The Perpetual Work Life of Crowdworkers: How Tooling Practices Increase Fragmentation in Crowdwork

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Crowdworkers regularly support their work with scripts, extensions, and software to enhance their productivity. Despite their evident significance, little is understood regarding how these tools affect crowdworkers' quality of life and work. In this study, we report findings from an interview study (N=21) aimed at exploring the tooling practices used by full-time crowdworkers on Amazon Mechanical Turk. Our interview data suggests that the tooling utilized by crowdworkers (1) strongly contributes to the fragmentation of microwork by enabling task switching and multitasking behavior; (2) promotes the fragmentation of crowdworkers' work-life boundaries by relying on tooling that encourages a 'work-anywhere' attitude; and (3) aids the fragmentation of social ties within worker communities through limited tooling access. Our findings have implications for building systems that unify crowdworkers' work practice in support of their productivity and well-being.

CCS Concepts: • **Human-centered computing → Computer supported cooperative work**.

Additional Key Words and Phrases: Crowdwork; Tooling; Work Practice; Interview; Fragmentation.

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1 INTRODUCTION

Over the past decade, crowdwork has risen as an established and thriving work practice for thousands of people across the globe [20]. In a 2010 survey of US-based Amazon Mechanical Turk (MTurk) workers, less than 5% of the participants identified as spending 40 hours or more on crowdwork [42]. Recent data-driven analyses of long-term worker activity on MTurk found that the population of crowdworkers on the platform is generally stable, but that "tens of thousands of new workers that arrive on the platform each year" to replace workers that abandon the profession [21, 61]. Beyond MTurk, a 2016 survey found that more than 5 million individuals in the UK are actively engaged in crowdwork [39], and 53% of a 2017 survey's respondents with crowdworkers in Switzerland reported the profession as their full-time job [40]. Spurred by the changing nature

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of information work today, understanding how crowdworkers accomplish their work has become an increasingly important area of research for CSCW and HCI researchers alike.

Crowdworkers, like many other professions in information work, employ a myriad of tools to support their work. Crowdwork, by design, revolves around the completion of Human Intelligence Tasks (HITs) that are posted to crowdsourcing platforms (e.g., Microsoft's UHRS [1], Figure Eight [2]) by requesters. Browser extensions and scripts, such as PandaCrazy and MTurk Suite, are frequently used to assist workers on MTurk in finding HITs to complete [52]. Online community platforms, such as MTurk Grind and TurkerNation, are not only used to aid the work-finding process, but also serve as a bastion for organizational support among workers [29, 105]. Both software tools and community platforms help workers assess prospective HITs by integrating with platforms (e.g., TurkOpticon [46]) that maintain community-driven ratings of requesters. Recent research has taken steps toward building tools that assist workers by estimating the amount of time a HIT may require [86], recommending specific HITs [33], and visualizing the HIT marketplace [33]. While prior research recognizes the importance of tooling for facilitating earnings goals [52], the broader effect of crowdworkers' *tooling practices*, i.e., how they *actually* make use of tools and how this usage impacts their quality of life and work, remains relatively unknown.

In this paper, we examine the effect of crowdworkers' tooling by conducting semi-structured interviews with 21 crowdworkers who work "full-time" on Amazon Mechanical Turk. Specifically, our interview questions aimed at understanding workers' work practice and how tooling is situated within it. At a high level, we find that tooling use increases the *fragmentation* (i.e., discontinuity) that crowdworkers experience in their broader work practice. First, tooling enables task switching and multitasking behavior, thus contributing to the discontinuity of HITs. Second, we found that workers regularly employ tooling in ways that fragment their work-life boundaries, often conditioning workers into adopting a 'work-anywhere' attitude. Finally, tooling practices that stem from limited or commercial access contribute to the fragmentation of social ties within worker communities, driving workers to engage with specific communities or avoid social activity altogether.

We begin by highlighting prior research in information work and crowdwork that describes the nature of fragmentation in work, crowdwork as a work practice, and the current state of crowdworkers' tooling in the literature. Afterwards, we detail our interview's study design while clarifying the overarching goal of our work. We then report our study's findings, first describing findings related to workers' general tooling practices and second how these tooling practices drive fragmentation. We conclude by discussing our findings in the scope of future tools in crowdwork.

2 RELATED WORK

The purpose of our study is to understand the effects of tooling usage in crowdwork. Here, we describe prior research relevant to understand and interpret the role of tooling in work practices. We approach our overview of prior work from the broad perspective of computer-mediated work, coalescing relevant literature both from information work and from crowdwork.

2.1 Information Work and the Workplace

2.1.1 Tooling Practices in Information Work. Understanding how and why people utilize tools in the workplace is a well-studied topic in HCI and CSCW research alike [89]. Exploring the value of work-related communication tools, such as instant messaging apps [32, 56], wikis [19], internal blogs [23], and social networking sites [13], has been a central point of interest for workplace research. Isaacs et al. [48] and Handel and Herbsleb [32], for example, demonstrated that tool utility varies heavily with the user's context. Turner et al. [97] conducted an analysis of a communication tool use over a year-long period in a small US corporation and established several key findings: (1) individuals assemble tool "ecologies" to meet their various needs and desires; (2), individuals

generally extend their tool ecologies without relinquishing existing tools; and (3) individuals choose to sustain their tool use based on the social capabilities it affords. To further contextualize their findings, Turner et al. also introduced a coding of five categories to represent key strengths and weaknesses of each type of examined communication tool. Beyond communication tools, Gonzales et al. [25] found that that teams of individuals employed a multitude of software tools in solving collaborative, complex tasks, and observed that each tool plays a particular role within the team: (1) managing tasks, (2) alerts and notifications, (3) soliciting help, and (4) feedback.

2.1.2 Interruptions and Multitasking. Work is inherently fragmented by *interruptions* [83]. Research in human-computer interaction has given substantial attention to understanding the effect of both internal [4, 50] and external interruptions [38]. In their seminal study, Czerwinski et al. [18] characterized difficulties in task switching based on the data collected from a week long diary study and showed that task complexity, task type, task duration and number of switches affect the difficulty in managing multiple tasks. In separate field studies with information workers, Ibqal et. al and Solingen et al. found that interrupted work is demonstrably costly to information workers' productivity, observing that interrupted tasks took upwards of 15 minutes to resume [44, 100]. Mark et al. observed more severe costs from interrupted work with their participants taking, on average, 23 minutes to resume their tasks [73]. The effect of notifications and alerts have been studied extensively for more than a decade [17, 37, 45], and it is generally well understood that excessive amounts of notifications can lead to "interruption overload" [82]. Empirical findings regarding the challenges of resuming interrupted work are well supported by research in cognitive science that suggests task switching produces "attentional residue", a type of memory footprint from prior tasks that yields sustained impairments on cognition [5, 66]. Despite these costs, consumer technology has continued to enable multitasking behavior [10, 18, 26, 81].

2.1.3 Supporting Interruption Recovery. Systems for supporting the recovery of interruptions have been explored at depth, ranging from simple note-taking tools [99] to complex software for recording and reestablishing task history and context [22, 35]. Recent systems, such as PlayWrite [43] and Mercury [103], allow users to partially avoid interruptions in information work by continuing their work in low-attention effort format called "microtasks" [96]. Research has demonstrated the practical utility of microtasks by comparing them to their macrotask counterparts, showing microtasks are more resilient to interruptions [16], yield higher quality work [16], and can be used to scaffold the cognitive process of maintaining and rebuilding context for complex tasks [14, 87].

2.2 Crowdwork

2.2.1 Crowdwork as a Work Practice. Crowdwork, in comparison to information work, is a relatively nascent work practice. Recent surveys demonstrate that crowdwork is increasing in popularity [21, 39, 40], and estimates of population change suggest that the adoption rate of crowdwork as a work practice will continue to grow substantially each year [21]. Similar to studies of gig economy engagement [71], research has found that autonomy and flexibility play significant roles in the adoption of crowdwork as the work enables crowdworkers to work when they please [57]. However, studies of work experiences in crowdwork have found that crowdworkers suffer from low job satisfaction [12]. To that end, in a 2018 data-driven analysis of crowdworkers' earnings, Hara et al. found that the median hourly rate for workers' compensation was $2 per hour with only 4% of workers making the minimum wage of $7.25 [34]. In a similar vein, prior work has highlighted the imbalances of power between workers and employers (i.e., requesters) in crowdwork, noting that agency is rarely in the worker's favor [75]. Studies have suggested crowdwork platforms design not only for requester-worker trust [78], but more broadly for the ethics of fair labor [47]. Sutherland and Jaharri [93], for example, employed the concept of information infrastructure and collaborative

empowerment as a means for supporting the "digital nomad" in the broader gig economy. More recent attention has been given to algorithmic fairness within gig economy work practices [49].

