THINGS AT WORK: HOW THINGS CONTRIBUTE TO PERFORMING WORK

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Abstract

A crucial question for organizations is what constitutes work performance. While the importance of human competence and motivation to work performance has been established, less well understood is how 'things' – such as algorithms, tools, instruments, and raw materials – contribute to work performance. As 'intelligent' and 'agentic' technologies become further involved in work, it is increasingly important to understand the impact of things upon work performance. Although research adopting an entanglement perspective (e.g., practice theory, sociomateriality, affordances, science and technology studies) has convincingly demonstrated things are integral to work performance, there is a need for heightened clarity on *how* things contribute to performing work. Informed by an ontology of things and drawing on an ethnographic study in the biotechnology industry, we propose things are constitutive of work performance in three interrelated ways: (1) by belonging to a nexus of useful things (2) through performing interlinked roles (3) while co-constituting work performance in concert with practitioners. Our theoretical and empirical account offers a more *integrative* and *comprehensive understanding* of how things are constitutive of work performance compared to the existing entanglement literature. This opens several new possibilities for enhancing work performance in organizations, which we outline in the paper.

Keywords: work performance, entanglement, things, technology, algorithms, affordance, sociomateriality, STS, practice theory

INTRODUCTION

Although work performance involves both humans and things (e.g., algorithms, tools, instruments, raw materials etc.), the dominant focus has been how humans (through their competence, motivation, job satisfaction etc.) engage in work performance (e.g., Carpani, Parker and Griffin, 2017; Denisi and Smith, 2014; Gittell, Seidner and Wimbush, 2010; Knight and Parker, 2021; Orlikowski, 2007). However, as we rapidly move into the fourth industrial revolution (Schwab, 2017), with emphasis on digital transformation of work (Hanelt et al., 2021) through greater involvement of 'intelligent' and 'agentic' technologies, the question of how things contribute to performing work is increasingly pertinent. Involvement of these technologies results in 'blurring the lines between the performativity of users and the performativity of technology' (Babtista et al., 2020, p.3), as seen in robotic surgery (Beane, 2019), AI-enabled recruitment (Hunkenschroer and Luetge, 2022), and wearable technologies, including 'body-born computational, sensory and interactive devices' (Rapp, 2023, p. 81). Moreover, superior work performance in a field is determined not only by human knowledge and skills, but also by having access to better and more advanced tools and instruments than others (Brynjolfsson and McAfee, 2014). Investigating not only how practitioners, but also how things, contribute to performing work is critical, therefore, for advancing our understanding of work performance, and how it can be managed and enhanced in organizations.

Research on things in work performance is broad and varied (e.g., Carlile, Nicolini, Langley, and Tsoukas, 2013), spanning from Trist and Bamforth's sociotechnical theory of the

1950s (e.g., Leonardi, 2012) to more recent studies on the role of objects in work and organizational processes (e.g., Alaimo, 2022; Ewenstein and Whyte, 2009; Hussenot and Missonier, 2010). Within this broad span, the integral part things play in work performance has arguably been most researched and convincingly demonstrated in studies referred to as *the entanglement literature* (Cooren, 2020; Hodder, 2012). It consists of several overlapping bodies of research, including science and technology studies (Latour, 2005), sociomateriality (Orlikowski, 2007), practice-based studies (Nicolini, 2012), affordance studies (Gibson, 1979) and, more recently, technology-centred studies that '(re)pose the question of organization in light of its technological conditions' (Beyes et al., 2022, p. 1003).

The entanglement literature argues humans and things are not separate, but inevitably entangled, in organizational practices. For example, several practice-based studies of knowledge and learning in organizations (e.g., Hasse, 2014; Nicolini et al., 2003) have demonstrated work performance is not primarily based upon specific human competence, but rather a relational system of knowledge, skills, things, and other people embedded in a broader and evolving sociomaterial practice (Gherardi, 2009; Lave, 1993; Sandberg and Pinnington, 2009). Affordance studies have similarly shed light on the intricate and dynamic interaction between things and humans in performing work (e.g., Burke and Wolfe, 2012; Davis, 2020). Additionally, an emerging body of technology-centred studies (e.g., Beyes et al., 2022; Couldry and Hepp, 2017) argues things not only enhance human capacity but also mediate our engagement with the world, shaping the way we think and act.

