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Tasks of a Different Color: How Crowdsourcing Practices Differ per Complex Task Type and Why This Matters

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Crowdsourcing in China is a thriving industry. Among its most interesting structures, we find crowdfarms, in which crowdworkers self-organize as small organizations to tackle macrotasks. Little, however, is known as to which practices these crowdfarms use to tackle the macrotasks, and this goes hand in hand with the current practice of the HCI research community to treat all forms of complex crowdsourcing work as practically the same. However, macrotasks differ substantially regarding structure and decomposability. Treating them under one umbrella term - macrotasking - can lead to an imprecise understanding of the workforce involved. We address this gap by examining the work practices of 31 Chinese crowdfarms on the four main macrotask types, namely: modular, interlaced, wicked, and container macrotasks. Our results confirm essential differences in how these nascent crowd organizations address different macrotasks and shed light on what platforms can do to improve the uptake of such work.

CCS Concepts: • **Information systems → Crowdsourcing**.

Additional Key Words and Phrases: Crowdsourcing; Crowdfarms; Work Practices

1 INTRODUCTION

Crowdsourcing involves individuals or organizations creating an open call for tasks that interested workers can work on remotely and earn money. By using individual intelligence to help solve problems that rival the effectiveness of computational systems and related technologies, crowdsourcing has been remarkably successful in different tasks. These tasks include data clustering, content labeling, and file editing (e.g., article shortening and audio captioning). Consequently, when mentioning crowdsourcing, a list of small, similar, homogeneous, and relatively straightforward tasks

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- "microtasks", as they are commonly referred to - automatically comes to the minds of industrial practitioners and researchers. However, crowdsourcing is an evolving practice. An increasing number of crowdsourcing calls concern larger and more complex tasks; tasks that involve interdependent knowledge, higher levels of expertise, and tighter collaborations. Such tasks include industrial design, software development, and advertisement production. In juxtaposition to microtasks, these types of tasks are known as macrotasks [20]. Macrotask crowdsourcing allows crowdworkers to contribute to a broader range of work and harnesses their potential, often capped when they work on simple microtasks. As such, macrotask crowdsourcing solves more challenging problems of critical social and economic value. At the same time, it provides crowdworkers with opportunities to upskill, reskill, and develop their careers through working closely and learning from peers.

Macrotask crowdsourcing has drawn the attention of researchers worldwide. Grier et al. [12] claim that macrotask crowdsourcing is a "professional form of crowdsourcing". Their work emphasizes the stark differences macrotasks have compared to microtasks regarding task instructions and required expertise. Kim and Robert [23] identify collaboration and coordination among individual crowdworkers as one of the most central elements of macrotasking. Building on the importance of coordination, Haas et al. [13] identify quality control as one of the main problems for designing efficient macrotask workflows. Valentine et al. [43] go one step further and develop the notion of Flash Organizations, in which individual crowdworkers are organized in formal collaborative structures involving roles, teams, and hierarchies that delineate responsibilities, interdependence, and information flow in an agile manner. This latter work illustrated that joint crowd structures, rather than solo crowdworkers, are more efficient in handling the complexity of macrotasks, especially for work that requires advanced expertise and tight collaborations, such as software application development.

Rooted in a crowdsourcing community of 30 million digital workers [15], macrotask crowdsourcing is flourishing in China. According to Wang et al. [46, 47, 50], most of these workers do not perform individually; rather they self-organize into small companies and teams explicitly focused on undertaking complex crowdwork. These structures, known as "crowdfarms" – a mix between "crowdsourcing" and "farming work out" – are rising in China, due to a unique mix of three favorable conditions. These conditions are, first, the many complex macrotasks available in the Chinese crowdsourcing market, second, the favorable government policies (such as the "mass entrepreneurship and mass innovation program"), and, third, the presence of crowdsourcing platforms like ZBJ that incubate crowdworking companies as part of their business strategy [1] [46]. Crowdfarms, as illustrated by Wang et al., adopt structural and organizational approaches when dealing with macrotasks, including internal quality control by managers, subcontracting for external collaborations, and regular post-task refinement for reputation maintenance [50]. Crowdfarms are an emerging phenomenon and their macrotasking practices can profoundly affect not only Chinese crowdsourcing stakeholders but also the evolution of the gig economy as a whole, as well as the well-being of millions of workers who are currently engaged in individual crowdsourcing works [47]. Being the most advanced structures in commercial macrotasking, Chinese crowdfarms are the ideal setting to explore this new emerging type of crowdwork, and identify what works well and what can be improved.

Although macrotasking is often thought of as the "next big thing" in crowdsourcing research and practice, current studies use macrotasking as an umbrella term covering all types of large and complex crowdwork. This approach is to be expected, given the need for early research to examine the novel practices that distinguish macrotasking from the

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[1]http://work.zbj.com

predominant microtasking; practices such as the explicit collaboration among crowdworkers or the coordination mechanisms that allow them to handle the higher complexity of the work at hand. However, as macrotasking matures and becomes more and more a viable commercial alternative to mainstream businesses, the current research approach of treating all macrotask practices indistinguishably is no longer pertinent. Instead, there is a growing need to explore current macrotasking practices through the lens of the underlying structural differences among the different macrotasks, to inform future research and practice in a meaningful manner. Such analysis can, for example, tell the reasons behind the seemingly random work-related choices of crowdfarm workers when choosing to actively participate, subcontract, or refine some macrotasks but abstain from others.

To address this gap, in this paper, we take a systematic approach in examining macrotasking. We base our analysis on the taxonomy framework derived from [20], which categorizes macrotasks in four main types of different structure and decomposability, namely (1) modular macrotasks (well-structured, high decomposability), (2) interlaced macrotasks (well-structured, low decomposability), (3) wicked macrotasks (ill-structured, low decomposability), and (4) container macrotask (ill-structured, high decomposability). We then proceed to explore, in-depth and for the first time, the macrotasking practices of 31 crowdfarms on these four types of macrotasks on one of the largest macrotasking markets, namely China, and one of the largest crowdsourcing platform supporting crowdfarms, namely the ZBJ platform. We interview workers and managers affiliated with these crowdfarms, through an exploratory research approach, based on semi-structured interviews, investigating the explicit work practices of crowdfarms on the four macrotask types of our framework. For each of these four macrotask types, we examine (1) task procurement, (2) task execution, (3) work issues and related solutions for reputation maintenance, (4) attitudes - their perception of a certain macrotask type, and (5) alternative workflow - the application of different methods to a given macrotask type but with different requirements.

This work contributes to a clearer and more rigorous understanding of the macrotasking practices of crowdfarms in four ways:

- First, and for the first time, we specify the work practices of crowdfarms per macrotask category with a conscious study of not only predominant macrotasks but also macrotasks that are rarely touched by previous studies, providing a more in-depth and comprehensive understanding of contemporary macrotasking practices.
- Second, we suggest that the majority of crowdfarming workflows focus mainly on modular and interlaced macrotasks (the first and second categories of our framework), and make a critical evaluation of the pros and cons involved in these practices.
- Third, we uncover a gap in today's crowdfarm work concerning the non-handling of wicked problems (our framework's third macrotask category and a vital element of rapid innovation) and provide possible reasons behind this phenomenon.
- Four, we analyze the dilemma of crowdfarms in undertaking container tasks (the fourth macrotask category studied) with three cases that for the first time exemplify such problems in the general crowdsourcing context.

Based on this new understanding, we provide a set of high-level recommendations for crowdsourcing platforms, facilitating them to offer category-specific support on macrotasking that can eventually increase their own economic and industrial value, as well as the value of the crowdsourcing sector as a whole. These recommendations include:

- A more reasonable payment mechanism is needed for the multiple reworks and iterations involved in the interlaced macrotask type.

- A diversified reward mechanism can motivate the participation of the crowdsourcing workforce in the wicked macrotask type.
- The development of an expert and/or collaborators search engine can structurally facilitate the collaboration among crowdsourcing workers, which is essential for container macrotasks.