2.2.2 Interruptions in Crowdwork. Research has shown that work-related discontinuity harms crowdwork [63]. Necka et al. found that crowdworkers engage in multitasking behavior while participating in online experiments [80]. Similar findings were reported by Chandler et al. who found that workers divide their attention between work (i.e. a HIT) and non-work (e.g. TV) while working [15]. Gould et al. conducted a lab study in which they observed that participants switch between tasks every 5 minutes, and that participants expressed a willingness to interrupt their work [27]. Rao et al. introduced "multiplexing" between active and passive tasks to better optimize multitasking in crowdwork [85]. In a survey with 317 MTurk crowdworkers, Lascau et al. mapped crowdworkers' multitasking preferences, finding that a tension exists between the crowdworkers' multitasking preferences and the demands of their crowdwork platforms, and that crowdworkers, on average, employ boundary management strategies that prioritize non-work over work [62].

2.2.3 Tooling and Platforms in Crowdwork. The importance of tooling and platforms in crowdwork is well-studied in the literature. Online platforms play a significant role in supporting workers both organizationally and independently [76]. Gray et al. found that crowdworkers engage in communities to manage administrative work, seek out work opportunities, and build social ties mirroring those in the traditional workplace [29]. Yin et. al mapped the communication between these communities that workers belong to, showing that overlap exists between them and that workers engage in communities at varying scales [105]. The use of requester reviewing platforms, such as TurkOpticon [46], is standard practice in evaluating prospective HITs [52]. Recent research has taken steps toward building tools that assist workers by estimating the amount of time a HIT may require [86], recommending specific HITs [33], and visualizing the state of the HIT marketplace [33]. In a 2018 survey with 360 crowdworkers, Kaplan et al. cross-analyzed workers' earnings with the software tools they employ to find that high-earning workers on MTurk used more tools, were more involved in worker communities, and more heavily used batch completion strategies [52].

In summary, prior work has shown that crowdwork is a nascent and evolving work practice. In this work, we explore crowdworkers' tooling practices by conducting an interview study aimed at understanding crowdworkers' perceptions and opinions about the role that tooling currently plays in their work. Our approach is heavily inspired by prior studies of information work [79, 103] that share the goal of identifying opportunities for improving peoples' efficiency in their work [51].

3 INTERVIEW STUDY

Crowdwork is comprised of short tasks, known as HITs, that can last a few seconds to multiple hours in length [34]. Given that crowdwork is growing in magnitude both in terms of numbers of people entering the field, and number of people for whom it is primarily full-time employment, what impact does full-time crowd work have on workers' cognitive load and work life boundaries? Importantly, a range of tools are available to support crowdworkers, which are relied on heavily [62]. The goal of this study is to investigate the impact that these tools have on work practice and work life boundaries for crowdworkers whose primary means of work is conducting crowdwork.

The best methodology for understanding the complex interplay of cognitive, social, and technological factors involved in crowdwork is through conducting in-depth interviews, which provide an essential opportunity to hear participants' perspectives [92]. To better understand the role of tooling more broadly, we framed our interviews around understanding the crowdworker's day-level work practice. Inspired by prior workplace studies, we focused on four key facets of work common to information work practices: (1) Environment, Devices, and Tooling (EDT), (2) Social Resources (Social), (3) Multitasking and Interruptions (MI), and (4) Work-Life Separation (WLS). To better

Table 1. The sequence of questions used to guide the conversation during the interview. Each question represents a particular area of crowdworkers' work practices: (1) Environment, Devices, and Tooling (EDT), (2) Social Resources (Social), (3) Multitasking and Interruptions (MI), and (4) Work-Life Separation (WLS).

#	Area	Question
1	EDT	Can you walk me through how you started your workday at your primary computer today?
2	EDT	What devices and tools do you use to help your work? How do they help you?
3	EDT	Have you always used your devices and tools this way? If not, how has it changed?
4	Social	How often do you interact with other workers through community platforms, e.g. forums?
5	Social	What worker communities do you belong to? How do they help you in your work?
6	MI	Can you tell me about a time when you've had to multitask on two HITs simultaneously?
7	MI	How frequently do you multitask in crowdwork? Why do you feel the need to multitask?
8	MI	Can you tell me about a time when you've had to temporarily stop working on a HIT?
9	MI	How frequently do you temporarily stop working on a HIT to work on another one? Why?
10	WLS	Can you walk me through how you end your workday when you're ready to stop working?
11	WLS	Do you feel like you ever "stop working"? Are you satisfied with your work situation?

understand how tool use affects work practices and work lives, we administered a post-study survey that included validated instruments that address topics relevant to our main research question.

3.1 Study Design and Protocol

Each interview was scheduled to last 30 minutes. However, many interviews exceeded the 30-minute timeframe, ranging from 27.3 minutes to 79.0 minutes (M=42.4; SD=13.2). All interviews were conducted over Skype and were scheduled during each participant's workday to more easily draw on first-hand experiences that were both recent and relevant. The researcher initiated the interview by explaining our general interest in understanding how crowdworkers "get things done". Each interview began by asking participants questions related to demographic information, including age, sex, full-time tenure, and related characteristics of work history (e.g., total number of HITs completed). We then engaged participants in a conversation that asked them to reflect about different aspects of their work that spanned the four aforementioned areas. We were careful not to instruct the participants about what they should consider tools to be, and we instead asked them to define them for us. Table 1 shows the sequence of questions used to guide the interviews.

3.1.1 Post-Study Survey. To better understand individual differences between participants, we administered a post-study survey that utilized established scales to characterize our participants' behavioral tendencies for engaging with their work. Specifically, we administered the following:

(1) *Multitasking Preference Inventory (MPI)* [84]: A 14-item (5-point Likert) questionnaire to measure an individual's preferences and tendencies to engage in multitasking behavior. Prior studies have administered the MPI to crowdworkers and found that the majority of crowdworkers lean more toward multitasking than monotasking [62].
(2) *Work-Life Indicator (WLI) Scale* [59]: A 17-item (5-point Likert) questionnaire to measure boundary management strategies that an individual uses to separate work and non-work. In administering the WLI instrument to crowdworkers, prior research has shown they primarily have strategies that prioritize their nonwork (i.e. family) instead of work [62].

Inspired by prior research on individual differences in crowdwork [55] and information work [74], we also administered the 8-item Neuroticism sub-scale of the Big-5 personality scale [77] and the 23-item Perseverance and Urgency sub-scales of the UPPS impulsive behavior scale [101]. However, in our analysis, we observed no differences between neurotics and non-neurotics nor impulsive and non-impulsive individuals, and we have therefore chosen to exclude them from our analysis.

All interviews were recorded with TechSmith Camtasia. During the interview, participants were encouraged to leave their camera off unless they felt more comfortable sharing their camera. Base remuneration for the 30-minute interview included a $10.00 Amazon gift card. In cases where interviews extended beyond the planned 30 minute timeframe, we added an additional $5.00 to participants' total gift card amount for every additional 15 minutes of participation.

3.2 Analysis

All interview recordings were transcribed and analyzed using iterative inductive content analysis [20]. During the first cycle of coding, we classified excerpts into several iteratively-refined hierarchical codes and developed a coding schema. The primary and secondary codes included:

(1) **Goal**: Properties of work-related goals; goal type, goal measurability, goal feasibility.
(2) **Task**: Properties of work-related tasks; task type, interestingness, deferrability, effort, polychronicity, monetary reward, reliability of requester, time constraint.
(3) **Tool**: Properties of work-related tooling; improved efficiency, ease of use, significance of automation, accessibility, integration with existing practice, tool authorship and risk.
(4) **Device**: Properties of work-related devices; type of computing device, purpose of computing device, screen size, interaction design, mobility, tool availability.
(5) **Social**: Properties of work-related social interaction; type of social interaction, rationale for social interaction, level of engagement, perceived cost and reward of social interaction.
(6) **Availability to Work**: Properties of work-related availability; social constraints, task availability, device availability, interruptability.

In the first pass analysis, statements from interview transcripts were directly coded from the interview transcripts to generate our coding scheme. This analysis revealed how tooling pervasively amplifies the fragmented nature of crowdwork. Based on recurrent themes in the coded data, the second cycle of coding identified three areas of work in which fragmentation is both apparent and influential. Our findings are organized around these three areas of fragmentation, and are grounded in a summary of general tooling practices as observed from our interviews.

3.3 Recruitment and Participant Overview

We used a snowball sampling approach to recruit 21 "full-time" crowdworkers who have actively worked 35 hours or more per-week on Amazon Mechanical Turk for at least six months continuously. We specifically targeted "full-time" crowdworkers to ensure we were engaging individuals who had familiarity not only with state-of-the-art tooling, but also the work practice itself. The sampling process was initiated both over e-mail and through crowdworkers' community platforms by a member of the research team who previously worked as a crowdworker.

Participants' ages ranged from 19 to 62 (M=45). Participants' tenure as full-time in experience ranged from 6 months to 7 years (M=2.2 years), and the range of total number of completed HITs ranged from 6,318 to 355,976 (M=74,821). Participants' approval rates ranged from 99.3% to 99.9%. Table 2 details the demographics of recruited participants alongside their post-study survey data.