Although the entanglement literature clearly demonstrates things are necessary for performing work, there is scope for greater clarity about *how* things are constitutive of work performance – that is, how they actively shape and define, rather than merely sustain, work in its performance (Hodder, 2012; Jarrahi and Nelson, 2018; Maller and Strengers, 2019; Shove, 2017). More specifically, it remains unclear what roles things play in performing work, how things are linked together in performing work, and how things and humans jointly perform work.

As all organizational and managerial practices inherently involve various things, such as algorithms, tools, equipment, and raw materials, gaining increased empirical and theoretical clarity about how things are constitutive of work performance is essential if we are to better understand contemporary ways of performing work in organizations. Achieving such clarity would not only improve our understanding of how things contribute to work performance, but also enhance our knowledge of central human resource management (HRM) practices, such as work design and competence development (Parker and Grote, 2022), strategy work (Burke and Wolf, 2009), work collaboration (Kellogg, Orikowski, and Yates, 2006), as well as coordination (Beane and Orlikowski, 2015), and organization of work, more broadly (Beane et al., 2020; Cascio and Montealegre, 2016; Hanelt et al., 2021). Additionally, it would aid technological innovation, such as the development and design of new algorithms, tools, and instruments for optimal work performance (Anthony, Bechky and Fayard, 2023).

The purpose of this paper, then, is to investigate more closely how things are constitutive of work performance. Three conceptual delimitations are necessary from the outset. First, while 'thing' and 'object' are often used interchangeably in everyday and scientific discourse, in phenomenology an 'object' is typically independent of humans, whereas a 'thing' is embedded within social practices (Harman, 2007). We adopt this embedded

interpretation of 'thing'. Second, when we refer to 'things' our focus is *useful things* (which we clarify further below), that is, those things that are useful in performing work, such as algorithms, concepts, formulae, digital devices, raw materials, tools, instruments and so on. Third, when it comes to 'work performance' our primary interest is in *doing* or *performing* work, rather than in the quality of work performance (e.g., more or less skilful/efficient) or its result (e.g., a specific product or service).

We begin by reviewing research studies within the entanglement literature and conclude that, while they convincingly show humans and things are inextricably entangled in work performance, there is scope for enhanced clarity and precision on *how* things are constitutive of work performance. We outline some central concepts from Heidegger's ontology of things, which we then use as sensitizing concepts in an ethnographic study exploring how things contribute to performing work in biotechnology.

Based on the findings, we propose and elaborate a theoretical account of things in performing work, which enriches existing entanglement literature on work performance through three principal contributions. First, the proposed account shows things are constitutive of work performance in three distinct, but interrelated, ways: (a) by belonging to a nexus of useful things (b) through performing interlinked roles (c) while co-constituting work performance in concert with practitioners. Second, we provide a more differentiated account of the roles things play, as well as how these roles are interlinked, in performing work. Third, by identifying and articulating various roles things play in performing work, our account synthesizes several disparate bodies of research within the entanglement literature, which previously have recognized and theorized some of these roles.

THE ENTANGLEMENT LITERATURE ON WORK PERFORMANCE

Organization and management studies have primarily focused on how humans, rather than things or materiality, more broadly, contribute to work performance. As Orlikowski (2007, p.1436) aptly notes 'a quick perusal of much organization literature reveals the absence of any considered treatment or theorizing of the material artifacts, bodies, arrangements, and infrastructures through which practices are performed.' However, during recent decades the entanglement literature, consisting of several overlapping areas of research including science and technology studies (STS), human-machine interaction, sociomateriality, practice-based studies, and affordances, has shown that not only humans but also *things* (e.g., algorithms, tools, instruments, materials) play a critical part in performing work.