The remainder of this paper is organized as follows. First, we review the macrotask crowdsourcing literature, starting from the definition of macrotasking, then covering the latest research works on the topic, and then focusing on macrotasking in China. Next, we outline the methodological design of this study and explain how we analyzed the data. Subsequently, we present our findings, elaborating on the work practices of crowdfarms per macrotask type. We conclude this paper with a discussion of our findings, a reflection on its limitations, and a consideration of possible directions for future research.

2 BACKGROUND

2.1 From Microtasks to Macrotasks

Crowdsourced tasks can be categorized as microtasks or macrotasks. A microtask is a small task that humans can solve more efficiently than computer systems. Typical examples include image labeling [44], document editing for shortening and proofreading [4], audio captioning for accessibility [26], and feedback for articles [24]. The characteristics of microtasks have been well-studied, as they are the most common types of tasks found in crowdsourcing. Multiple research works describe microtasks as simple, straightforward, self-contained, and with short completion times [18, 27, 51]. Microtasks also tend to be homogeneous (e.g., multiple images to be labeled), with similar requirements, requiring non-expert skills Lykourentzou et al. [20]. Data from five globally operating crowdsourcing platforms also indicate that microtasks tend to contribute a relatively low income to the involved crowdworkers, and to limit the development of their skills and career [36]. Developing this point further, a number of scholars [17, 32] argued that the rights and interests of crowdworkers involved in microtask should be better protected with technologies and infrastructures (e.g., the Turkopticon facilitating the interaction between crowdworker and requestor [16]).

In contrast to microtasks, macrotasks refer to larger and more complex work posted through crowdsourcing platforms. Typical examples include software development [39], product design [40], and document writing [42]. Compared to the mature and exhaustive studies on microtasks, the research on macrotasks is still developing, with a handful of studies defining the characteristics of macrotasks. In 2013, Grier et al. [12] proposed that a macrotask is a "professional form of crowdsourcing" that can be freelanced on a global scale. The study emphasized that macrotasks differ from microtasks in that the workers can carry them out independently without support from the requester, can be easily described with clear criteria of completion, have concrete deadlines, and require special skills. These perspectives are partially supported by Machado et al. [29]. In their study of a software development task, they define macrotasks as larger than microtasks and with a higher requirement of specific knowledge. More recently, after comprehensively evaluating the nature of these large and complex tasks, the feature of their required skills, and the related managerial aspects, Lykourentzou et al. [20] provided a first integrated definition of macrotask crowdsourcing:

> "Macrotask crowdsourcing refers to crowdsourcing that is designed to handle complex work of different degrees of structure and decomposability, assumes varying levels of (expert) knowledge over one or more domains, requires a range of 21st century skills, benefits from worker communication, collaboration, and training, and incorporates flexible work management processes that potentially involve the workers."

2.2 Macrotask crowdsourcing practice

Accompanying the growing understanding of the nature of macrotasks is the increased attention to the macrotasking practice. To deal with the high coordination costs involved in macrotasking, Kittur et al. [25] proposed CrowdForge. This system facilitates the assembly and management of small interrelated contributions from multiple individuals working towards large-scale article writing and assists their decentralized decision-making. Little et al. [28] suggested that platforms can use algorithms to structure non-expert contributions into expert-level outputs. This approach is particularly handy for structured macrotasks with clear instructions, such as transcription or writing image descriptions. Retelny et al. [37] introduced Flash Teams, a system that facilitates the assembly of elastic expert groups, who are hired as needed to address a given macrotask.

Certain studies indicate that there is a need for workflows that decompose macrotasks as a means of better quality control. In this line, Vondrick et al. [45] showed that the decomposition of macrotasks is of great importance as crowdworkers tend to complete smaller work units with a higher degree of quality. Working on three task cases, namely simple arithmetic, text sorting, and audio transcription tasks, Cheng et al. [7] also find that splitting the macrotask into smaller parts enhances its final quality and makes it easier for crowdworkers, although it does extend its completion time. Both the aforementioned works indicate that the best strategy to deal with a macrotask is "divide-and-conquer".

However, Haas et al. [13] seem to disagree, stating that decomposition as quality control is not always beneficial, at least not for certain macrotasks. Their work illustrates that data-heavy macrotasks, such as authoring a paper or a presentation, cannot be easily decomposed; Schmitz and Lykourentzou argue that these tasks require participating crowdwokers to maintain the broader context for the task to be successful [41]. The aspects of collaboration and cooperation, rather than the combo of successful division and coordination, seem to be most important for certain macrotasks; hence these aspects have also drawn scholarly interest. In this line, Valentine et al. [43] developed Flash Organizations, an approach to enable the collaboration of individual crowdworkers in a firm-like structure. Their results suggest that crowds-as-organizations is a structure with significant potential to tackle structured and modularized macrotasks such as application development. Brunswicker et al. [5] further demonstrate that by enabling the collaboration of crowdworkers at both the team and individual level, crowdsourcing can be applied to handle wicked problems such as civic innovation.

In addition to the efforts from academia, the crowdsourcing industry is also keenly aware of the emergence of macrotasks. Numerous crowdsourcing platforms have proposed supportive initiatives. For example, in 2019, Upwork unveiled a new policy called "Agency Experience"[2]. The purpose of this policy was to support boutique agencies: small firms specializing in large, complex, and high-value crowdtasks. Likewise, Fiverr announced a new service called "Studios"[3], which also offers crowdworkers the ability to join forces to tackle larger and more challenging tasks quickly.

2.3 Macrotask crowdsourcing in China

According to Huo et al. [15], by 2017, there were already 30 million Chinese crowdworkers serving more than 190,000 enterprises and individuals worldwide. During the past several years, two of the largest Chinese crowdsourcing platforms, ZBJ[4] and Epwk[5], have established themselves as the most prominent crowdsourcing platforms in China with around 19 million active crowdworkers each. These two platforms cover a wide range of crowdsourcing tasks from

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[2]https://www.upwork.com/press/releases/upwork-unveils-new-agency-experience
[3]https://blog.fiverr.com/post/introducing-fiverr-studios
[4]http://www.zbj.com
[5]http://www.epwk.com

microtasks (e.g., click-work) to macrotasks (e.g., software development) while shifting their business focus gradually to the latter [46]. Taking the ZBJ platform as an example, it has aimed to be the incubator for crowdsourcing companies that hire full-time workers and specialize in macrotasks since 2016. This is done by 1.) providing office space to these firms with cheaper rents, 2.) building 26 of what they call "crowdsourcing factories"[6] in 26 major cities in China, which aim to create a "crowdsourcing business community" for these companies, and 3.) establishing a special bidding mechanism for macrotasks, in which only eight bidders are allowed per macrotask to improve the efficiency of the pre-task negotiation between workers and requestors, plus a contract-signing process to protect the benefits of both parties.