3.3.1 Monotasksers and Multitaskers. MPI scores can range from 14 to 70 and represent individuals' preferences in engaging in multitasking behavior. A larger MPI score suggests that an individual is more preferential toward engaging in multitasking behavior. Following standard practice for calculating MPI scores [84], we find that our sample's multitasking preferences lean more toward monotasking than multitasking. Participants' MPI scores ranged from 14 to 51 (M=33; SD=11), suggesting that our sample contains monotaskers and multitaskers. We cross-examined participants' MPI scores with the number of tools used in their practice and found a weak correlation between between participants' MPI scores and the number of tools they use (Pearson's $r(19) = 0.37$, $p = 0.09$).

Table 2. Participant's demographic information (i.e., gender, age, tenure as a worker, total number of completed HITs, approval rate, and the number of software tools they use) and their post-study survey information.

	Demographics						Post-Study Survey	
P#	**Gen.**	**Age**	**Tenure**	**HITs**	**Appr. Rate**	**Tool Count**	**MPI**	**WLI Classification**
P1	F	24	3.0 years	250,094	99.6%	10	46	Work Warrior
P2	F	40	0.5 years	19,751	99.2%	9	23	Family Guardian
P3	F	30	2.0 years	40,501	99.8%	2	22	Work Warrior
P4	F	46	0.5 years	6,944	99.3%	3	30	Family Guardian
P5	M	36	3.5 years	50,124	99.8%	9	43	Overwhelmed Reactor
P6	F	31	2.5 years	102,848	99.9%	6	19	Work Warrior
P7	M	23	1.0 year	140,009	99.5%	7	12	Work Warrior
P8	F	52	2.5 years	51,304	99.9%	9	45	Work Warrior
P9	M	57	5.0 years	74,051	99.5%	8	27	Work Warrior
P10	F	56	3.0 years	74,990	99.4%	8	35	Work Warrior
P11	M	22	1.5 years	5,899	99.7%	2	23	Family Guardian
P12	M	29	1.5 years	24,231	99.6%	2	34	Work Warrior
P13	F	29	1.5 years	35,798	99.6%	7	29	Work Warrior
P14	F	32	2.0 years	172,187	99.9%	9	38	Work Warrior
P15	F	47	1.0 year	19,991	99.5%	2	22	Work Warrior
P16	F	62	3.5 years	34,564	99.7%	4	26	Overwhelmed Reactor
P17	F	33	1.5 years	43,094	99.3%	5	43	Overwhelmed Reactor
P18	F	32	7.0 years	355,976	99.6%	10	50	Work Warrior
P19	M	22	0.5 years	6,318	99.6%	2	26	Family Guardian
P20	M	19	1.5 years	18,749	99.4%	2	51	Overwhelmed Reactor
P21	F	59	1.5 years	37,820	99.9%	9	44	Family Guardian

3.3.2 Work Warriors, Overwhelmed Reactors, and Family Guardians. Following standard practice [59, 62], we calculated WLI scores based on the scale's five dimensions, each of which ranges from 1 to 5. Among our participants, we find three types of WLI characterizations: (1) Work Warriors, (2) Overwhelmed Reactors, and (3) Family Guardians. Work Warriors are individuals who have high work identity (M=4.1, SD=0.9), low family identity (M=2.8, SD=1.2), and primarily allow work-related activity to interrupt nonwork time (M=4.0, SD=0.8). Overwhelmed Reactors have similar work (M=4.3, SD=0.9) and family identity (M=2.9, SD=0.6). However, they not only allow work to interrupt nonwork (M=3.1, SD=0.2), but also permit nonwork to interrupt work (M=3.2, SD=0.7). Unlike Work Warriors and Overwhelmed Reactors, Family Guardians maintain high boundary control (M=2.9, SD=0.9) and high family identity (M=4.6, SD=0.4) while simultaneously allowing nonwork to regularly interrupt work (M=3.4, SD=0.7) [59]. As Kossek et al. [59] states, our participants, on average, allow "work to puncture non-work time".

Upon visually assessing the data, we observed a trend that suggested a relationship may exist between WLI dimensions and participants work-related demographics. After confirming the data was normally distributed, we ran a multiple regression for each of the five dimensions used to calculate participants' WLI scores, using demographics as independent variables (i.e., age, sex, numbers of completed HITs, years spent working on MTurk, and number of tools). We found two statistically significant effects in analyzing these models. We first found that an effect that suggests behavior for allowing work to interrupt non-work time increases as crowdworkers employ a larger number of tools in their practice (β=0.19; SE=0.06; t(19)=3.25; p=0.006). We also found an effect that suggests that the number of years spent doing full-time crowdwork contributes to feelings of less control in separating non-work and work-time (β=-0.46; SE=0.21; t(19)=-2.22; p=0.04).

As our sample size is not large enough to make substantial claims about these findings, we extended our analysis by assigning each participant to one of the six clusters that are defined in the WLI [59]. In total, our sample includes 11 Work Warriors, 7 Overwhelmed Reactors, and 4 Family Guardians. The key distinction between Work Warriors and Overwhelmed Reactors is that the latter not only allows work to interrupt nonwork, but also permits nonwork to interrupt work. Family Guardians are notably different to these two WLI clusters, having high boundary control and high family identity while simultaneously allowing nonwork to regularly interrupt work [59].

4 AN OVERVIEW OF TOOLING PRACTICES

Our participants broadly defined "tooling" as physical or digital artifacts that "make [their] job easier while at work or otherwise" (P15). P2, for example, described her tooling (e.g. browser extensions, scripts, etc.) specifically as "the glue that makes [their work] possible". Here, we detail the tooling practices that crowdworkers employ as observed through our study. Table 3 summarizes the types of tools observed and the tasks they serve to support in participants' broader work practices.

4.1 Workstations as Tooling Platforms

Crowdworkers' workstations serve as the centerpiece to their tooling practices. All 21 participants' primary work environment was situated within their home or apartment. 15 participants stated that they use a desktop workstation as their primary work computer. The remaining six participants use a laptop as their primary work computer. Amid the many features of their machines, participants uniformly highlighted display quantity as the most productivity-defining attributes of their primary work computer. Participants' workstations included the use of only one display (6), two displays (11), and four displays (4). Only one [P9] voiced concerns against the use of multiple displays:

> "*I know there's some people that have two monitors and stuff, but more power to them. I don't know how they do it. It's too confusing for me. I want to focus on one thing at one time, and having an additional monitor won't help. It'll just make it harder to focus.*" (P9)

All multi-screen proponents shared a common strategy for "partitioning screen space" [30] toward (1) a work-finding display (i.e., in which workers primarily utilize for finding and accepting HITs) and (2) a work-doing display (i.e., in which workers primarily utilize for completing HITs). Similar techniques for mapping screen space were also commonly described by single-monitor users, e.g. "I'll split my display with a window for doing work and a window for finding work" (P20).

In general, we find that that crowdworkers employ an ecology of computing devices within their work practice to enable them to meet their work-related needs. Within the workspace, eight participants described using multiple workstations, multiple laptops, or a combination of the two to engage with her work simultaneously to "distribute CPU load" (P2) or use tooling that was "limited to a particular operating system" (P1). Beyond the primary work environment, five participants reported using their tablet device (e.g., iPad, Amazon Fire) to engage with their work to complete specific types of work while away from their primary work computer. e.g., "surveys in bed or on the couch" (P10). Each of the 15 participants voiced the challenge of engaging with work on-the-go as "most tools are designed as desktop browser extensions and don't work on mobile devices" (P14).

4.2 Tools for Finding and Completing HITs

HIT-finding scripts and extensions were observed as the most common and most central type of tooling used by participants. By nature, these tools attempt to assist crowdworkers' in populating their HIT queue, which can include up to 25 HITs at any one time. The two types of HIT-finding tools used by all participants were HIT scrapers and HIT catchers. HIT scrapers improve the efficiency of searching for HITs by incorporating visual information (i.e., requester reliability) to

Table 3. Tooling types and their supported tasks as observed from our interviews.