A central theory behind most of these entanglement studies is actor-network theory (ANT) developed from Latour, Law and Callon's science and technology studies in the early 1980s (Baygi et al., 2021; Preda, 1999; 2000). ANT emerged as a response to the critique that existing sociological theory privileged humans and their interactions in explaining social order and, consequently, marginalized the involvement of non-human objects (technologies, material, devices etc). What is perhaps most distinctive (and controversial) about ANT is not its emphasis on non-human objects in understanding social order, but that it regards non-humans as 'actors' that carry out activities together with humans. Being an actor doesn't mean ANT considers things have intentions or motives but, rather, they actively perform tasks, such as kettles 'boil' water, locks 'close' rooms against uninvited visitors, (Latour, 2005:71), and fitness tracking devices 'collect' data to give athletes feedback on pace, time and distance

(Matthews, 2021). However, things and humans carry out activities jointly, not separately, such as a chef and knife working together to cut ingredients. From an ANT perspective, therefore, enacting social phenomena occurs through a constantly shifting network of humans and non-human objects (Fenwick and Edwards, 2010; Suchman, 2003, 2007).

The insight that things are not passive, but jointly carry out activities with humans, has been elaborated in a range of STS studies (e.g., Felt et al. 2017; Pickering, 1995; Rheinberger, 1997), as well as in ethnomethodological studies of scientific practices (e.g., Lynch, 1993; Goodwin, 1995; Sormani et al., 2017) and of workplaces, more broadly (e.g., Hindmarsh and Heath, 2000; Rawls, 2008). For example, Knorr-Cetina (1999) provides a detailed account of how epistemic machinery (e.g., instruments, tools, materials, procedures) performs tasks together with scientists in producing scientific knowledge. In high energy physics, 'accelerators', 'colliders', and 'detectors' etc. jointly generate scientific knowledge with physicists, while specific laboratory equipment, such as 'sequencers', 'pipettes', and 'PCR machines' produce scientific knowledge together with molecular biologists.

In a similar vein, over the past two decades, scholars of human-machine interactions and sociomateriality have empirically shown the social and material are not separate, but inseparably entangled in accomplishing work activities (e.g., Jones, 2014; Orlikowski, 2007; Orlikowski and Scott, 2008; Suchman, 2007, 2012; Riemer and Johnston, 2017; Baygi, Introna and Hultin, 2021). Orlikowski (2007, p. 1445), for example, demonstrates performative inseparability of people and material in that researchers do not simply 'use' Google Scholar to obtain information. Instead, information search is a sociomaterial practice 'constituted by the performativity of computers, networks, software, algorithms, directories, databases, and infrastructure, as these are enacted by the human agencies entailed in their design, construction, and operation.' In other words, information search is neither solely performed by the researcher nor by the Google search engine, but by the sociomaterial assemblage of humans and technology.

Cutting across many areas in the entanglement literature is the idea that human beings rarely, if ever, interact directly with the world. Instead, to varying degrees, this interaction is *mediated* by things (Beyes, Holt and Pias, 2020; de Boer, 2021; Karanasios et al. 2021; Miettinen, 1999; Orlikowski and Scott, 2008). Through their mediating character, things significantly shape the knowledge and skills implicated in work performance (Leont'ev, 1964, in Rückriem, 2009; Miettinen, Samra-Fredericks and Yanow, 2009). For example, the work of scientists can be mediated by electron microscopes and telescopes, significantly shaping their knowledge and skill, since they can see things that would not be visible with the unaided eye. Furthermore, several STS studies have demonstrated that equipment used in scientific laboratories not only mediates the research process, but also influences the emergence of the research object itself (e.g., de Boer et al., 2021; Knorr-Cetina, 1999; Rheinberger, 1997).