Investigating the developing macrotask crowdsourcing sector in China, Wang et al. provide several consecutive studies on the topic. First, they identified that the primary participants in macrotask crowdsourcing in China is not typical solo crowdwork. Instead, they are organizations and fixed teams possessing advantages over individuals (e.g., teamwork, resources, advanced expertise) in dealing with large and complex crowdwork. To pointedly describe these crowdworking organizations, Wang et al. [46] employed the relevant English "farming work out" (i.e., outsourcing) concept to dub them "crowdfarms." They illustrated that the emergence of crowdfarms in the Chinese crowdsourcing context is attributed to the following reasons: (1) the increased number of large and complex macrotasks available on the Chinese crowdsourcing market, (2) the favorable government policies (e.g., the "mass entrepreneurship and mass innovation program"), and (3) the long-term support from the Chinese crowdsourcing platforms as mentioned above [49]. Thereafter, they examined the work practice of crowdfarms and demonstrated that, in comparison to solo crowdworkers, crowdfarms tend to take more structural and organizational approaches to procure and carry out macrotasks and to manage their reputation. For example, crowdfarms carry out macrotasks through systematic workflows that include (1) the initial task planning, pertaining to both the management and crowdfarm workers; (2) task execution, based on the supervision by managers; (3) task refinement, based on feedback from managers and requestors; (4) task integration and inspection, based on cooperation between teams and colleagues; and (5) the final task submission [50]. Based on the results noted above, their recent work [47] suggested that crowdfarms are a double-edged sword for solo crowdworkers, requestors and crowdsourcing platforms. More specifically, profit-oriented crowdfarms rely on their advantages in teamwork and professionalism to take on as much crowdwork as possible, which leaves solo crowdworkers at a disadvantage with the competition from specialized companies taking on an increasing array of tasks that had previously been their primary source of income. On the other hand, the decomposition and sub-contracting of macrotasks by the crowdfarms to solo crowdworkers (whose primary focus is microtasking) provide the latter with opportunities to take part in more advanced macrotasks, and develop their careers through the different skills and experiences obtained in this process. For requestors, crowdfarms provide an efficient and professional one-stop crowdsourcing platform to find the expertise they need for a particular job. However, the risk for them is that the subcontracting behavior of crowdfarms may lead to unknown third parties performing aspects of the tasks, increasing uncertainty about the quality of the final submission. For platforms, crowdfarms provide the opportunity to expand macrotask crowdsourcing and unleash the potential of their services to solve more complex problems that are economic or social in nature. This expanded business scope will attract more enterprises and individuals to post a wider variety of tasks, increasing the profits of the platforms. Nonetheless, the emergence of crowdfarms challenges the operation and management of platforms through forming a secondary market where subcontracting crowdfarms take charge.

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[6] http://work.zbj.com

Summarizing the related literature on macrotasking practices, we see that while research started by treating macrotasks as larger collections of microtasks, it is becoming more and more evident that we are dealing with a different type of complex work, one that at times may be decomposable, while at other times may rely on the collaborative interactions among the involved parties. Even without a perfect understanding, the industry is slowly accommodating this new type of work through experimental settings. Our present study contributes to this growing body of research by closely examining the industrial practices of macrotasking, this time distinguished by the specific categories of macrotask work on which they are applied.

3 METHODOLOGY

This study aims to understand the explicit work practice of crowdfarms in different types of macrotasks. In this section, we describe the employed macrotask taxonomy framework that categorizes the types of macrotasks, research design, the recruited participants, and the data collection and analysis process.

3.1 Framework

The macrotask taxonomy framework we utilized in our study is proposed by Lykourentzou et al. [20]. This framework took into account the complexity, decomposability, and structure involved in macrotask and provided a systematic and integrated characterization. Of these axes, complexity refers to the number of knowledge domains involved in a macrotask and the degree to which these domains interact with each other; decomposability refers to the extent to which a macrotask can be divided into smaller work units and sub-problems; structure measures the extent to which one can determine the required interrelated knowledge domains and expertise in a macrotask. This framework led to four distinct macrotask types, summarized below (see Figure1):

- **Modular macrotask.** This type of task consists of well-structured problems with high decomposability. It can usually be solved by a "divide and conquer approach," in which the whole task would be divided into smaller work units assigned to different crowdworkers. However, the way of decomposition is not always evident and may require the involvement of experts designing a specific workflow. Typical modular macrotasks are taxonomy creation, itinerary planning, and document editing.
- **Interlaced macrotask.** This type of task consists of well-structured problems with low decomposability. Such work is usually found at the beginning of a creative project. Crowdworkers are expected to solve it through a "continuity of useful action" in which every consecutive worker maintains the global context while iteratively refining the task to reach the final acceptable outcomes. Examples of interlaced macrotasks include defining a research methodology or formulating an R&D approach.
- **Wicked macrotask.** Problems in this type of task are ill-structured with low decomposability. Their requirements and interrelated knowledge domains are not well-understood, and they do not have standard solutions. The purpose behind the task is usually to collect as many ideas as possible to seek breakthrough ones instead of developing a particular idea iteratively. In a crowdsourcing context, one may see examples in innovation idea contests like the tasks on Open IDEO.
- **Container macrotask.** This type of macrotask aims to tackle ill-structured problems with high decomposability. Again, the involvement of experts is often necessary for workflow design and the determination of the required expertise. A minimal number of studies have touched upon this type of macrotask, while Wood et al. [52] recently observed a phenomenon where experienced crowdworkers would delegate complex work to other
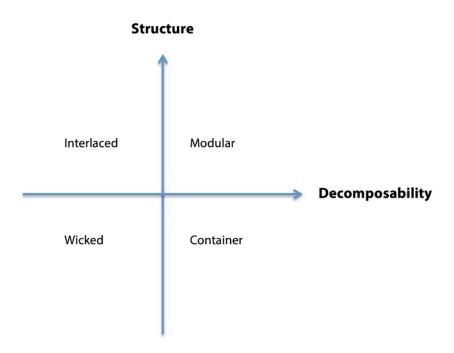
Fig. 1. Four Types of Macrotasks

crowdworkers or persons in their social circle and train them (in the form of instructions) on how to accomplish the delegated work units.

3.2 Study design and data analysis

Our study aims to understand the work practice of crowdfarms on modular, interlaced, wicked, and container macrotasks categorized in the aforementioned framework. To do so, our empirical study utilized an exploratory approach, based on semi-structured interviews, investigating the explicit work practices of crowdfarms on the four macrotask types involved in the framework mentioned above.

The previous studies on this topic generally utilized straightforward opportunistic sampling methods to recruit crowdfarms for efficiency without attention to the types of macrotask they usually do. However, as it is noted in the Introduction section, this can result in understandings primarily derived from the types of macrotask that are popular among crowdfarms, while overlooking the macrotasking practice of other types. Therefore, in order to obtain the best possible understanding of crowdfarms' practice in all types of tasks that our study intended to examine, we did not simply post an interview task on the ZBJ platform to prevent a biased sample. Instead, we examined our database consisting of interviews with crowdfarms and re-contacted those with clear evidence of undertaking multiple types of crowdwork. Meanwhile, to improve our sample's representativeness, we also contacted and recruited new crowdfarms with rich experience on different types of macrotasks after examining the task histories (i.e., completed tasks) on their ZBJ homepage. The diversified work fields of crowdfarms (e.g., IT, design, media) were also considered for representativeness.

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To ensure the quality of the data, we first went through a pilot online discussion with the target participants (13 newly recruited and 18 previous respondents; all with experience performing multiple types of macrotasks). In this process, we clearly stated that (1) the aim of this study is to investigate the work practice of crowdfarms on four types of macrotasks, (2) the description of the four task types, (3) participation requirements (work in crowdfarms; undertake two or more types of macrotasks; etc), (4) the expected topics and completion time for the interview (around 40 minutes), and that (5) the data collected in the study would be anonymous, confidential, and for academic use only.

To collect data, we conducted a series of semi-structured telephone interviews with the 31 Chinese crowdfarm workers and managers from one of the largest Chinese crowdsourcing platforms, ZBJ. For the questions involved in each of the four macrotask categories, the topics commonly revolved around the following:

- The procurement of the given type of macrotask (e.g., How does your company procure the tasks? Whose decision? Based on what criteria?).
- The execution of the given type of macrotask (e.g., How do you usually organize for this type of task? Could you please give an example?).
- The major issues threatening their macrotask practice and the corresponding solutions (e.g., What are the most common problems you encounter with this type of task? How do you deal with them?).
- The alternative workflows for the particular type of macrotask in question (e.g., Would you take different workflow in different tasks (of the given type)? How are they different?

During the interview, we utilized objective data (e.g., years of crowdwork) and subjective data (e.g., "We do not like to take wicked macrotasks.") as ad-hoc probes to clarify ambiguous answers and to evoke further questions (e.g., "Why do you not like to do a wicked problem, can you please tell me why?"). The methods we utilized enable us to obtain a deeper knowledge of a particular situation in a given type of macrotask, such as the understanding of general reluctant attitudes towards wicked macrotasks. All interviews were conducted in Mandarin Chinese and recorded on the researchers' smartphones. Most of the interviews (23 out of 31) lasted for 45-55 minutes, five lasted around 35 minutes, and three lasted for more than an hour.