	Description	Supported Task	Discussed Tooling	Used By
HIT-Finding	Automates finding work. Tasks include scraping / filtering MTurk to "catch" specific HITs by ID, and auto-accept HITs based on a specific criteria (e.g. minimum pay).	Scraping HITs	HIT Finder*, HIT Forker	All (100%)
		Catching HITs	HIT Catcher*, Overwatch, PandaCrazy, TurkMaster	All (100%)
		Auto-Accepting HITs	Private Tools	1,3,5,7,9,21 (29%)
Cognitive	Augments cognition. Tasks include guiding focus toward particular HITs, managing visual aspects of HIT browser windows, and interacting with a HIT's Browser UI for the worker.	Organizing and Focusing on HITs	PandaCrazy Queue Helper, Private Tools	1,3,5,7,11,13,14 16,17,18,21 (52%)
		Managing Browser Windows	AquaSnap, Window Layout, The Great Suspender, Private Tools	1,3,5,6,7,18,21 (33%)
		Interacting with Browser Windows	Private Tools	1,5 (9.5%)
Social	Facilitates community engagement. Tasks include reviewing HITs, discussing HITs in online groups or forums (e.g. to seek help), and sharing HITs with other workers.	Reviewing HITs	TurkerViewJS*, TurkOpticon Extension	1,2,3,5,6,7,8,9,13,16 17,18,19,20,21 (71%)
		Discussing & Sharing HITs Publicly	TurkerView, MTurkGrind, Reddit, Facebook Groups	All, but 10,15 (90%)
		Discussing & Sharing HITs Privately	Messenger, Discord, Telegram, Email	1,5,7,8,14 16,17,18,21 (43%)
Administrative	Maintains HIT history and state. Tasks include logging completed HITs (i.e., to retain work history) and documenting active or on-going HITs.	Logging HITs	HIT Tracker*	1,2,3,5,6,7,8,9,13,16 17,18,19,20,21 (71%)
		Documenting HITs with Physical Tools	Notebooks, Wall Calendar	4,5,8 (14%)
		Documenting HITs with Software Tools	Google Sheets, Google Docs, MS Word, Paint	1,2,3,6,7 (24%)
Mobility	Enables workers with the ability to work while on-the-go. Tasks include monitoring the HITs in their HIT queue, finding HITs to complete on-the-go or save for later, and completing HITs.	Monitoring HITs	Mobile Browser, PandaCrazy, Distill	1,2,3,5,6,7,8,9,10 13,14,15,16,17 18,19,20,21 (86%)
		Finding HITs	Mobile Browser, Discord, Messenger, Private Tools	1,2,5,7,8,10,13,14 16,17,18,21 (57%)
		Completing HITs	Mobile Browser, Chrome Remote Desktop	1,2,5,7,14,21 (29%)

* *This tool is included in an aggregate tool named "MTurk Suite".*

ease the decision-making process of selecting which HIT the worker should add to their queue. However, many HITs are "scooped up before you can even click the accept button" (P9):

> "*I look for HITs with good pay, and then I kind-of click through to take a peek. I tend to aggressively just grab things and return them if I don't like them. It's so competitive that,*

> *if you wait to look at what a task is before you grab it, it doesn't work. The good work will be gone before you even have a chance to decide.*" (P5)

The primary mechanism by which crowdworkers fill their queue is with HIT catchers, such as HIT Catcher and PandaCrazy, that are software tools that "catch" HITs in the case where they are returned to the HIT marketplace (i.e. relinquished by another worker). Importantly, HIT Catchers allow crowdworkers to specify a list of HIT IDs to seek out, which are used to make repeated and carefully timed requests directly to the MTurk API. If these tools find that a HIT has been returned to the marketplace, it will automatically add the HIT to the worker's HIT queue.

Beyond HIT Catchers, six crowdworkers utilize HIT Auto-Accepters, a script, extension, or desktop application that automates the HIT-finding process entirely by allowing workers to auto-accept HITs that meet a particular criteria (e.g., minimum reward). The key difference between HIT Auto-Accepters and HIT Catchers is that the prior requires no human intervention to perform the search process while the latter requires workers to add a HIT ID to a catcher's list of HITs to seek out. Both types of HIT-finding tools deliver notifications and alerts when new HITs are found and added to workers' HIT queue. Importantly, these notifications and alerts can be customized by the user to play certain messages or sounds (e.g. a car horn) based on the properties of newly-accepted HITs (e.g. time constraint).

More recent iterations of HIT catchers and auto-accepters have embedded support for administrative tools, specifically those that involve reviewing HITs and requesters on online platforms, such as TurkOpticon [46], but several participants noted they prefer using separated versions of the extensions. Community platforms were also mentioned explicitly by most workers as "invaluable tools", serving as a central source of work opportunities as found in prior work [29].

Complementing their HIT-finding tools, crowdworkers use cognitive tools to augment their task switching abilities. This includes visually rearranging and sorting their HIT queue (e.g. by time constraints), using saved configurations to restore and suspend their browser window arrangement, and managing visio-spatial aspects of the HITs' browser windows:

> "*[The tool] not only accepts HITs for you, but it automatically opens them in a tab. So, I can start with the first HIT in a batch, and then, as I submit it, it closes that tab and immediately opens up the next one. I love it for batch HITs. I just find it faster to still use a regular browser, but I know one of my friends relies on using the tool's feature for his workflow.*"" (P1)

Two participants [P1,P5] also described that they employ private tooling to interact with browser windows to further improve their efficiency, noting its overall use is for "small optimizations" (P5).

4.3 Tools for Enabling Mobile Tasks

The most common mobile task performed by 18 participants was monitoring their HIT queue. 16 participants described a strategy in which they proactively configure their HIT-finding tools on their workstation to continue to seek out work, populating their HIT queue while mobile:

> "*While I'm out, I only do HITs for emergencies, because it's a lot slower to do them on my phone. I also use my phone to see what HITs PandaCrazy is finding while I'm away from my computer and whether they're worth going to a computer to do.*" (P3)

While on-the-go, most participants describe their monitoring processes as one facilitated by refreshing their HIT queue webpage with their mobile browser. One participant [P1] noted the use of a service (i.e., Distill) that monitors their HIT queue webpage, pushing alerts to their mobile device when changes are detected. HIT-monitoring was described as "frequent", particularly when participants were expecting a particular HIT to be released (e.g., a closed qualification HIT). While near their working environment (e.g. in a different room of their home), participants' monitoring strategies primarily rely on the audible alerts generated by their HIT-finding tools.

Alongside monitoring their HIT queue, 12 participants actively engage in the task of finding HITs while mobile. The most common strategies employed for finding HITs in mobile settings were those that relied on other workers. Resembling the model of friendsourcing [11], we find that our participants leverage their close social ties to support their task-finding needs while mobile:

> "*I've been in a group message on Facebook Messenger with several ladies for a while now, and we look out for each other while we're not at our computer. If one of us finds a well-paying HIT, we'll let each other know to make sure everyone can catch it.*" (P14)

Several participants described similar uses of close-knit social groups with alternative tools, namely Discord. Social scenarios aside, three participants who do not engage in socializing with workers mentioned they primarily find HITs directly because "there's no other way to do it", suggesting that social ties play a significant role in facilitating mobility. Importantly, the 12 participants who find work while mobile noted they generally do not complete found work on-the-go, but rather use it to prime their ability to work upon returning to their primary work computer.

The least common type of mobile task in our participants' practices was completing HITs. The inability to complete HITs while mobile is the result of "the terrible nature of the MTurk mobile web interface" (P11) and the inability to utilize any of their primary workstation's scripts or extensions. As P5 said, "it inherits all of problems of Mechanical Turk as a platform, is somehow even more difficult to use" (P5). The most common tool used to complete HITs while mobile was private tooling. However, two participants [P14,P21] described the use of Chrome's Remote Desktop extension:

> "*I'll just use the Chrome Remote Desktop extension to jump into my desktop. From there, I have access to all of Catchers and other scripts I need to be productive. It can be tough to do things like Copy-and-Paste, but you can make it work.*" (P14)

While these two participants are the minority, the use of their tooling highlights the ingenuity and creativity that participants' leverage in their tooling to empower their work practice with mobility.

4.4 Tools for Engaging with the Community

A majority of our participants actively engage in online forums, including Reddit, MTurkGrind, and numerous groups on Facebook, to share and discuss HITs with other workers. Several participants used a new platform – *TurkerView*[1] – which they described as a "new and improved version of TurkerHub" (P7). Importantly, TurkerView was mentioned by name by every participant in our study. Participants described it as a valuable resource not only for its community aspect, but also for reviewing HITs. Like TurkOpticon [46], TurkerView offers a browser extension that allows workers to quickly and conveniently review the HITs that they've done in the past. While the extension was launched as an independent Tampermonkey script, participants noted that recent iterations of TurkerView's reviewing functionality had been built into the popular tool MTurk Suite, which most of our participants utilized in their work. Despite its growing reputation, 4 participants clarified that they avoid the platform and stopped using MTurk Suite because of TurkerView's integration.