In addition, echoing ideas of phenomenologists such as Heidegger (1977) and postphenomenologists like Ihde (1990) and Verbeek (2008), an emergent body of technology-centric studies argues that things (or technologies) not only mediate our skills and the objects or services we produce, but are constitutive of human life and (social) reality more broadly (e.g., Baskerville, et al., 2020; Beyes, at al., 2022; Couldry and Hepp, 2017; Power, 2022; Zuboff, 2019). Mediation by things is therefore not neutral but, rather, 'has transformative effects' (Den Eede, 2011, p. 149) on ourselves, our work performance, and our overall

engagement with the world, not only in positive but also in negative ways (e.g., Couldry and Hepp, 2017; Zuboff, 2019). Hence, according to this research, understanding how things are constitutive of work performance requires considering not only how they mediate our abilities and the production of goods or services, but also how this mediation is constitutive of work practices and human life more generally.

Related to the concept of mediation are theories of *affordances,* which have increasingly been used in analysing and theorizing human-technology relations and the performativity of things (Davis and Chouinard, 2017; Faraj and Azad, 2012). The idea of affordances was first developed by Gibson (1979) to highlight 'the possibility for action' that things offer for humans and other living beings (Hutchby, 2001, p. 447). Although the meaning of affordance is ambiguous and highly debated (e.g., Goodyear, Carvalho, and Dohn, 2016; Davis and Chouinard, 2017), it is commonly seen as determined by both the specific properties of a thing and its relation to humans within sociotechnical systems (Davis, 2020, p. 60). As Goodyear et al. (2016, p. 95) note, 'an affordance of a thing for a person depends on qualities of the thing relative to capabilities of the person (skills, perceptual acuity etc.).' For example, in a study of IT affordances, Bilal et al. (2014) showed an airline check-in system varied in affordance for different users. Affordance is thus not static but processual, and seen as 'unfolding action possibilities rendered available in sociomaterial interactions' (Burke and Wolfe, 2012, p. 363). This means, we need to acknowledge a 'certain objectness of things … without jettisoning the gains that have been made in understanding things as closely tied to humans and their ways of knowing' (Hodder 2012, p. 14).

In addition to mediating and affording, some studies have identified other broad categories of things contributing to work performance. In a study of mobile knowledge workers, Jarrahi and Nelson (2018) suggest things not only *enable* work performance, as commonly assumed, but also *constrain* it. While mobile devices, such as scanner apps and digital signature technologies assist mobile knowledge workers in creating, accessing, and manipulating information across time and space, the design of these devices also constrains their use by these workers. Hodder (2012) similarly observes both the positive and negative aspects of dependency on things in work performance. On the positive side, particular things enable humans to accomplish tasks like cooking, shopping, and building. However, on the negative side, we cannot complete these tasks without those things, thereby constraining and limiting how work can be performed.

Moreover, Shove (2017) observes the two most common ways of categorizing materiality in *practice theory* – as 'material elements' integral to performing practice (e.g., Reckwitz, 2002) and 'material arrangements' in which practices occur (e.g., Schatzki, 2019) – are of limited value, as they fail to differentiate the various roles materials play in performing practice. For example, although Schatzki (2019, p. 56) acknowledges things play 'diverse roles' in material arrangements, he does not examine what specific roles things may play in performing practice. To address this limitation, Shove (2017, p. 162) proposes three broad categories of things in social practices: infrastructural-oriented (such as electrical grids and roads), device-oriented (such as power tools and computers), and resource-oriented (such as electricity, gas, and oil).

While Shove uses these categories to explain energy use and consumption patterns in society, she argues they are evident in the constitution and enactment of any practice. Nicolini

et al. (2012) propose three similar categories in a study of collaboration in a multidisciplinary research and development project, where "tertiary" objects represent the infrastructures (e.g., email systems, physical spaces) making collaboration possible; "secondary" objects are boundary objects (e.g., blueprints, models) facilitating collaboration; and "primary" objects (e.g., scientific problems, design concepts), encompass epistemic objects and activity objects providing motivation and focus for collaboration' (Scarbourgh, Panourgias and Nandhakumar, 2015).