The data analysis first went through the stage of data familiarization, in which all interview data were translated from Chinese to English and transcribed by two Chinese-speaking researchers. An external language expert was also invited to ensure the accuracy and quality of the translation before the transcript was sent to another coder who is an English speaker. Then, we started to create an initial thematic framework based on the transcript, focusing on (1) crowdfarm practices on macrotasks as studied in the prior literature, and (2) topics that surfaced in the previous data familiarization phase. After that, the data were coded individually by the two Chinese-speaking researchers and the English-speaking coauthor. At this stage, we utilized precise quotes from participants to inductively identify potential themes and emerging patterns within the data, before collating all the relevant coded data extracts within established themes, drawing on our preliminary structure as a suitable schema. At the same time, in order to help us position the practices of crowdfarms with respect to the problems that they can solve, and how they solve them. We did this by using the definitions of the macrotask framework as a guide and collectively through consensus mapped the tasks against it. This enabled us to understand task-related processes (e.g. procurement, workflows etc). At last, we revisited the data set in its entirety and reviewed the coded data extracts together to improve the initial thematic framework in terms of disagreement resolution, and identify additional themes beyond the existing schema. We completed the data analysis as soon as we had a coherent account based on a proper thematic framework that fitted our dataset adequately.

3.3 Participants

The 31 participants came from 31 crowdfarms involved in our study. Due to the different work arrangements of the participated crowdfarms for our task (i.e., an interview task), the individuals comprised 13 crowdfarm management and 18 crowdfarm workers who, by our active request, are commonly familiar with the workflow in their firms with an average crowdfarming experience of up to 3.6 years. The same interview questions were therefore asked for these two groups. Crowdfarm management in this context refers to the manager and team leaders who mainly run the crowdfarm or certain core parts of a task while being partially involved in the task itself. Crowdfarm workers, on the other hand, focus primarily on detailed work. Besides, our participants were generally young in their late 20s or early to mid-30s (20 out of the 31), while the rest were around 40 years old with one exception who was up to 50 years old. Most of the participants (27 out of 31) were well-educated, possessing a bachelor's degree or above and the rest four graduated from high schools or vocational schools. All of the participants earned more than 5,000 CNY (approx. US$769) per month, including seven with a monthly income of more than 20,000 CNY (approx. US$3077) and 11 who earned over 10,000 (approx. US$1538). This is significantly above the national income in China (approx. US$450/month in 2021).

4 FINDINGS

In this section, our findings elaborating on the work practices of crowdfarms in relation to the following macrotask types (1) modular, (2) interlaced, (3) wicked, and (4) container macrotasks are presented.

4.1 Macrotask Type 1: Well-structured, High-decomposability problems

We found that all of the 31 crowdfarms in our study undertake well-structured and highly-decomposable modular macrotasks. This type of task is usually large and complex, while it can be broken down into smaller work units, assigned to multiple workers, and recomposed into a final deliverable by combining the separate subtasks. Typical examples we encountered include software/web development and video/audio production (e.g., wedding, promo). For over ninety percent of the participants (29/31), modular tasks are the regular crowdwork their companies undertake, while the other two indicated that they would gradually focus on such tasks when their crowdfarms recruit more workers. When we further inquired why this work is popular among our participants, they explained that these tasks are the most common and readily available jobs in the market.

Crowdfarm management usually takes charge of procuring modular tasks. They start with the evaluation of the tasks' financial value (i.e., task remuneration) and non-financial value (e.g., training new staff), in which the former is constantly the primary determining factor for all crowdfarms while the latter plays a weaker part in the cases. Crowdfarm workers are seldom involved in this process due to the general belief that the management, from their managerial position, can better select a task with more comprehensive considerations of the practical capacity of the team, the overall arrangement of work, and the long-term development of the company. Moreover, given that ZBJ allows a maximum of eight bids in a macrotask (see Section 2.3), there is a consensus in many crowdfarms (19/31) that the small-scaled management-only task selection improves the efficiency of decision-making so that their companies can timely react to a task of interest. After the management decides on a task, they would then contact the requestors to demonstrate their intention to participate and further negotiate the task requirement as well as the actual payment. This communication is usually done over the phone. If everything goes well, the management, on behalf of the crowdfarm, would sign a contract with requestors to settle down the procurement.

Once a modular task is procured, the next step is to decompose the tasks into smaller work units and allocate them to particular workers based on their expertise. This is again the responsibility of the crowdfarm management. However, in contrast to relevant literature which suggested that task decomposition and allocation can be costly and time-consuming in macrotask due to the involvement of experts [21], the crowdfarms we interviewed can handle these processes quickly and efficiently. For a large portion of the participants (27/31), a pre-task meeting within an hour would be enough for them to understand their duties. For the rest four, these meetings are even unnecessary as they could "spontaneously" figure out their work units without much need for guidance. With further inquiries, we found the reasons behind this phenomenon are twofold. First, the crowdfarm management often procures eligible modular tasks involving familiar skills/knowledge to ensure they are competent for the requirement, avoiding potential loss on the final remuneration and reputation. Second, after repeated practice on multiple similar tasks, the work roles and duties of crowdfarm workers are relatively fixed. Taking the video-making task as an example, the media crowdfarms have photographers devoted to raw materials, technicians focusing on video editing, and the particular staff to arrange the travel to the shooting scene/location. As P1 (33 years old, male, media crowdfarm) compendiously said: *"Everyone knows how to taste the old wine, no matter what the new bottle looks like."*

When executing the procured modular tasks, the management in all of the crowdfarms (31/31) would actively supervise the work process by requiring and checking the periodical or daily results from workers. Although this brings extra stress to some, most of our participants (23/31) reckoned the timely work report is necessary to overcome lassitude, reduce errors, and consequently improve the general quality of the final deliverable. Similarly, Cheng et al. [7] found that solo crowdworkers would produce a higher-quality job in deconstructed macrotasks and attributed the reason to the boundary-clear and interruption-friendly nature of subtasks increasing workers' level of immersion. Our finding largely agrees with this result while further suggesting that traditional management methods - in our case, the top-down supervision - can be the double insurance to control the quality of the decomposed macrotasks in a crowdsourcing context.

We further explored the major issues crowdfarm would encounter in their modular task practice. Only six indicated that the negative rating from requestors is occasionally a challenge for their reputation. To solve it, they generally conduct a rework and refinement. Meanwhile, most of the respondents (25/31) identified no significant issues. This is because, on the one hand, their established workflows, from careful pre-task selection to in-task quality control, save them from post-task troubles. On the other hand, the well-structured feature of modular tasks provides relatively objective, explicit, and well-acknowledged acceptance criteria for the final deliverables. Therefore, crowdfarms rarely encounter serious issues in a modular task, as long as they follow the requirements of requestors.

The 13 crowdfarm management and 18 crowdfarm workers showed distinct attitudes toward modular tasks. Specifically, all 13 managers like their companies taking these tasks to maximize profits. However, the 18 crowdfarm workers tend to have a neutral and even slightly negative viewpoint. Although they too reckon that modular tasks are the most lucrative crowdwork, they are generally worried that it is difficult for them to acquire new skills and satisfy their personal interests with massive homogeneous tasks.

The last topic revolved around the work practice of crowdfarms on modular tasks is their options on alternative workflows. Over seventy percent of the interviewees (22/31) reckoned they would hardly make modifications as the current procedures are the most efficient in their massive practices on modular tasks. Indeed, the nine companies that said they would adapt their workflows for different tasks would only simplify some of the work procedures when they have recyclable prototypes/templates (e.g., website prototypes) formed in previous similar crowd tasks. This finding

reveals that the cost savings and profit maximization considerations, rather than the changed content in tasks, drive crowdfarms to modify their workflows.