Alongside public community platforms, private, more close-knit groups of workers have become a commonality for many crowdworkers' work practice. 10 participant described belonging to a private "team of workers" (P14). Participants noted that these groups manifest themselves through messaging applications, such as Discord, Facebook Messenger, and Telegram, and serve multiple purposes "often beyond merely working" (P21). Alongside "sharing and discussing HITs" (P14) and "building and sharing tools" (P5), the opportunity for friendship was key to engagement:

> "*Some of my closest friends I've met through doing this kind of work. A lot of trying to share and work together. It's definitely not a typical line of work. As you build friendships,*

[1] https://www.turkerview.com

you kind of want to start looking out for each other because a lot of us have had different reasons for why we've chosen to stick with this kind of work. It's really cool." (P1)

4.5 Understanding How Tooling Practices Develop and Evolve

A common theme that emerged from our analysis is that crowdworkers' practices are the product of exploration, experience, and self-evaluation. Learning hurdles were apparent across all participants and included finding realistic monetary goals, finding useful software scripts and tools, understanding how tools function, understanding how to multitask work-related tasks', and understanding how to interface with worker communities. Having only worked full-time for six months, P2 said:

> *"A few weeks ago, I figured out that using multiple windows for a few things works better for me. That's why having two displays is so much better. Otherwise, I used to only have one, and I had everything stacked on top of each other and I was like 'Oh, I can't see what's going on', but now, I'd get another one if my desk was big enough."* (P2)

Senior crowdworkers who had longer periods of tenure as full-time workers voiced similar sentiments and reflections on their past "Aha! moments" (P8) of discovery. However, these individuals in particular clarified that the tooling they employ in their practice had continued to evolve as a means of reaching their daily or weekly earnings goals. As P1 stated:

> *"It's something where you have to be a self-starter, and you have to be willing to try something and experiment. A lot of the scripts that I use now – like two years ago, I was intimidated by them and I thought, "That's a lot. I'm fine with my hourly the way it is", but you just have to take a risk and see what a difference it makes. Like, 'Okay, what else can I do?'. Now, I'm just constantly trying to find a way to improve my workflow."* (P1)

4.5.1 Tool-Building and Private Tooling. The vast majority of tools used by our participants are publicly available for download as scripts or extensions hosted on the Chrome Extension store or the Tampermonkey website. Owing to the characterization of self-starters, we find that crowdworkers recognize and leverage tool-building as a pathway for enhancing their efficiency. Specifically, we observed an awareness of *private tooling* which one participant succinctly described as "productivity-improving tools that are engineered by a crowdworker, or team of crowdworkers, that are inaccessible to the general public" (P8). To that end, four participants described themselves as "tinkerers" (P5) who put together scripts or extensions on-the-fly as needed:

> *"I'm not a programmer, but I know some things simply because of necessity. If I can quickly throw together a script that helps me earn 20-cents per-minute instead of a 5-cents per-minute, I'll do it. Some people are so heavily into it that they'll write scripts for penny HITs to try and turn them into something worth doing. I don't have the time or the patience for that."* (P12)

Importantly, these participants noted that their authored tools are generally not shared publicly (e.g. on community forums), but instead kept to themselves or shared privately within their close-knit, social circles. Tool-builders aside, several crowdworkers corroborated the importance of tool-building experiences, noting their own usage of "invaluable" private tools (P21) that they had access to as a result of financial or social contacts as we discuss in Section 5.3.

In sum, we find that crowdworkers establish bespoke tooling practices. Specifically, we find that tooling practices are self-tailored to the worker themselves and the work-related goals they seek to meet. We also observe that crowdworkers recognize a need to learn and adapt themselves to "the trick of the trade" (P7). While crowdworkers have developed tooling practices that unquestionably empower their productivity, we find the tooling infrastructure comes with several costs that greatly influence the work practice at large. We now detail these costs as they relate to our broader mission of understanding how tooling practices affect crowdworkers.

5 HOW TOOLING PRACTICES INCREASE FRAGMENTATION

A predominant theme among interviewees' accounts of their work practice was the overwhelming fragmentation tied to their tooling use. Here, we discuss three ways that tooling use increases fragmentation in crowdworkers' tasks, work boundaries, and the communities they engage with. Where relevant, we incorporate data from our post-study survey to strengthen our analysis.

5.1 How Tooling Practices Increase HIT Fragmentation

Crowdwork is inherently *fragmented*. Crowdworkers are often tasked with completing a sequence of arbitrary and unrelated tasks. With tasks ranging from ultra-brief image tagging to longitudinal research studies, there is a persistent need to interleave and switch between HITs arbitrarily throughout the workday. Tooling, specifically HIT-finding tools such as HIT catchers and HIT auto-accepters, play a central role in crowdworkers' work practice. A key theme that emerged in our analysis was that these tools amplify the fragmentation of crowdworkers' tasks.

5.1.1 *Tooling Use Promotes Interruptions.*

> "*You learn the ropes, and like everyone else, you eventually start relying HIT catchers. And from there on, you'll definitely catch HITs, but you'll be interrupted left and right.*" (P12)

Our analysis suggests that HIT Catchers / Auto-Accepters promote the fragmentation of HITs by surfacing notifications about newly-found HITs "at the wrong time" (P16). Participants recognized that the activity of these tools is reactive to the availability of work, but also regarded that "there are times to notify and times not to notify" (P18). To that end, participants often tune the notification preferences in their HIT-finding tools to match their attentional capacity for interruptions:

> "*I regularly work on a series of HITs that involve substantial reading. It's a legal case, and I need to remember who did this, who is being accused of that, the evidence provided by both parties. It's a task I absolutely refuse to put on pause.*" (P16, MPI Score = 26)

Crowdworkers are aware of the cognitive costs that stem from fragmenting HITs. Participants specifically mentioned that cognitive costs vary between different tasks, and they therefore maintain preferences toward tasks they should fragment (i.e., batch HITs) and tasks they should not fragment (e.g. HITs that resemble information work). In some cases, tooling surfaces an opportunity that cannot be turned down, i.e. because of a high reward, and a task switch is deemed "unavoidable" (P7). Some crowdworkers were able to reflect on the frequency of these scenarios and how they've come to terms with them:

> "*As you do more work, you develop ways of prioritizing your work in your head, so that you're not suffering the discord [from switching]. My notifications will still fire, and I'll still accept work, but I'll do that work in a certain order or be strategic about when I divert my attention. I guess I've created a coping method to avoid suffering that discord.*" (P5, MPI Score = 43)

In addition to surfacing notifications at inopportune times, we find that HIT-finding tools facilitate *interruption overload*, a form of distraction caused by the excessive number and inappropriate delivery of notifications or alerts [82]. When asked to reflect on their first-hand experiences, all 21 participants recounted scenarios in which their HIT-finding tools had found and accepted not one new HIT, but an excessive number of new HITS. These scenarios in particular were described as regular occurrences throughout the workday:

> "*There's times where your tools catch so many things drop at once, and you have to stop and consider 'Okay. What can my hourly be if I switch to this task?' or 'Which tasks do I enjoy more? Which one's going to be faster?'. I know that this requester typically uses bad servers, but I always make really good money from their HITs. It's like a stress-inducing game in your head where you have to decide 'What is my attention to going to?'*" (P1, MPI Score = 46)

The challenge of these scenarios is that they often force crowdworkers into "a momentary shift from my actual work to my administrative work" (P14), specifically the management of their HIT queue. Several participants explained that excessive notifications were particularly stressful as it implied that their HIT queue may have reached capacity, which would prevent their HIT Catchers and Auto-Accepters from finding "the $10 surveys that everyone wants" (P9). Participants noted that managing their HIT queue was a process that required their full attention as it involved evaluating which HITs should be kept in the queue and determining which HIT they should engage with after managing their HIT queue. Participants noted the process itself "can take several minutes" (P16) as it forces them to re-evaluate HITs in their queue, considering each HIT's time constraints, task demands, and reward. However, even after engaging with the next HIT, participants noted that the interference facilitated by these tools rarely shows signs of stopping:

> "*I get stressed when I have a ton of work in my queue, and I want to do all of them. Even after managing the notifications, new HITs are still coming in like crazy, and I'm being alerted. And that is when I get stressed. When I'm doing this, I'm thinking about 'Oh my God, I gotta hurry up and finish this' because I have all these other HITs that I have to get done, too. And there's a time limit. It's constant stress.*" (P2, MPI Score = 23)

Participants unanimously described these scenarios as "overwhelming" (P3), "distracting" (P21) and "highly disruptive" (P4), as the scenario requires them to temporarily stop working and devote their attention to evaluating "the path of greatest reward" (P9).

Despite these negative effects, the consensus among participants was that HIT-finding tools are irreplaceable in their work practice. Participants expressed an awareness of the distractions that come with these tools, noting that "crowdworkers just have to deal with them" [P1]:

> "*Notifications from these tools always come at the wrong time, but there isn't a 'good time' for them to come either. You're trying to make as much money as possible, and it's hectic – but hectic means that I'm have more money lined up and stuff to do.*" (P12, MPI Score = 34)

Owing to the inadequacies of notification timing, P14 described their HIT catcher as "nothing more than a terrible manager that's unaware of your already insurmountable to-do list", suggesting that its major drawbacks are its lack of awareness of crowdworkers' current state of mind and workload.