Taken together, the entanglement literature clearly demonstrates things are constitutive of work performance in that: (a) things are not passive, but play an active part in performing work, (b) humans and things are entangled in performing work, rather than separate, and (c) through mediating and affording, things significantly shape work performance, as well as our engagement with the world more generally. Despite these important insights, there is significant ambiguity in *how* things are constitutive of work performance. First, although the entanglement literature has identified some broad categories, such as mediating, affording, and enabling/constraining tasks, these broad classifications do not fully capture the specific roles things assume in performing work. Second, while the entanglement literature has provided significant knowledge about the interconnectedness between humans and things in performing work, we still have limited understanding of how things relate to each other in constituting work performance. Third, although several entanglement studies propose things and practitioners co-constitute each other in performing work, precisely how this co-constitution occurs remains unclear.

The entanglement literature is therefore in need of greater clarity and precision in explaining how things are constitutive of work performance. In particular, a more theoretically nuanced and empirically grounded account is needed to further clarify: (a) what *roles* things take on in performing work; (b) how things 'work together' in performing work, that is, how they *relate to each other* in performing work; and (c) how things performing in concert with practitioners *co-constitute* work performance.

AN ONTOLOGY OF THINGS: SOME CENTRAL CONCEPTS

To address the questions above, we introduce central concepts from Heidegger's ontology of things in everyday activities, drawing predominantly on Chapter 3 in Heidegger's (1996/1927) *Being and Time*. Providing support for this endeavour, philosophers (e.g., Dreyfus, 1991; 2010; Okrent, 1988) and organization and management scholars (e.g., Chia and Holt, 2006; Riemer and Johnston, 2017; Sandberg and Tsoukas, 2011) have observed Heidegger's ontology of things provides a rich vocabulary.

Heidegger's examination of the ontology of things in *Being and Time* can be distinguished from his later exploration of the nature of modern technology, such as in *The Question Concerning Technology* (Heidegger, 1977). In this later work, he warns about the danger of 'enframing' (Heidegger, 1977, p. 325) in which modern technology 'frames' the very constitution of the world, such that nature and human beings are treated as resources for technical application, perpetually exploited for further use, leading to an endless cycle of instrumentalization (Blitz, 2014, p. 12). For Heidegger, such a technological framing of the world profoundly shapes our experience and understanding of reality, to the point where we risk losing the capacity to understand ourselves and things in any other way. This instrumental

way of relating is evident in industrialised science (e.g., Ciborra, 2006), as seen in production of genetically modified (GM) crops. The notion of an increasingly technological framing of the world informs many of the technology-centric studies discussed earlier (e.g., Beyes et al., 2022).

While Heidegger's later work on technological framing is informative and relevant to our study (see below), we primarily draw upon his earlier work because it offers an elaborated and distinct vocabulary for investigating how things are constitutive of work performance, the focus of this study. Although some studies in the entanglement literature draw upon concepts from Heidegger, such as ready-to-hand (e.g., Kaplan, 2011), equipmental whole (e.g., Introna, 2019), and practical coping (e.g., Yanow and Tsoukas, 2009), his ontology of things has rarely been employed in a systematic and comprehensive manner to investigate how things shape work performance, as we aim to do. Specifically, we employ four ontological concepts from *Being and Time*, highlighted in earlier studies as central to performing work (Dreyfus, 2014; Sandberg and Pinnington, 2009): being-in-the-world, useful things (or equipment),[1] ready-to-hand, and teleological structure. We use these as 'sensitizing concepts' (Blumer, 1956) to empirically examine how things are constitutive of work performance.

Similar to many entanglement theories, such as ANT and theories of practice, Heidegger rejects an entity-based assumption on performing work, namely, that humans, work, and things used at work are discrete entities, externally related to each other. Instead, he considers our basic form of relating to world is *being-in-the-world*, which has been foundational for several prominent entanglement scholars, including Hodder (2012), Ingold (2011), and Latour (1999). This notion stipulates we are not primarily separated, but always already interrelated (i.e., internally related) with others and things through our ongoing engagement in specific practices (Dreyfus, 1991; Sandberg and Tsoukas, 2011). As Heidegger points out, 'taking care of things always occurs on the basis of a familiarity with the world' (1996/1927, p. 71). Dreyfus (2014, p. 5, italics added) notes that 'in our most basic way of being – i.e. as skillful copers – we are not minds at all but *one with the world* … [so that] the inner-outer distinction becomes problematic. There's no easily askable question about where the absorbed coping is – in me or in the world.'