> *"The workflow is rarely adjusted, but sometimes we are able to take a shortcut using templates for different types of websites. [...] We have a template for shopping websites like Taobao. When there are similar tasks, we can use this template without coding and integrating it all over again. [...] Sure, we will rework part of the website according to the requirement of the task, but basically, they are often some details like UI, pictures and descriptions of the products and so on."* (P2, male, 37 years old, IT crowdfarm).

4.2 Macrotask Type 2: Well-structured, Low-decomposability problems

We then investigate the work practice of crowdfarms on well-structured crowdwork with low decomposability, which is also known as the "interlaced" task. Such tasks involve expertise and knowledge that are clearly determined but are usually impractical to subdivide into smaller work units. Typical examples in our study are creative copywriting and designs on advertisement/product packaging. This is consistent with a previous crowdsourcing study that suggested interlaced problems are often found in creative projects [14, 20]. Unsurprisingly, media and copywriting crowdfarms (22/31) undertake interlaced tasks more often, while the nine IT crowdfarms merely perform some UI design for applications, websites, and games once in a while.

In contrast to the management-only task selection in modular tasks, we found that crowdfarm workers engage more in interlaced task procurement. In doing so, they either determine the choices together with management (17/31) or directly choose by themselves and then report to the management for records (14/31). When we further asked why this is the case, our participants generally mentioned that, due to the low-decomposability nature, it is the exact task performer that could best assess whether they are competent for an interlaced task. Moreover, the required creativity leads to the diversity of interlaced tasks in the market. Thus, the management cannot assertively select suitable tasks solely based on personal experiences as they do in modular tasks. Understandably, the particular crowdfarm worker operating the task would lead the subsequent negotiation processes with requestors, while the management merely takes charge of the contract signing.

As a result of the low decomposability, there is hardly a task allocation or decomposition in interlaced tasks. Instead, the next step goes directly to task execution, which is, for the most part, highly personalized based on the work habits of individuals. For example, some crowdfarm workers will commence an advertisement design task with background color, while others start with the characters. Nonetheless, we found two relatively common strategies that crowdfarm workers utilize to deal with interlaced tasks. First, almost all of them (29/31) work on a Beta Test mode, in which they would finish a draft/prototype in advance, send it to requestors and then rework it based on the feedback. With further inquiries, we found that they generally developed this work habit based on suggestions from managers and experienced colleagues as a way to control quality. Second, a large part of them (23/31) would do a pre-task study by looking into references and templates (e.g., designs/copywriting on similar topics), especially those previously employed by the exact requestor of the task. According to them, such preparations provide an intuitive perception of the required styles, manners, and senses that are sometimes difficult to convey precisely between people in words.

> *"Creative design is a very subjective work, so we (P3 and her colleagues) usually work in our personal style and start with a part where the inspiration comes. [...] We do have a common step at work: everyone in our*

company is suggested to finish a draft in advance and rework based on the feedback from requestors at least one time to improve the quality of the work." (P3, female, 26 years, design crowdfarm).

Although crowdfarm workers usually perform interlaced tasks individually, it does not mean that there is no collaboration in the process. Based on our results, nearly half of the participants (15/31) would ask for support (e.g., ideas/suggestions) from colleagues when they run out of inspiration. Additionally, after the Beta Test, the management in most of the crowdfarms (27/31) would provide support based on requestors' feedback to control the task quality. They do so by assigning one or two colleagues to assist in the task refinement. If the requestor shows significant dissatisfaction with the draft/prototype, the colleagues can even take over the task, refining the work with a thought different from the previous task performer. This finding agrees with Altshuller's argument [1] that people can solve the interlaced tasks through a "continuity of useful action" in which the consecutive workers maintain the global context of the problem while iteratively refining it until the solution is acceptable.

Despite the collaboration supporting the task performance, many participants (20/31) reckoned that the burdened rework is the primary challenge in the interlaced macrotasks. Even with the pre-task study and Beta Test facilitating the production of quality work, the disparate subjective feelings about creative work without well-acknowledged criteria can frequently lead to disagreement between crowdfarm workers and requestors on the outcome. None of the interviewed crowdfarms is willing to accept a rejection affecting their reputations, so they generally keep working until the requestors are satisfied. However, as eleven participants mentioned, the cost of the invested human and material resources in multi-time reworks can sometimes go far beyond the remuneration of the task per se. Moreover, for several crowdfarms (4/31), dedicated reworks cannot even guarantee the payment stipulated in the contract. This is because the low-decomposability of interlaced tasks and the resulting oneness in the final deliverable prevent crowdfarms from bargaining the actual payment based on the completion of different work units. Consequently, with the absence of objective measurable proof-of-work, some tightfisted requestors tend to pay as low as possible by intentionally being hypercritical on the final deliverables.

"We have revised a design nine times for a requestor, which is just a simple gift box design for fruit, paying around 1,000 CNY (approx. US$153). We did it for a week, but the requestors just kept dissatisfied, and the entire human and material cost was absolutely more than 1,000 CNY. [...] It is never easy to negotiate with requestors about compensation in a packaging design task, as the final outcome is the only thing you can rely on to earn the payment. [...] No one cares what kind of changes did you make during the process, or what brilliant design ideas did you come up with. These workloads cannot be measured or quantified. If the requestors deliberately say that they are not satisfied, we cannot get the full remuneration, let alone the extra cost of the massive reworks." (P4, male,37 years old, design crowdfarm).

However, the participants in our study generally showed positive attitudes toward taking on interlaced tasks. For crowdfarm management, they like it because such crowdwork brings profits to the companies and reduces their personal workload (e.g., less responsibility for task selection). For crowdfarm workers, besides task remunerations, they also attributed the reason to more work autonomy enabling them to select tasks of their own interests. Moreover, the pre-task study also drives them to learn widely from other inspired works/materials, which nourishes their creativity for future work. This finding aligns with previous crowdsourcing studies, which suggested that crowdworkers learn through exposure to diverse information at crowdwork, and the acquired knowledge enhances their career potential [30, 31].

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With regard to the alternative workflows involved in the interlaced task, we found that around one-third of crowd-farms in our study (11/31) would change the way they work once in while. However, similar to our findings in modular tasks, the reason is hardly related to the changed crowdwork content but more to cost control. More specifically, after three to four refinement attempts, all these 11 crowdfarms would stop reworking. Instead, they start controlling the cost by either handing the task over to a reliant local business partner or simply posting a task on ZBJ or other crowdsourcing platforms asking for new designs/copywriting with lower prices (usually 80%-90% of the payment they will get from the requestors). From their perspective, although this means they would give most of the profits away, they could skip the time-consuming refinement process and use such time to procure a new task and work on it. The remunerations of the new task plus the 10%-20% payment saved from the subcontracted tasks maximize their profits. Meanwhile, subcontracting enables them to effectively gain work with new ideas/creativity, increase the possibility of the acceptance of requestors, and, therefore, protect their reputations.

> "Generally, we will rework three times according to the requestors' suggestion. If it still does not work, we will simply stop working and subcontract it at a relatively low price to control the cost. [...] Usually 80% (of the task payment), and sometimes 90% (of the task payment) if the deadline is close. [...] On the one hand, others may possess different design concepts and styles that better fit the aesthetic of requestors. On the other hand, we would of course maximize our own profits in the subcontracting. We have already put a lot of effort into the work after all." (P5, male, 34 years old, design crowdfarm).

4.3 Macrotask Type 3: ill-structured, Low-decomposability problems

The third type of macrotask is the so-called "wicked problem". Here, the relevant knowledge domains are poorly understood, and the requirements are incomplete, contradictory, and sometimes ever-changing. In a crowdsourcing context, one can find such tasks in innovation contests on OpenIDEO, such as the idea collection to combat food waste and solution design for global plastic waste issues. All of the crowdfarms in our study have not undertaken this type of task before. In fact, over half of the respondents (16/31) indicated that they have participated in ZBJ's innovation contests, such as idea collection for logos and slogans. However, based on their description and our investigation of the tasks they mentioned, we identified that those are essentially interlaced (type 2) macrotasks in the form of a contest, as the required expertise, knowledge, and outcomes are relatively clear and straightforward. When we took tasks on OpenIDEO as examples to illustrate what are "wicked problems," all of the crowdfarms reckoned that they had never worked on similar ones.

