “at its height, $k\%$ of garment workers were pieceworkers” or something. that seems a bit wishy-washy though; I’d like to say something like “ $k\%$ of the entire U.S. workforce was working under some sort of piecework regime”.]

By 1847 we find a concise definition of piecework in Rayn-bird’s essay (where he also calls piecework “measure work”, “grate work”, and “task work”), particularly driven toward en-

capsulating the manual labor of farmwork. Raynbird does this by contrasting with the “day-labourer” — “the chief difference lies between the day-labourer, who receives a certain some of money ... for his day’s work, and the task-labourer, whose earnings depend on the quantity of work done” [24]. Chadwick defines it through examples: “payment is made for each hectare which is pronounced to be well ploughed ... for each living foal got from a mare; ... for each living calf got” [7]. This framing offers a more intuitive sense; “payment for results,” as he calls it, is not only common in practice, but well-studied in labor economics as well [10, 29, 30, 16].

It’s worth acknowledging that “this distinction [between piece-rates and time-rates] was not completely clear-cut” [15]. Indeed, employers adopted piece-rate compensation in some aspects and time-rate compensation in others. The Rowan premium system, which essentially paid workers a base rate for time plus, potentially, an additional pay dependent on output [26]; this was just one of several alternatives to categorical time- and piece-rate remuneration paradigms. As Rowan’s premium system guaranteed an hourly rate regardless of the worker’s productive output *as well as* additional compensation tied to performance, workers under this regime were in some senses “task-labourers”, but in other senses “day-labourers”.

It may be worth thinking about piecework through the lens of its emergent properties to help understand it. Raynbird argues for the merits of piecework, pointing out that “piece work holds out to the labourer an increase of wages as a reward for his skill and exertion ... he knows that all depends on his own diligence and perseverance ... [and] so long as he performs his work to the satisfaction of his master, he is not under that control to which the day-labourer is always subject”. The argument that “task-labourers” enjoy freedom from control crops up in Raynbird’s and later Rowan’s works [24, 26].

We see this sense of independence in myriad times, locales, and industries. Satre offers a look into the lives and culture of “match-girls” — young pieceworkers, mostly women, who assembled matchsticks in the late 19th century. Of interest was their reputation “... for generosity, independence, and protectiveness, but also for brashness, irregularity, low morality, and little education” [27]. Hagan and Fisher document piecework from 1850 through 1930 in Australia, finding similar notions of independence and autonomy among piecework newspaper compositors: “If a piece-work compositor ... decided that he did not want to work on a particular day or night, the management recognised his right to put a ‘substitute’ or ‘grass’ compositor in his place” [13]. This sense of independence and autonomy appears to be an inherent component of piecework.

[al2: I think now that this is moved to this area there’s a good opportunity to frame this more as “now that workers could choose their own schedule, style, etc. ..., newfound interest in how to manage these workers emerged”. Thoughts?] The early growth of piecework led to discussion on how best to manage pieceworkers, generally regarding workers antagonistically [23, 8]. This was a far cry from the earlier rhetoric on piecework, which promised that piece workers would gladly work as diligently and as hard as possible because incentive-based pay would reward workers directly for hard work [].

Piecework opened the door for people who previously couldn't participate in the labor market to do so, and to acquire job skills incrementally. During World War II, women received training in narrow subsets of more comprehensive jobs, enabling work in capacities similar to conventional (i.e. male) workers [15]. Workers with specific skill subsets could be matched to suitable tasks. Women previously had virtually no opportunities to engage in engineering and metalworking apprenticeships as men did; now, they could be trained quickly on narrowly scoped tasks, demonstrate proficiency, and become experts.

Piecework's popularity in the United States and Europe plummeted almost as quickly as it had climbed. Between 1938 and 1942, piecework in a number of metal workers had climbed as steeply as from 11% to 60% [14]; by 1961, that proportion dropped to as little as 8% [6]. Carlson details that, from 1973 to 1980, the remaining bastions piecework — where more than 50% worked under incentive wage plans — were principally in clothes-making (e.g. hosiery, footwear, and garments). Hart and Roberts's work substantively explores the precipitous decline of piecework in the last third of the 20th century.

[al2: “, ultimately arguing that...”]