This inevitable entanglement with world forms a significance whole (Heidegger, 1996/1927, p. 81), providing *intelligibility* to who we are, what we do, and things we use in our activities and projects. In other words, from a Heideggerian point of view, this form of entanglement is the a priori background against which people and things emerge as meaningful in the first place. For example, our entanglement with others and things in teaching practice provides an inevitable background against which we make sense of ourselves as teachers; carry out specific activities like lecturing, online discussion, and marking exams; as well as using textbooks, the internet, and marking sheets for carrying out teaching activities. From an ontological perspective, then, through familiarity with the world, our entanglement with others and things making up specific practices enables us to perform work.

[1] In translating Heidegger's *Being and Time,* Macquarie and Robinson translate the German term, 'Zeug', as 'equipment' (1962/1927, p. 97), while Stambaugh uses 'useful things' (1996/1927, p. 64). We adopt the latter translation in this article, as we consider it more broadly captures things of interest here, including algorithms, concepts, formulae, raw materials, artifacts, tools, and scientific instruments.

What 'things', then, are constitutive of performing work? For Heidegger, these things display the following features: they are useful in performing work; belong to a nexus of useful things; and are ready-to-hand for practitioners. *Useful things* can be intangible or material, such as algorithms, concepts, formulae, digital devices, raw materials, tools, and scientific instruments. For things to be useful, they need to be both suitable and relevant to the task in question (1996/1927, pp.64-78). For example, while both a cutting board and a work bench are suitable for cutting food ingredients on (as both are hard and flat), only the cutting board is normally seen as relevant to this task, since cutting directly on a work bench may blunt the knife or spoil the ingredients.

Importantly, Heidegger (1996/1927, p.64) considers things are useful with reference to other useful things in performing work: 'Strictly speaking, there "is" no such thing as *a* useful thing.' Instead, a useful thing always belongs to a *nexus of useful things* within a specific practice. Items in a nexus of useful things refer to each other in specific ways when performing work. For example, in cutting food ingredients, the knife bears on the cutting board on a work bench, while the ingredients relate to the recipe for the dish being prepared and so on. Items used for producing something (e.g., knives, cutting boards, food ingredients, and recipes), as well as what is produced (e.g., a soup), belong to a nexus of useful things. Moreover, the nexus of useful things is not static, but 'constantly varies in range, expanding and contracting', depending on the activity we are performing (Heidegger, 1988, p. 163). Hence, useful things contribute to performing work in terms of how they refer to each other, rather than separately.

Useful things within such a nexus perform in concert with practitioners, then, thereby co-constituting work performance. These useful things are *ready-to-hand* for the practitioners, who employ them to do what they are for. As Heidegger (1996/1927, p.65) notes with regard to a hammer, 'the act of hammering itself discovers the specific "handiness"' of the hammer', that is, what the hammer is for. Paradoxically, for useful things to be ready to hand for practitioners they must withdraw, becoming 'invisible', such as when reading glasses enable us to read, but we don't experience them as a thing on our nose. However, when things cease to be ready to hand, they no longer contribute to performing work, for example when equipment is broken.

In addition to useful things in a nexus performing in concert with practitioners, every social practice such as cooking, teaching, or accounting involves a *teleological structure* (Schatzki, 1996) of normative, hierarchically related purposes that are significant for the practice (Heidegger, 1996/1927, pp.78-9, 81; 1988, p.295). This teleological structure is not deterministic, however, so an activity can be carried out by practitioners in diverse ways, employing various useful things of relevance. Nor is practice necessarily deliberative but, rather, it can be 'purposive without the actor having in mind a purpose' (Dreyfus 1991, p. 93). A teleological structure of purposes, nonetheless, organizes a nexus of useful things for performing work in terms of: (a) what something could be used for; (b) what could be produced; and (c) the overall point of the performance, that is, why we are using these things and carrying out these activities. In being restaurant chefs, for example, a range of useful things such as recipes, knives, cutting boards, strainers, ladles, and whisks may be used for preparing food ingredients, towards making various dishes like soups, bread, steaks, and sauces, in providing food for patrons.