> "Our company has actually participated in an innovation contest organized by ZBJ, but the task is quite different from the example (a wicked problem on OpenIDEO) you just described. [...] Basically, we were still pretty sure of the knowledge and expertise the work required as well as the final outcome they were expecting." (P6, male, 37 years old, design crowdfarm).

Therefore, we talked with our participants about why type 3 tasks are rare in their crowdwork. In detail:

- It is a common viewpoint that a wicked problem can be a thankless job as the unfamiliar knowledge domains and the problematic requirements can easily lead to unsatisfactory outcomes with little or no payment. Being profit-oriented companies, it is understandable that crowdfarms tend to avoid procuring tasks that could potentially harm their financial interest.

- Many participants (15/31) also reckoned that the crowdfarms' professionalism in a specific field (e.g., IT, design), as well as their scaled teamwork, are the major competitive edge in crowdworking. However, they cannot fully take advantage of them in the low decomposability wicked problem that requires more knowledge comprehensiveness than specialization. Therefore, they are less likely to undertake such tasks.

    "I think the advantage of crowdworking as a company, like ours, is the teamwork and professionalism in IT. If we participate in the kind of task you just mentioned, then our advantages will no longer exist. [...] Take the food problem you just mentioned as an example, the participant should of course understand some technologies and techniques but they should also know more about food, policy, economics, and so on. These aspects are not the advantages of our team." (P7, 42 years old, male, IT crowdfarm).

- Some (7/31) indicated that it is also risky for crowdsourcing platforms like ZBJ to support wicked tasks. Given that such problems do not usually have a solution with standard format or criteria, if requestors cannot get a satisfactory result, the loss for the platform is twofold: a.) it may affect the confidence of requestors in using crowdsourcing and the platform to solve their future tasks, b.) it may bring extra legal pressure to the platform in mediating contract disputes between requestors and crowdfarms.
- Considering the focus of OpenIDEO on wicked problems, one more reason can be that requestors are more willing to use dedicated platforms that own a group of crowdworkers devoted to wicked macrotasks and are designed in a particular manner to support the needs of these tasks.

As the closing-up question, we asked the attitudes of our participants towards wicked problems if they encountered one on the crowdsourcing market. Unsurprisingly, a large portion of them (24/31) reckon that they are not likely to take on these tasks due to the obstacles mentioned above. However, the rest seven mention that, although wicked problems may not be a preference for crowdfarms and their workers, they are personally interested in these tasks due to the potential social benefits of solving these questions.

4.4 Macrotask Type 4: ill-structured, High-decomposability problems

The final type of macrotask aims to tackle "container" problems that are ill-structured but with high decomposability. These problems usually require expertise and knowledge that cannot be determined a priori automatically, but one can handle them with the help of experts and collaboration with others. Due to the lack of well-acknowledged examples addressed in the crowdsourcing literature [20] or any typical task found on the ZBJ platform, we simply briefed our participants on the definition of container tasks and asked if they had done one before. Similar to the situation in the "wicked problem," a vast majority of the crowdfarms (28/31) suggested that they never undertook such tasks due to the aforementioned obstacles, such as the risks in the task completion and obtaining payment. When we reminded them that they might offset these risks by collaborating with experts and other parties, the negative attitudes still remained as (1) hiring experts can be expensive; (2) it is time-consuming to seek an expert matching properly with their needs; (3) finding collaborators from other work fields, with whom the crowdfarms are unfamiliar, can also be questionable in terms of the work coordination, quality control of the shifted work units, and the payment distribution.

"Seeking expert assistance is unrealistic in many cases. For example, I saw a task to write a plan for an urban garden, which may require experts in plants, urban planning, and construction. [...] Taking the time

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to find them is just one of the problems. When you find them, what about their cost, professionalism, and availability?" (P8, male, 38 years old, copywriting crowdfarm).

"To me, subcontracting (the work units beyond their profession) to an unfamiliar collaborator is not a good option. Because you are not in that work field, you are unable to evaluate the capabilities of a random collaborator, the quality of their completed work, or the market price (of the shifted work units) in their business." (P9, male, 40 years old, design crowdfarm).

In spite of the difficulties mentioned above, however, there are still three participants suggesting that they have done container crowdwork before. In detail, P10's IT crowdfarm provided a full-package service for an enterprise in need of a portal, in which they were mainly responsible for the implementation of the web functions and subcontracted all the other work units (e.g., UI and interactive design, advertising and copywriting for promotion, and web maintenance) to third parties. P11's copywriting crowdfarm finished a promotional writing task for a dairy firm, in which they employed a camera crew for on-the-spot materials in the dairy firm and portrayed the firm's milk processing technology under the guidance of an expert who majored in the technique of Pasteurization. P12's IT crowdfarm established a full-featured health system for pets. At the time of our interview, they collaborated with a hardware manufacturer and local pet hospitals to produce scannable nameplates storing clinic history for pets.

Understandably, crowdfarm management usually makes the decision to procure container macrotasks that require massive internal and external resources. P10, P11, and P12 are all managers, which also supports this finding. However, in contrast to any other type of macrotasks where the selection process takes place only within crowdfarms, procuring a container task is more complex as it includes multi-time discussions with external experts, collaborators, and requestors. More specifically, the three crowdfarm management would initially contact the potential expert and collaborators to brief them on the task's information and check their willingness to participate. Once all parties are confirmed, they would then together clarify with the requestors on the detailed task requirement and further evaluate the feasibility of the tasks. After that, crowdfarms, experts, and collaborators would specify the working details, including the work plan and the payment distribution. Finally, they would sign a contract with the requestors as the payment of such tasks is usually substantial up to tens of thousands or even hundreds of thousands of CNY.

After the task procurement stage, the followed execution process, for the most part, is similar to the work practice on a typical modular or interlaced task, depending on the work shares distributed to the crowdfarms. Here, they would again start with the task allocation, actively check the completed work, and rework it based on the staged feedback from requesters to ensure quality. That being said, due to the more required coordination than other macrotasks, crowdfarms need to pay more attention to task integration and re-composition in carrying out a container task. They usually do so by utilizing work-supported technologies such as using Github to embed the produced advertisement in the coded webpage or drafting collaboratively in Tencent Doc (a product similar to Google Doc). According to our participants, the strategy of staged integration facilitates them to reduce the error in the final large-scaled re-composition and also enables them to update the progress to requestors for feedback and further clarification of the requirements.

Afterward, we asked several closing-up questions regarding the container tasks they did. In detail: The significant issues crowdfarms encountered and how they solved the problems. All three participants reckoned that the primary challenge comes from the incompleted task requirement. According to them, requestors posting container tasks only have a general blueprint of the final deliverable with insufficient expertise to instruct the task at a detailed level. Therefore, crowdfarms have to put massive extra effort and time into helping requestors sort out a completed task

requirement for different work units. Unfortunately, these efforts may not always pay back as there is a risk of abortion in the process of perfecting the requirement for a container task. Two of the three participants mentioned that they or their collaborators had to drop a container task as they found that the cost of finishing this job was gradually higher than the remuneration during the working process.