5.1.2 Tooling Use Promotes Multitasking. A common criticism of HIT-finding tools voiced both by monotaskers and multitaskers was that these tools "make it so easy to multitask when you shouldn't" (P21). While the decision to engage in multitasking behavior ultimately made by the worker, 12 participants specifically explained their multitasking behavior as a practice enabled not only by their desire to reach their earnings more quickly, but also by the availability of secondary work in their HIT queue:

> "*When you're forced to wait for a minute, you have to evaluate whether you want to decide what you value your more – your attention or your money. Catchers make it easy because the work is already in your queue, just waiting for you.*" (P19, MPI Score = 29)

Although we saw no significant differences in impulsivity as measured with the UPPS scale, participants who were measured to have high impulsivity generally voiced similar sentiments, stating they would "probably be more focused if I wasn't even aware of the other work I could do" (P3). Conversely, low-impulsivity particants describing pending work as something "that can wait on me to get there" (P7). While participants were willing to avoid multitasking if the pay was high enough, they also described their own personal aversions to multitasking despite regularly engaging in it. Participants described multitasking as "stressful" (P6), "confusing and costly" (P2), and most frequently "harmful to my overall work quality" (P4):

> "*I want to do my best, and I want a high approval rate. If I'm dividing my attention between 3 tasks, I can't pay attention enough to do a good job.*" (P8, MPI Score = 26)

Resembling task multiplexing techniques from prior work [85], participants commonly described a strategy in which they fill their primary task's downtime with a secondary HIT that requires little attention. Surveys and batch HITs were explicitly mentioned as secondary HITs for their brevity and minimal context, both of which "make it easy to put down and pick back up". Participants with higher MPI scores also noted technical downtime as a driver to their multitasking behavior:

> "*I usually can do three or four batch image-tagging HITs simultaneously. I open four different browser windows because it takes time to load the image each time I submit a HIT, which takes time away from me, from making money. [Requesters] understand that there's loading time for the photos and that takes another three seconds or four seconds sometimes when you could be doing another HIT, so they allow it.*" (P3, MPI Score = 36)

Participants also noted that their multitasking behavior is driven by the nature of the work they're currently engaged in. Collaborative or interactive HITs that have forced waiting periods or periods of inactivity were specifically mentioned by more than 18 of the 21 participants:

> "*I frequently do HITs where I'm asked to chat with other crowdworkers. Most of the time, your partners are really slow. So, you have a lot of lag time in between when you reply and when they reply back. If there's a quick batch HIT, like a penny HIT, in my queue, I'll open two windows, and I'll go back and forth between both of them.*" (P8, MPI Score = 30)

5.1.3 Tooling Use Promotes Beneficial Interruptions. Despite the stress-inducing scenarios that accompany their use, we find that HIT-finding tools play a central role in fragmenting HITs beneficially. Tools can serendipitously improve engagement by surfacing opportunities to task switch in moments where participants needed to "mentally refresh themselves" [P9] from mononotous work:

> "*I switch all the time. I have no attention span. I'll work on one HIT for a while, and after some time, I'll constantly be looking through the HIT Catchers and Finders to see if anything else is coming up with a short timer on it that I can use to clear my brain.*" (P8, MPI Score - 45)

Participants said that switching to a different task "fires different neurons, you know, and just engages me differently" (P5), "improves the quality of my ability to work" (P7), and "generally makes the work more enjoyable" (P9). However, mental strain from monotonous work does not always guarantee that a task switch will occur. In fact, many crowdworkers leverage the moments to temporarily step away from work entirely:

> "*Sometimes, I'll get mentally exhausted. I'll switch into a different window and check Twitter or Tumblr or something like that. Maybe I'll go like make a cup of tea, or I'll try to do some chores for a little bit and come back to the work I paused after I feel better.*" (P6, MPI Score = 16)

Importantly, crowdworkers' work practices are driven by earnings goals, and we find earnings opportunities can often overpower the need to "mentally refresh" for proficient toolers:

> "*If I wanted to put myself through Hell, I could. If I wanted to do the monotonous, garbage, $12-per-hour grunt work, I could put myself through that. I don't choose to, I don't need to. However, when you pay enough, nothing is monotonous - I can promise you that.*" (P7, MPI Score = 12)

Despite its generally negative effect on the work-related engagement, crowdworkers acknowledge that a time and place exists for monotonous work that can help you "zone out" (P10). In general, the negative sentiment surrounding task monotony is driven by the notion that HIT-finding tools fail to account for diversity in crowdworkers' workflows in any capacity.

In summary, we find that tooling use promotes interruptions with unprincipled notifications and alerts that disrupt crowdworkers in excessive quantities or at inopportune times. We also find

that tooling use encourages multitasking behavior by making passive work easily accessible. We finally find that workers rely on their tooling to fragment their work beneficially by utilizing it to diversify their HIT workflows, specifically in large streams of monotonous work.

5.2 How Tooling Practices Increase Work-Life Boundary Fragmentation

A common theme in our analysis was that work "sometimes doesn't end" (P1) after it's been set aside. All 21 participants described their work practice as one they "tried to follow a routine work schedule" (P12). However, participants' work schedules varied heavily between one another, and ranged from "the standard 9-to-5" (P11) to "working sun-up to sun-down" (P18). We find that tooling plays a significant role in increasing their on-demand availability during nonwork time as well as their mental attachment to their work.

5.2.1 Tooling Use Increases On-Demand Availability.

> "*I wake up, and it's always time to work because it just never ends on MTurk and you never know when it's gonna get busy and when it's not.*" (P12, *Work Warrior*)

Crowdworkers leverage tooling to make themselves available when and wherever possible. Many participants mentioned strategies for configuring their tooling to run, but never knowing when it may trigger an interruption during their nonwork time. However, we find differences among our participants in the extent to which they go about making themselves available. To that end, we find similarities within the WLI clusters, i.e. Work Warriors, Overwhelmed Reactors, and Family Guardians, and the strategies they employ in practice for increasing their availability.

Among our participants, all four Family Guardians employed strategies that were focused on making themselves as inaccessible as possible during nonwork hours. Participants described strategies for firmly separating themselves from their work by leaving the room for the rest of the night, committing to social plans, and simply focusing on nonwork matters:

> "*In the evening, I'm busy with other things. I've got other things that need my attention, but I might leave my catchers running to check in periodically*" (P4, Family Guardian)

These participants described little interest in working with devices while away from their computer with the one exception being closed qualification HITs that have extremely limited time constraints.

Conversely, Overwhelmed Reactors and Work Warriors described strategies that center around "micromoments" – small gaps in time for getting things done [95]. These participants described a diverse set of work-on-the-go scenarios, "while sitting in in the living room" (P9), "while watching my kids outside" (P18), "in the line at the grocery store" (P3), and even "while I'm sitting at a red light" (P16). Tooling plays a key role in allowing people make use of these moments:

> "*[The tools] keep me occupied if I'm riding in the car or if I'm walking to my office at the University. University parking kind-of sucks, and I might as well use the 10-minute walk from my car to my office to be a little bit productive.*" (P13, *Work Warrior*)

While these scenarios vary between individuals, we find that Work Warriors specifically maintain a desire to make productive use of every moment possible, even if an opportunity arises at an inconvenient time. In several instances, participants described such scenarios that demonstrated making use of every moment possible meant sacrificing their engagement toward something else:

> "*If you're at a boring dinner or something, and you get an alert – 'Oh, this batch pays well'. Yeah, sure. I'll just mindlessly tap this under at the table, and no one will know.*" (P1, Work Warrior)

> "*I recently woke up at 2:00am to go to the bathroom, and like any tech-minded individual today, I checked my phone. I saw an alert on my private tool from a requester about an opportunity for a $20 survey. I finished the survey in 15 minutes and went back to bed.*" (P20, Work Warrior)

Several workers, primarily Work Warriors, have their entire work practice centered around perpetual availability:

> "*I can carry it with me, and the work never leaves. In that case, it's important because when you're so involved in crowdwork, you could sit and work for 14 hours straight without a break very easily because the HITs are flowing. You have to regulate yourself and if you don't do that, you'll become a workaholic.*" (P10, *Work Warrior*)

The desire to continue work is primarily driven by money. Our participants' earnings goals were often limited to the day or the week as more long-term goals could not be set to "account for the ups-and-downs of the market" [P20]. Participants generally described using their earnings goals as a form of finish line to mark the end of their day. Overwhelmed Reactors or Family Guardians demonstrated an ability to set work aside after their goals had been made. Work Warriors, however, described an affinity toward continuing work if the opportunity exists:

> "*I have a different philosophy on goals because it can be so tough to put down. If you made $30, you can make $33. If you made $33, you can definitely make $37. It goes on and on.*" (P8, *Work Warrior*)

The sentiment voiced by P8 was specifically echoed by participants who have worked on MTurk for more than a year — goals become become more like "guidelines rather than finish lines" (P18), which may explain the relationship we find between WLI scores and demographics in Section 3.3.2.

5.2.2 Tooling Use Facilitates a Mental Attachment to Work. Across all three classifications of boundary management strategies observed in our study, we find it common practice for crowdworkers to actively leave their HIT-finding tools running during their nonwork time, allowing them to remain passively engaged with their work. We find that this behavior largely contributes to a sustained feeling of being "mentally connected" (P1) to their work regardless of whether they actually engage with their work during their nonwork periods.