In summary, Heidegger's ontology of things asserts *being-in-the-world* – our entanglement with things and people in practice worlds – forms the background through which people and things gain meaning. Within this entanglement, a nexus of *useful things* and practitioners co-constitutes work performance. These useful things are *ready-to-hand*, organized by a *teleological structure of purposes* specific to the practice in question. Below, we use these features of things as sensitizing concepts to empirically investigate how things are constitutive of work performance.

METHOD

Research Setting: Performing Work in Biotechnology

To examine how things are entangled in and contribute to performing work, we utilized empirical material from an ethnographic study of work performance in biotechnology, for two main reasons. First, biotechnology has many features that characterize emerging knowledge intensive work in contemporary organizations, such as IT, engineering, research and development (R&D), and in professional services, such as accounting, law, and management consulting. Second, like much other knowledge intensive work, biotechnology relies on a broad array of things, from simple tools, such as tweezers and pipettes, to more complex instruments, such as robots, software programs, algorithms, and other digital devices. This provides a rich empirical context for investigating how things contribute to work performance.

The research context was a mid-sized Australian agricultural biotechnology firm (henceforth 'the agbiotech') involved in the research, development, and commercialisation of novel crop varieties and farming technologies of significance to Australian agriculture. At the time of the study, the agbiotech was engaged in a high-risk, long-term R&D project to genetically modify a major crop to produce a herbicide-resistant (HR) variety. A large multinational company was contributing funding for the HR project and imposed milestones based on commercial imperatives. Regulations governing the testing and development of genetically-modified organisms (GMOs) in laboratory settings shaped the work, as well as regulatory frameworks for eventual approval and commercial release of GMOs. This multi-layered setting in which a local firm secures funding from a multinational partner to perform work of national and/or international significance within relevant regulatory frameworks is common in the biotechnology industry.

We position our investigation of how things are constitutive of work performance within this broader context of biotechnology, in line with Heidegger's concept of the significance whole: the prior background against which people and things gain meaning. The significance whole for biotechnology includes a 'technological' framing of the world in which nature and humans are perceived as exploitable resources for instrumental (e.g., commercial) purposes, such as improving crop yield. This framing impacts the selection of projects that are considered valuable and viable, and the manner in which the work is carried out, which can involve tensions for practitioners (e.g., see Dall'Alba, Sandberg and Sidhu, 2018). As we show below, however, somewhat countering such a technological, instrumental framing, we observed scientists collaborating in conscientiously and skilfully employing useful things towards producing high quality work.

Overview of the HR project phases. Following agreements between the agbiotech and multinational company, the HR project commenced in the laboratory with the insertion of

genetic materials into plants via genetic engineering techniques. Novel HR plants were then propagated and screened, with promising plantlets undergoing trial and evaluation. The main phases and activities of the HR project are summarised in Figure 1 and explained further in what follows.