The attitudes towards container tasks. All three participants demonstrated a relatively neutral attitude. On the one hand, they are commonly attracted by the substantial payment provided in the container task, which is multiple times higher than other types of macrotasks. On the other hand, they suggested that container task is still rare in the Chinese crowdsourcing market, so it is financially wiser for them to focus on tasks they can easily obtain and complete. Moreover, they also expressed concerns about experts' cost and trust in the collaborators as other crowdfarms. In fact, in all three cases, the participants had known the associated experts and collaborators from their social circle before the task, reducing the costs and risks of finding, hiring and working with new ones. With further inquiry, they commonly reckoned that they would be hesitant to do a container task without knowing any potential external assistance in advance. Would the current workflow remain for the container tasks in the future? All three participants suggested that the current workflow is highly changeable. This is because the coordination among crowdfarm, experts, and collaborators plays a crucial role in the container tasks, resulting in one's workflow being closely related to the work progress of other associated parties. As P12 (34 years old, male, IT crowdfarm) said: *"We would work with the hardware manufacturer first, but if the pet hospital gives us the data in the next few days, the database would then be our first priority."*

5 DISCUSSION

The practices of crowdfarms on macrotasks reported in previous studies [49, 50] broadly agree with our findings on modular and interlaced macrotasks, and provide no insights on wicked and container macrotasks. Further, some of these prior results may incorrectly regard interlaced macrotasks as a collection of microtasks due to their low-decomposable and standalone nature. This demonstrates the limitations of previous studies due to the lack of a systematic taxonomy to understand macrotask systems, and underscores the necessity of this paper. This section will therefore not repeat any detailed findings concerning modular and interlaced macrotasks that are similar to previous studies. Rather, it focuses on providing a dialectical analysis of the related practices we studied, and elaborates more on the wicked and container macrotasks, for which very scarce literature on crowd work practices can be found.

5.1 Practices on modular macrotasks: Efficient, generalized, and limited

Our findings indicate that crowdfarms have developed a relatively efficient workflow for modular macrotasks. This is in contrast with previous crowdsourcing studies, which suggested that undertaking modular tasks can be money/time-consuming due to the involvement of experts designing workflows [6, 22]. This phenomenon is primarily attributed to the way crowdfarms organize modular tasks. To be more specific, the management in crowdfarms often relies on their extensive crowdwork experience and mastery of the companies' general work settings to procure, decompose and allocate tasks. This leads to the fact that they play the role of built-in experts who are not only specialized in the crowdfarms' business fields but with better acknowledge of the companies' capacity and workers' strength. In comparison to ad-hoc teams of crowdworkers, the in-house experts significantly reduce the time and money cost of employing external support, and the management's greater familiarity with the workers enables them to design a more effective workflow tailored to the specific team. At the level of crowdfarm workers, the tailored workflow improves their understanding of personal duties and roles, stabilizing the pattern of cooperation. This further facilitates the efficiency

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of crowdfarms in handling modular tasks. This is largely supported by the study of Kim and Robert [23], in which they suggested that accountability (i.e., who is responsible for a specific task), predictability (workers' anticipation of the content and needed actions of sub-tasks), and common understanding (i.e., workers' shared knowledge about the whole tasks) are the three key conditions in the efficient execution of macrotasks. Meanwhile, given that establishing such conditions for macrotasks would require a specific set of personnel and practices [23], the personnel composition and work practices of crowdfarms may provide an alternative for constructing and improving the accountability, predictability, and common understanding of crowdworkers in a more general crowdsourcing environment.

Most of the crowdfarms in our study have generalized their workflow on modular tasks, though some of them may use prototypes/template as shortcuts. This is in contrast with a prior crowdsourcing study indicating that the designed approaches for modular tasks usually suffer from non-generalization [20]. However, one should note that the generalized workflow of crowdfarms on modular tasks is primarily attributed to their practice of undertaking similar tasks involving work units that are homogeneous in terms of size, skill requirement, and ways to integrate. This is to say, they may employ a standardized routine to develop plenty of websites regardless of whether they are for shopping or for news, but the same routine may not work in other types of software development, such as for games. Critically, even though the generalized workflow in crowdfarm does provide an exception against the concern of the non-generalization of the workflow in modular tasks, it is highly limited to and affected by the business focus of crowdfarms. The generalization of workflow in modular macrotasks can also limit the self-development of crowdfarm workers. That is, the relatively fixed roles and work duties involved in the generalized workflow deprive crowdfarm workers from opportunities to undertake other work units of their interests and learn new knowledge. Given that previous research among Chinese crowdworkers suggested that self-development is an important motivation for them to participate in crowdwork [48, 53], crowdfarms, and any other crowdworking teams/groups targeting modular tasks, should balance the relationship between the workflow generalization and the personal development of their workers to avoid the emergence of depressed morale and, consequently, increased turnover.

5.2 Practices on interlaced macrotasks: Collaboration matters but continuous reworks increase costs

In contrast with the relatively standardized and streamlined practices on modular tasks, crowdfarms gradually choose to provide some of their workers with more autonomy to procure and carry out low-decomposable interlaced macro-tasks. Although the particular task performer usually works independently, internal collaboration, such as inspiration from colleagues, feedback from managers, and direct take-over on problematic submissions, plays an essential role in the completion of a high-quality interlaced macrotask. These provisions not only help crowdfarm workers with a detailed task, but create a benignant work environment for crowdfarm workers where they can attempt to take up more interlaced macrotasks that interest them, as they know that there are people around to help them when they are in trouble. Compared to solo crowdworkers who may gain remote help from their online social networks [11, 33], the environment of face-to-face collaboration in crowdfarms can further improve the productivity of workers, especially for complex tasks [3]. Together with our other finding that crowdfarm workers can learn and develop good work habits in the company to deal with interlaced macrotasks (i.e., the Beta Test work mode), it is, therefore, our contention that the study on low-decomposable interlaced macrotasks should not be restricted to the confines of individual work. On the contrary, the practice of crowdfarms illustrated the importance of a collaborative environment for this type of macrotask, which sheds light on the potential support for other crowdworkers performing interlaced macrotasks in a more general context.

Despite the strengths of crowdfarms' practice on interlaced tasks, they suffer from the pressure of continued rework required by the requestors. This is not surprising considering that interlaced crowdworks are usually creative tasks, in which the perception of creativity is varied and subjective from person to person without a unified standard. A previous study on crowdwork also laterally supports this by illustrating that constant iteration is necessary for the successful completion of interlaced tasks [1]. However, due to the lack of measurable work units caused by the low decomposability of interlaced tasks, about half of the crowdfarms in our study encountered difficulties in getting a remuneration that matches their multiple iteration efforts. In these cases, some of them fully bear the extra cost in order to protect their reputation; others control the excessive rework cost by subcontracting, which not only reduces the benefits that crowdfarms should obtain, but also increases the risk for requestors receiving a deliverable out of their expectation [50]. As the intermediate between the crowdfarms and the requestors, these losses and risks will eventually pass on to the crowdsourcing platform, leading to the drain of crowdfarms and distrust of requestors. Therefore, we recommend that platforms should design a more reasonable payment mechanism for the iterations involved in interlaced tasks. They can, for example, set a cap on the number of reworks requestors can require in a particular interlaced task. Once the crowdfarm has completed the required amount of rework, the requestors should pay a certain percentage of the total payment, whether satisfied or not. Alternatively, if the cap on the number of reworks cannot be pre-determined for certain interlaced tasks, crowdsourcing platforms can also regulate the minimum charge the requestors should pay for each round of the rework. This can better cover the essential human and resource burden for crowdfarms so that they can control costs by subcontracting less often, decreasing the risk for requestors having their tasks performed by unknown third parties.

5.3 Practice on wicked macrotasks: How to inspire enthusiasm for increased participation

Different from modular and interlaced tasks, which focus on the production of particular deliverables, wicked problems in the current crowdsourcing context focus more on topics relating to social issues and social goods (e.g., combating food waste). However, we saw that the crowdfarms in our study rarely undertake such work. Based on our findings, this is primarily because crowdfarms perceive that the wicked problem is unprofitable due to its inherent ill-structuredness leading to difficulties in producing satisfactory solutions and, therefore, increasing the risk of not getting paid. This is understandable as previous studies have shown that one of the primary reasons for crowdworkers, including these companies, to engage in crowdwork is to earn money [19, 34, 49]. Nevertheless, these studies also noted that the non-monetary rewards, such as acquiring more customers via crowdtasks to expand their business network, are also of significant importance to crowdworkers. Therefore, crowdsourcing platforms can design a more diversified reward mechanism to motivate crowdfarms to participate in wicked problems, which also enables platforms to expand their own business scope. Monetarily, one solution would be to reduce the commission fees taken by the platform for such tasks from 20% to 10%-15%. Non-monetarily, platforms can support crowdfarms performing wicked macrotasks on their branding (e.g., short-term free advertisement), so that these organizations can have access to more customers that they generally regard as an important reward at crowdwork.'