Crowdworkers noted that they are motivated to remain"on call" (P5) in part because of the feeling of serendipity of discovering unanticipated HITs, especially after hours. As one participant said, "[you] never know when something valuable will show-up" (P13). Several participants referred to their HIT-finding tools as a technology that "plays on the fears of missing out" (P19):

> "*Even when the catchers aren't running and I've shut it all down, sometimes the thoughts creep back in. What am I missing? What's on the market?*" (P21, *Family Guardian*)

To our participants, "escaping work is fairly impossible sometimes" (P12). For example, work-related communication, such as e-mails from requesters, often need to be addressed as soon as possible, and leaving it unaddressed runs the risk of losing money for work that a worker had already done earlier in the day or week. Several participants described these communications as "forcing them to come back to work mode" (P7) even when they choose not to attend to them.

For a small number of crowdworkers, an attachment to work is not always regarded as negative. While Family Guardians and Overwhelmed Reactors expressed a desire to be less focused on work than they already are, Work Warriors sees their sustained connection to work is one of enjoyment:

> "*I do feel that [I'm always attached], I really do. I mean, I actually like this work because I have autonomy. I can make my own hours. I'm my own boss. And I actually enjoy most of this work. I really like it.*" (P10, *Work Warrior*)

When asked to clarify if their connection to work is rooted in the nature of the work or the tools they use, participants expressed conflicting sentiments. On one hand, participants were quick to suggest their tooling was at fault, but often backtracked, recognizing the decision to continue using their tooling is ultimately their own to make:

> "*I want to blame the tool's because they're designed to work this way, but it's my fault, too. I mean, come on. I'm in control. It's just when the HITs are flowing and the opportunity to make good money is there, the tools make it easy to jump back in.*" (P9, *Work Warrior*)

During the interview, participants commonly followed these remarks with a stated desire to change their tooling in such a way that would allow them to devote more attention to things unrelated to work during nonwork time. When this occurred, we continued the discussion by asking participants to imagine and describe the type of tooling that could help them do so:

> "*We have catchers and auto-accepters, sure. But we just don't have the right tools to help us avoid these problems. We just do our best to not have those days occur.*" (P2, Family Guardian)

One participant (P21) was interested in seeing a tool that "could help [them] forget about work entirely" at the end of the workday, but was unable to characterize exactly what they meant. More commonly, several participants described that "the current model of catching HITs" was too central to crowdwork for an alternative approach to exist, speaking to the sociotechnical limitations of crowdsourcing platforms as touch-and-go systems for work.

In summary, we find that crowdworkers affiliate their sustained mental attachment to their work as one intermixed between the work itself and the tools they use in their practice. By maintaining this attachment to work, they fragment their boundary between work and nonwork, engaging with work-related tasks at the whim of a notification or alert. The significance of their attachment is that it is often sustained despite workers being aware of the adverse consequences that may follow.

5.3 How Tooling Practices Increase Community Fragmentation

Social ties are an important facet to crowdworkers' broader work practices. We find that tooling use is a central point of social tension that often had led to a fracture within their communities. Specifically, employing tools in support of productivity is a universal effort, but a gap exists between those who have access to the appropriate tooling and those that do not.

5.3.1 Limited-Access and Commercial Tooling. Throughout our analysis, we observe that several crowdworkers have access to private tools that enable them to work more efficiently, both while at their primary work computer and while away from it. We find that limited accessibility of these private tools play a significant role creating social fractures within the MTurk community.

As topics of discussion, TurkerView and private tooling were often interlinked. Participants who employed private tooling toward the task of auto-accepting HITs often avoided identifying the tooling source, instead stating that these tools "come from a private place from a person willing to offer that to me or to anybody else" (P5). While some participants find their tooling elsewhere, e.g. P5, many recognize TurkerView as a a hub for such tooling:

> "*Last summer, the founder of TurkerView was trying to create some more tools that were just a little bit more intensive than a browser script. He was charging a subscription for that because it was taking a lot of time out of out of his workday to maintain it.*" (P13)

P13 is a crowdworker who does not actively engage in TurkerView in any capacity and, like many others, has heard of TurkerView's rumors on other forums or social channels. The platform's association to the development of private tools was described by 16 of our 21 participants, 3 of which explicitly said that they pay for private HIT auto-accepters sourced from the platform. Participants also noted the platform's adopted a new subscription model for its popular reviewing extension, which runs separately from the private tools that our 3 participants stated they pay for.

While the platform serves as a valuable point of access to the broader crowdwork community, several crowdworkers perceive TurkerView's decision to commercialize their reviewing extension as a shift in "what's best for the community" (P10). While the majority of tools are pubilcly available,

the notion of private tools is not necesarily new [52]. The key distinction between TurkerView and its private tooling predecessors (e.g., Turkinator) is its centrality to crowdworkers' work flow:

> "*Kaduchi, who makes MTurk Suite, makes Turkinator that you can pay $10 a month for. It's not as efficient as using the other ones because of the way it searches. But with TurkerView, it's not like you can't use it. You need to be able to see the reviews.*" (P17)

We find that TurkerView's relationship to private tooling has shaped crowdworkers' perception of community platforms significantly. Participants who actively use the platform described the TurkerView community as one that is generally "more experienced than most Turkers you'll find elsewhere" (P7). While the perception of productivity is generally true for TurkerView's userbase, the commercialization of their software has lead people to question its motives:

> "*TurkerView has a monopoly on the community. There are suspicions that [the TurkerView extension] hides HITs from people who aren't paying for the full version. That's the main reason why I uninstalled it. I've also found TurkOpticon's reviews to be more accurate than those on TurkerView, which makes me think that they're gaming reviews, too.*" (P14)

In lieu of participating in TurkerView, P14 frequently participates in and moderates a Facebook group of more than 2,000 active crowdworkers. Unlike P14, many participants cite the open tooling practice as a significant deterrent for engaging with communities altogether:

> "*I've browsed TurkerView, and the things that people bicker over is insane. You'll see peoples say things like 'I made $85 today!'. It's just clear this person is bragging about their earnings and we know you just have the right tools. It's just – it's frustrating, and it's everywhere.*" (P20)

Even in scenarios where tooling is accessible, crowdworkers may not choose to utilize it in their work. We find that ambiguity in MTurk Policy Agreement[2] plays a significant role not only in crowdworkers' decision to utilize a particular tool in their work, but also how they perceive the fairness of their practice. Participants noted that over-automating components of their work too excessively can result in "a temporary suspension" (P7) or "a complete ban of your account" (P1). As a collective, participants engaging in private work highlighted the discrepancies in the policy that drive their decisions to engage in a potentially terminating tool practice:

> "*The terms tell us not to have scripts that needlessly pull data from MTurk. In order to catch any HITs, you have to do that. It's against the Terms of Service technically, but you're not gonna get anything done if you don't. It's 'Damned if you do. damned if you don't'.*" (P13)

Participants who shared P13's perspective were also those who belonged to more personal, close-knit groups that emphasize building scripts and extensions "as newer opportunities to optimize the workflow" (P1) arise. In contrast, we find that participants that did not belong to these communities expressing more ethically-minded remarks about the fairness of private tooling:

> "*The private tools I know of are just automatically accepting by the dollar value, and I know that I don't use them, but God, I'm sure it would be great, and I'm sure I'd make much more money. But it's just isn't particularly ethical to everyone else on the platform.*" (P3)

Tooling availability, in sum, strongly contributes to the fragmentation of social ties within and between crowdworkers' communities. Crowdwork is centered on the pursuit of work opportunities in which each worker has a fair chance of finding work. Private tooling practices are a significant barrier in preventing this premise from becoming reality by facilitating unequal access to work opportunities between workers. Motivated by mixed perceptions of unfairness in tooling practices, crowdworkers splinter their social ties between communities that continue to empower "the upper echelon" (P11) and those that instead strengthen the broader crowdworker community at large.

[2]https://www.mturk.com/worker/participation-agreement

6 DISCUSSION

Engaging a diverse set of full-time crowdworkers in discussions of their broader work practices allows us to understand how their tools affect the way they work. We found that crowdworkers regularly experience cues that facilitate interruptions and multitasking and cause attentional fragmentation while working. We have also found that crowdworkers maintain fragmented work boundaries between their work and nonwork spheres, passively engaging with their work during micromoments of availability or more broadly whenever they are called upon. Finally, we have found that notions of tooling fairness strain social ties within the broader crowdworker community, driving crowdworkers toward private communities or away from social engagements altogether. We now discuss the implications of these findings as they relate to the future of tooling.

6.1 Understanding Crowdworkers' Tool Ecologies

Prior studies of tool ecologies have introduced characterizations of tools in more traditional information work settings that bear similarity to our own characterization presented in Table 3. Gonzales et al. [25], for example, introduce four unique software roles that tools can play among teams engaged in solving a collaborative, complex task. Our work complements, blends, and expands on these software roles by introducing a more comprehensive assessment of software roles specific to the full-time crowdworker on Mechanical Turk. Similarly, Turner et al. [97] noted the value in leveraging multiple communication tools in the workplace, detailing that each tool offered a unique social value to the individual. Speaking to Section 4.4's findings on engaging in both public and private communities, we share Turner et al.'s conclusion in that workers similarly engage with these communication tools, whether they be public or private, for a range of reasons and that each tool's sustained use is driven by workers' social needs more than others (e.g. functional needs).