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

Viewing crowd work as a modern instantiation of piecework is relatively straightforward by this definition. First, platforms such as Mechanical Turk, Uber and TaskRabbit pay by the task, though some such as Upwork do offer hourly rates as well. Second, workers are attracted to these platforms by the freedom they offer to pick the time and place of work [20, 4]. Third, system developers as on Mechanical Turk typically assume no professional skills in transcription or other areas, and attempt to build that expertise into the work flow [22, 2]. Given this alignment, many of the same properties of piecework historically will apply to on-demand work as well.

Case studies in piecework

Throughout the rest of the paper, we will return to three major case studies to frame our analyses: railroad and other industrial workers; Airy's employment of *human computers*; and domestic and farm work (specifically, the “match-girls”). In introducing these cases at a high level, we'll trace the history of piecework while also framing the later analysis of the major research threads we named earlier (questions toward complexity, decomposition, and relationships, respectively).

[al2: should I drop this? Railroad and other]Industrial Workers Piecework might be most familiar to the HCI researcher in the context of the assembly line, which largely defined manufacturing through the 20th century. In the railroad industry and especially on the assembly line we see many of the mechanisms of work and worker management that later made their way into crowd work. Furthermore, it's from here the piecework literature draws most upon to find limits speaking to complexity and task granularity. We'll expose these facets of

piecework very superficially in the context of industrial work to better speak to these research questions in crowd work later.

Railway companies adopted piecework regimes in the early 20th century; what followed was a flourishing in the management practices with pieceworkers, as railway companies struggled to find effective ways to motivate and evaluate this skilled workforce of engineers. Graves takes up a case study of the Santa Fe Railway, finding that they employed “efficiency experts” to develop a “standard time” to determine pay for each task at the company informed by “thousands of individual operations”; Graves goes on to list some of the roles required to facilitate piecework in the early 20th century — among them, “piecework clerks, inspectors, and ‘experts’ ” [11].

This oversight, while controversial (especially among workers [18]), paved the way for piecework to grow substantially. With Taylor's formalization of scientific management in *Taylorism* (and Henry Ford's eponymously named *Fordism*), piecework in the early and mid-20th century surged, especially in industrial work. Scientific management promised that the careful measurement of workers would yield higher efficiency and output [28, 19]. While Brown points out that piecework dramatically advanced the instrumented measurement of workers, in Taylor's time highly instrumented, automatic measurement of workers was all but impossible [5]. Instead, managers conducted “stop watch time studies” [21], using completion times to inform per-task compensation, similarly to efficiency experts in the Santa Fe Railway, but substantially more precise.

Piecework through the 20th century centered around auto and other mass manufacturing, but found its way into the war effort during World War II. With the vast majority of men drafted into service, factories found themselves turning to a predominantly female workforce that had neither the formal training nor the years of apprenticeship experience that conventional workers would have had. Rather than attempting to train this new labor force in every aspect of industrial work, these women were trained for individual tasks and assigned to that task. One might reflect on the observation that “Rosie the Riveter”, an icon of 20th century America who represented empowerment and opportunity for women [17], was a pieceworker [9].

The 1930s represented a boom for piecework on an unprecedented scale, especially among engineering and metalworking industries. Hart and Roberts characterize the 1930s — and more broadly the first half of the 20th century — as the “heyday” of the use of piecework. They attribute this to the shortage of male workers, who would have gone through a conventional apprenticeship process affording them more comprehensive knowledge of the total scope of work.

[al2: some things I didn't cover:

- research finding that task variability is bad for piecework, but worker variability is good
- talk about the foreman
- worker advocacy groups

should I be making a serious effort to get that stuff in here? this section is kind of long already (and it'll definitely be much longer than the other case studies).]

Domestic and Farmhand Labor

The application of piecework to farm work in the late 19th century and later to manufacturing of small goods, such as garments and matches, at the turn of the 20th century proved to be a formative period for piecework as we would come to know it. Here, then, we'll discuss the implementation of piecework regimes in farms, in homes where workers assembled clothing and were paid by the *piece* of output, and finally in the early sweatshops where women made matchsticks under dangerous and even hazardous conditions.