The second obstacle for crowdfarms to undertake wicked macrotasks is their specialisation and scaled teamwork. These two features have proven to be their strength over solo crowdworkers, so, subjectively, these companies are reluctant to drop their advantages and participate in a macrotask where their sophisticated expertise in a certain domain may be defeated by an encyclopedic individual. Objectively, the cost of building expertise supported by multiple professionals can lead to a much higher cost of crowdfarms in learning, applying, and processing unfamiliar knowledge and skills than solo crowdworkers. Combined with the fact that many of the existing wicked problems have been

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commonly solved by solo crowdworkers (e.g., [2, 9, 10]), our study corrects the understanding that crowdfarm are more competitive than individual workers in macrotasks [46] by illustrating that this is not the case for wicked macrotasks. Nonetheless, the professionalism and scaled teamwork of crowdfarms are not necessarily disadvantages when it comes to wicked macrotasks. For example, with more crowdfarm's engagement that is potentially motivated by the above-mentioned diversified reward mechanism, platforms and researchers can conduct a more in-depth analysis of their work practices on wicked problems and design systems and tools to synthesize the specialization of different crowdfarms for knowledge/expertise comprehensiveness.

In addition to the issues at the crowdfarm level, crowdsourcing platforms are also concerned that it is too difficult for requestors to obtain satisfactory solutions for wicked macrotasks, which would result in the loss of customers and additional legal risks (e.g., contract disputes between crowdfarm and requestors). Understandably, insufficient support for wicked problems occurs not only in the ZBJ platform in China, but in other popular crowdsourcing platforms worldwide, given that there is a limited number of such tasks on AMT, Upwork, and F8 as well. However, as several researchers [8, 20, 35] foresightedly pointed out, with the development of technology, the application of crowdsourcing will not only be limited to business fields such as IT, design, and advertising, but should eventually bring positive development to future generations and social goods. Therefore, it is our contention that crowdsourcing platforms should pay closer attention to their support for wicked problems and further explore how to incorporate these tasks into their business scope. Based on our findings that requestors prefer to use dedicated websites and workers to deal with wicked problems, we suggest that platforms can use OpenIDEO as a template for their own platform design and user group building.

5.4 Practice on container macrotasks: External collaboration plays an essential role

With regard to container crowdwork, our findings provide three specific cases (see Section 4.4), filling the gap that such problems have yet to be exemplified and addressed in the crowdsourcing literature. Besides, it is interesting that no crowdfarms in our study undertook ill-structured wicked macrotasks but several of them do take container tasks, though this type of macrotask is ill-structured too. This is attributed to the higher level of decomposability involved in container macrotasks. Specifically, although crowdfarms would still face the issues caused by the ill-structuredness (e.g., difficulties in producing satisfactory solutions), the high decomposability of container tasks enables crowdfarms to solve the problems with the assistance of experts and collaborators, which also enables them to share and reduce the risk of the failure on the task. Consequently, the task nature (i.e., high-decomposability) and concerns about sharing risks in container macrotasks have encouraged crowdfarms to focus more on coordinating with other parties and become willing to adaptively change their workflows to cater to the work of collaborators. Previous studies on the crowdfarming topic generally believed that these companies usually master the processing of macrotasks including the collaboration with others (e.g., subcontracting with pre-determined prices and requirements) [49, 50]. Our study, however, deepens this understanding by illustrating that such task-related leadership of crowdfarms is more common in modular and interlaced tasks, while these companies tend to experience a more equal and decentralized collaboration in the practice of container tasks.

This phenomenon - crowdfarms are able to master the practices on modular and interlaced tasks but not on container tasks - illustrates that container macrotasks, at least in the Chinese crowdsourcing market, may contain more workload than the common macrotask, requiring broad collaborations at the organizational level among various industries. Nonetheless, there is a lack of mechanisms and tools at this stage to effectively support such practice, as only a minority - less than 10% - of the crowdfarms in our study have taken container tasks, and they commonly acquired their

experts and collaborators from their social network. Otherwise, they would also be hesitant to undertake a container macrotask. Previous research, such as Flash Teams and Flash Organizations [38, 43], have developed instruments for the cooperation and collaboration of random solo crowdworkers on large and complex tasks. If the crowdfarm can be viewed as a unit of work, like a solo crowdworker, there is great potential to develop similar tools that are flash teaming and organizing crowdfarms. Based on our findings that the time and money cost of hiring experts is the major concern of crowdfarms, crowdsourcing platforms can work with relevant consulting companies to list available experts with their expenses, areas of expertise, successful cases, and contact information to improve the efficiency of crowdfarm recruiting professionals. Similarly, as finding trusted collaborators is another issue encountered by crowdfarms, the platform can list solo crowdworkers and crowdfarms who are willing to cooperate with others with the profiles involving their ratings, skills, and preferred work content. This not only facilitates the cooperation between different crowdsourcing workforces but, due to the increased transparency of collaboration, helps deal with the detected issues caused by the crowdfarm's subcontracting behavior, such as the form of the secondary market in which the crowdfarm largely takes control and shifts works with excessive low payment.

6 CONCLUSION

Based on the study of crowdfarms, the primary macrotasking workforce in China, our work offers the first stepping point to understanding crowdsourcing practices on four types of complex macrotasks, namely modular, interlaced, wicked, and container. The use of an explicit taxonomy directly addresses the common limitation of previous research works, which studied macrotasks either within the confines of a specific field (e.g. software development) or at a general level and indistinguishably. Our results contribute to a better understanding of the topic by (1) specifying the work practices of crowdfarms per macrotask category; (2) revealing that existing literature has so far mostly studied modular and interlaced macrotasks, and placed its focus on the pros and cons involved in these tasks' workflows; (3) noticing the lack of crowdfarm practices on wicked problems with insights into the reasons behind; and (4) analyzing the dilemmas of crowdfarms when undertaking container tasks with three cases exemplifying such problems. Based on the novelty of its findings, our study also offers explicit design implications from platforms aiming to better support macrotask crowdsourcing. This includes proposing (1) the design of a more reasonable payment mechanism for the different reworks and iterations involved in interlaced tasks; (2) the establishment of a more diversified reward mechanism to motivate crowdfarms to undertake wicked problems; and (3) the development of an expert/collaborator search engine facilitating the work of crowdfarms on container tasks.

The present study is conducted in the Chinese crowdsourcing context, in which crowdfarms constitute the primary workforce undertaking macrotasks. As such, it provides limited insight into the work practices of typical solo crowdworkers on the four types of macrotasks examined. Although organizations undertaking large and complex tasks are a nascent trend worldwide (e.g., Upwork Boutiques), the study of individual crowdworkers is also of great significance to understand macrotask crowdsourcing, since these workers are the majority. Second, a combination of the present study's qualitative approach (interviews) with quantitative methods (such as questionnaires), may be of great help in sketching a more comprehensive picture of the crowdfarms' work practices on different types of macrotasks. Besides, multiple types of qualitative methods, such as in-crowdfarm observations, can also contribute to the richness of the data with the nonverbal (e.g., emotions) and contextual elements, which can facilitate an even better interpretation of the participants' verbal responses.

Based on the limitations mentioned above, future work on the topic can (1) explore how typical solo crowdworkers undertake different types of macrotasks, (2) investigate the role that solo crowdworkers play in macrotasks and their

interactions with more collaborative work structures, such as crowdfarms or similar crowdworking organizations, (3) collect and analyze more samples of crowdfarms and similar crowdworking organizations participating in wicked problems and container tasks.

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