Our study suggests that workers' tooling, in its current state, is designed to optimize for productivity. Beyond the scope of crowdwork, building tools in support of productivity and efficiency is often criticized for enabling a practice of Taylorism, a theory of management that prioritizes productivity (i.e., output) often at the expense of the individual [69, 104]. HIT-finding tools specifically are no exception to this criticism as they optimize for earnings without regard for other facets of crowdworkers' work and nonwork lives. Our study highlights the reality of these expenses by demonstrating the fragmentation workers experience both in their work and beyond it.

6.2 Reimagining the Crowdworker's Toolbox

Combatting the fragmentation that crowdworkers experience requires a reimagination of the tools they employ to find work. Here, we argue that this reimagination should be an independent venture, but a collaborative one. We describe several key considerations for designing and engineering tools in support of crowdworkers' work and non-work lives.

6.2.1 Empowering Workers' Tooling Practices with End-User Development. We find that crowdworkers' tooling practices are generally composed of software developed by people (i.e. workers) within the crowdwork community. Importantly, crowdworkers rely heavily on other individuals to build and maintain these tools that make their work practice possible. Further, within our study, we identified four "tinkerers" that already self-engineer tools that allow them to improve their efficiency as needed. Importantly, these "tinkerers" have a tooling practice that serves as a form of end-user development (EUD) [58, 68]. Studies of EUD have demonstrated that enabling the end-user to engage in the software development process can take shape in a variety of ways (e.g., allowing end-users and developers to co-develop software [6]) and can yield a plethora of reusable resources that allow others to learn and adopt the EUD process in their own workflows [41, 67]. However, a central question here is understanding how researchers can introduce new systems and

infrastructures that make the personalization of tooling workflows more accessible. Similar goals have been undertaken in other contexts with success, such as Microsoft's MakeCode initiative that enables students of any age to engage in programming [9]. From participatory design studies to co-developed systems, a key direction of future research is understanding how CSCW researchers can build high-value infrastructures that enable workers with the ability to craft a work practice that suits themselves.

6.2.2 Designing Tools for Productivity and Well-Being. Our study suggests that HIT-finding is at the core of productivity support tools. Prior research has taken first steps toward supporting crowdworkers' decision-making processes by building and evaluating tools that help workers make more informed decisions about the work pursuit[33], work acceptance [86], and work completion [90], signalling next steps toward task recommendation systems that handle work far more strategically than the HIT-finding tools that crowdworkers currently rely on. Our findings speak directly to the importance of the systems' ability to surface the right type of work and the right amount of work at the right time – all of which have been studied in prior information work settings [8, 45, 53, 103]. Per our findings, the most fruitful avenue of impact is enabling workers to further customize the cueing mechanisms (i.e., alerts and notifications) that enable them to sustain their engagement with work. Tools and systems used in practice should account for the worker's context both in and out of work, maintaining an awareness of their attentional preferences, their attentional capabilities, and their desire to engage with work-related tasks at a particular time. Importantly, these same tools and systems should also prioritize the protection of their users' privacy, employing techniques to ensure that user-generated data is both secure and managable.

While the design of HIT-finding tools is situated at the forefront of the problem space, we recognize that how people decide to use their tools ties into the work-related fragmentation they experience. Studies of organizational interventions of workaholism speak to the importance of "*managerial influence*" [36, 94] in the workplace, citing that change can stem from leading by example [7]. This is particularly true for psychologically detaching from work [91]. As crowdworkers often recognize their HIT-finding tools as managerial complements to their work, one possible solution is to innovate new systems and tools that make it more difficult to engage with work [74] or facilitate detachment from work with a tool, such as SwitchBot [102]. However, solving such a problem where there are external pressures to work (e.g., failing to meet an earnings goal) overlooks the larger problem of what is causing the pressure to work in the first place. In such a scenario, there is a strong presumption that technology can solve it, when we may need to look beyond the scope of technological innovations. We therefore recognize that the reimagination of the crowdworker's toolbox is a tool design problem that should be approached from an interdisciplinary lens, involving teams of many disciplines (i.e., computer science, sociology, occupational health, cognitive science) rather than being grounded in one particular area of research.

6.2.3 The Future of Fair Tooling: Ethics and Community. Prior research has recognized that the design of crowdwork platforms thrives on an inherent imbalance of power between workers and requesters [47, 75, 78]. We find that the private tooling practices that crowdworkers self-create and engage in serves as a form of power redistribution not between requesters and workers, but instead among the workers themselves. A lack of clarity and oversight on Amazon's behalf plays a central role in the inability to concretely define and understand fairness in the context of tooling. Should workers be allowed to self-engineer tools for themselves? Is tool-sharing permissible? What level of automation mandates a policy violation? Most importantly, who is qualified to address these questions? Off-loading the onus of answering these questions onto crowdworkers has enabled the current state of private tooling practices, driving mixed perceptions of fairness and accountability.

We argue that designing and promoting fairness can and should be a collective effort between workers and the research community – a process employed by a number of platforms that come before us, such TurkOpticon [46, 47] and Daemo [24]. However, collective action systems in crowdwork are particularly contentious as researchers and crowdworkers often have distinct goals, and if tool-building is to become an effort shared between workers and researchers, both parties should be incentivized appropriately. As prototype systems continue to be built and studied by academics, researchers can play an active role in promoting tool fairness by open-sourcing the tools they study. In line with EUD [58], workers and researchers could co-maintain a citeable web listing of prototype tools that have been studied, the type of workers they've been studied with, and a reference to the tool's source code repository. The web-listing could not only allow workers to share their code, but also allow them to receive donations for a particular script. Recent work, for example, has demonstrated that many feel comfortable using their labor as a form of donation (e.g. donating the competition of a HIT instead of a monetary donation) [54]. A similar model could be adopted to incentivize tool-sharing within the broader community to allow workers to more easily show appreciation to one another for their efforts as seen in open-source software [60].

6.3 Beyond Tooling: The Nature of Crowdwork Platforms

A key consideration in evaluating and investing in future tooling research is recognizing that this study's findings are grounded in the nature of crowdwork. Research has long recognized the many shortcomings of platform design in crowdwork [98]. Crowdsourcing platforms and marketplaces, for example, do not regulate or oversee that HITs have appropriate task constraints (e.g., allotted time), nor do they oversee that monetary rewards are commensurate for the amount of effort given toward a particular task [31]. Several efforts (e.g., Stanford's Fair Work initiative[3]) have taken steps toward building tools aimed at overcoming the constraints of these platforms in such a way that advises requesters to pay more fairly, should they need to. While these tools and systems are unquestionably well-aligned with the mission of reducing fragmentation, the demand for fair pay has continued as a central point of discussion both in and beyond academic literature [88].

The penultimate solution for combating fragmentation is one that drives change not only within tooling practices, but more broadly within the work practice itself. Agency, flexibility, and learning opportunities are valued aspects of crowdwork that extend to the broader gig economy [28, 65, 72, 106]. Recognizing that corporate interests often drive the design of these platforms, we encourage these crowdwork corporations – namely Amazon – to pursue and prioritize partnerships with research collectives of both academics and crowdworkers with the goal of exploring pathways for guiding the future of work. For example, to combat the fragmentation between work and nonwork, MTurk could provide workers with the ability to limit their work hours to an 8-hour window during the day. How would such a system ultimately influence work-life fragmentation? Could such a system nudge requesters to pay more fairly? Inspired by prior work-related studies, other platform-level changes could include suggestions for scheduling when *not* to work [70], limiting access to distracting websites while working [74], and managing the viewership of HITs from workers to promote engagement [64]. Such possibilities are largely subject to platform-level changes and rely on Amazon, among other corporations, to recognize the need for change. Until then, tool research will remain the most fruitful pathway for empowering workers both at their workstation and beyond it.

[3]https://fairwork.stanford.edu/

6.4 Limitations

Our study was conducted with crowdworkers who regularly work a minimum of 35 hours per week on Amazon Mechanical Turk. Our study makes no claims about the broader work practices (e.g. device usage, tool usage, etc.) of people who work less than 35 hours per week or work on alternative platforms, such as Microsoft's UHRS [1], Figure Eight [2], and LeadGenius [3]. We recognize the need to understand how tool definition, tool use, and tool effect varies across these platforms as a key direction for future research.

7 CONCLUSION

In this paper, we reported findings from an interview study aimed at exploring the tooling practices employed in full-time crowdwork. Our findings suggest that the tooling utilized by crowdworkers (1) strongly contributes to the fragmentation of microwork by enabling task switching and multitasking behavior; (2) promotes the fragmentation of crowdworkers' work-life boundaries by relying on tooling that encourages a 'work-anywhere' attitude; and (3) aids the fragmentation of social ties within worker communities through limited tooling access. We concluded our paper by discussing the implications of our findings in the context of engineering and studying tools that meaningfully impact the productivity and well-being of the crowdworker community.

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