Farm and field work emerged early on as a rich field for the use of piecework, perhaps in part due to the relatively low skillset necessary to complete work. We discussed earlier that farm work applied the idea of piecework to the farm by paying workers for things like picking bushels of fruit or bringing to birth animals [7]. Raynbird argues from another perspective, but along a similar thread, that the only factor important in piecework was whether the worker's final product was to the "satisfaction of his master" [24]. Piecework's advantage, Raynbird argues, was this hands-off management of workers.

Piecework was beginning to find its way into homes near the end of the 19th century. Textile manufacturers found that they could deliver fabric to people at their homes, paying them to sew together clothing. The manufacturers would later return to retrieve the finished garments, paying these workers for each *piece* of clothing made. They could, in principle, assemble as much or as little clothing as they wanted; the reality was more grim, as Riis documented in 1901 [25]. He found that workers endured bleak living conditions and worked long hours attempting to scrape together a living.

Piecework played a role in early mass manufacturing during the Industrial Revolution, as well as the early years of worker collective organization and action. At the end of the 19th century, manufacturers employed women to assemble matchsticks in factories. These match-makers were some of the first workers in mass manufacturing to successfully rally for political causes, first in the form of a march on parliament in 1871 to protest a proposed tax, and later (more famously) in what was later called "the match-girls strike of 1888" [27].

The match-girls strike of 1888 was sparked by a worker's arbitrary docking of pay, but much deeper resentment had been boiling over for years. Match-girls were already frustrated with the arbitrariness of management, poor working conditions, and having to work with phosphoric materials (which was proving hazardous). [al2: I might need to add some info here, and certainly citations, but there'll be overlap with the other citations here]

Regardless of the reasons, the lasting impact of the match-girls strike of 1888 was profound. This was one of the earliest and most famous successful worker strikes, and perhaps the beginning of "militant trade unionism" [27]. As Weyer, Webb, and Webb described, "the match-girls' victory turned a new leaf in Trade Union annals" [31]: in the 30 years after the match-girls strike, the Trade Union Movement enrollment grew from 20% of eligible workers to over 60%.

To understand how these women became such influential, if underreported, figures in labor advocacy's history, we should shine a light onto the reputation that had formed for these workers. Match girls were the only group in 1903 to have formed a trade union, according to Booth's account at the time [3]. Satre noted that match girls "... pooled their resources to purchase their plumes and clothes ... and expressed their solidarity through small [and major] strikes" [3]. But they were also, as Satre confesses, known for "brashness, irregularity, low morality, and little education" [27]. These were workers who treasured their independence, but also fiercely protected one another, contributing to the common good. Their "brashness" for instance may have detracted from their public image, but almost undoubtedly contributed to their sense of solidarity, making their propensity to act against such unfair treatment and poor conditions understandable and maybe predictable.

[al2: I want to discuss a few things here:

- there were protests about something sort of like surge pricing in crop-picking, but i don't know how to make that a paragraph (maybe merge it with match-girls?)

]

Airy's Computers

[MSB: This one seems way thinner than the others? Maybe it should be merged with the earlier description of Airy.] Some of the first systematic cases of what we would recognize as crowd work can be found in the study of astronomy. In the 19th century, the calculation of celestial bodies had become a competitive field with Airy needed to compute tables that would allow sailors to locate themselves by starlight from sea. This work ostensibly called for educated people who comprehensively understood mathematics. Airy realized that he could break the tasks down and delegate the constituent parts to "human computers" who "... possessed the basic skills of mathematics, including 'Arithmetic, the use of Logarithms, and Elementary Algebra' " [12]. As a result, many of Airy's computers had relatively rudimentary educations compared to the background of education that typically worked in the calculation of solar tables. Airy distributed tasks by mail, allowing work to be completed by a somewhat geographically distributed workforce, and paid for each piece of work completed. Airy also instituted a policy of firing his computers once they reached age 23 [al2: this has a "gosh isn't that interesting?" feeling to it. should i just leave it out until later when there's something to say about it (namely, that the mode of work was initially designed to stymie professional growth?)].

[al2: This should go later someplace, but not clear where:

This practice ensured two outcomes that arguably disfavored workers. First, it eliminated any potential to advance professionally, as workers' careers in this area ended relatively early in their careers, and without formal education in mathematics they struggled to find work for which their experience was meaningful. Second, it limited workers' ability to organize by ensuring that workers hardly spent sufficient time to successfully rally their peers.]

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