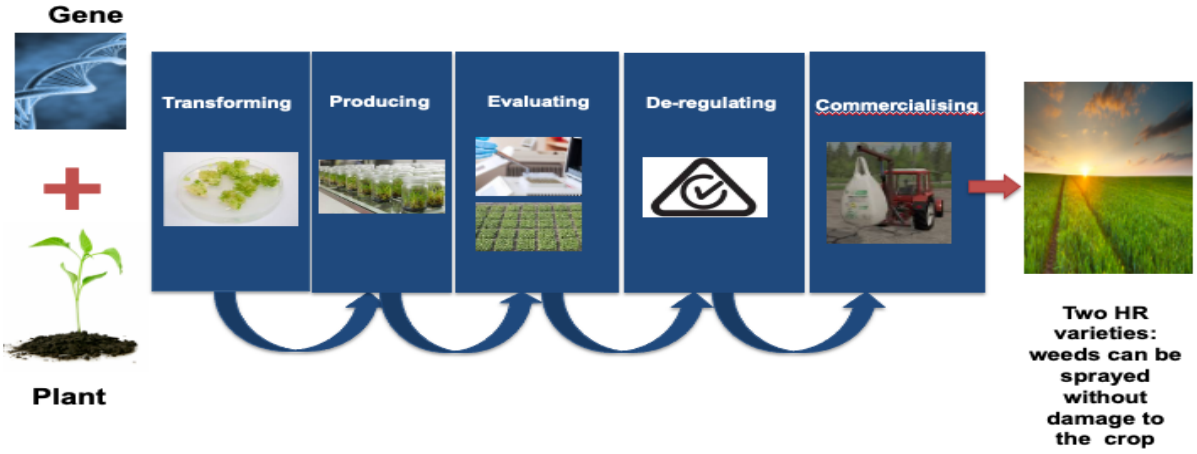

Figure 1: Overview of the HR project

In the 'Transforming' phase, HR project scientists in the agbiotech's main laboratory selected varieties of the target crop for initiation into plant tissue culture. They did so to generate callus, a rapidly growing mass of undifferentiated plant cells. The callus was then subjected to a genetic engineering technique called shooting, where genes conferring herbicide resistance were inserted into the plant cells (See below for more details on shooting). In 'Producing', the transformed callus was regenerated into plantlets and multiplied. During this phase, the plantlets were progressively exposed to small amounts of herbicide; only plantlets containing functional copies of the HR genes survived. In 'Evaluating', the candidate HR plant lines continued to grow in size and resilience, gradually being moved from the lab to the greenhouses, to outside benches, to readiness for planting in the field. Field trials of the HR plant lines with genetic characterisation in the lab aimed to identify one or two promising plant lines for 'De-regulation' (i.e., demonstrating compliance with regulatory frameworks) and 'Commercialisation' (i.e., bringing the approved HR plant varieties to market). These two final phases were expected to occur after our study was complete.

Empirical Material in the HR Project

Over a seven-month period, we undertook an ethnographic study of the team of 14 scientists and their day-to-day work on the HR project. The team members participating in the study ranged from the project leader and senior scientists through to junior scientists. Table 1 provides a summary of the study dataset generated via non-participant observation, semi-structured interviews, and the collection of relevant documents.

Data source	Description
Semi-structured interviews	24 interviews with 12 members of the HR team at beginning and end of the study (~750 pages of text)
Observations	150 hours of observations recorded via field notes (~32, 390 words), video recordings (7 hours of edited footage), and photographs (250)
Documents	PowerPoints, conference posters, reports, lab protocols, procedures, and policies

Table 1: Summary of dataset from the HR project

The *interviews* sought to understand the scientists' work in biotechnology, including the HR project and its aims; their role in the project; what activities were involved; how they work with others; the tools, equipment and other things involved; timing of key activities and milestones; challenging aspects of the work; what was central in performing well in their work; and project progress and outcomes at the conclusion of the study.

The *observations* focused on team members working on the project across various sites. Examples of the work activities observed included lab work, handling plants in the greenhouses, team meetings, informal interactions during lunch and coffee breaks, desk work in the office, and field trials of GM plant lines at a research station/farm. Detailed field notes were the primary means of recording observations as it was not always safe or permissible to video or photograph the activities observed. When videos and photographs were collected, they were integrated into the field notes, with the latter providing explanation, context, and reflections on the recorded activities.

The interviews and observations were complemented by *collection of documents* including project PowerPoints, conference posters, and progress reports, as well as (where relevant) lab protocols, procedures, and policies. These materials provided additional contextual insights into project aims, activities, and outcomes.

Useful Things in 'Shooting' Performance

In this paper, our analysis of how useful things are constitutive of work performance in biotechnology draws on the entire array of work activities performed by the HR team, while directing particular attention to a crucial project activity occurring during the transforming phase: biolistics or 'shooting'. Shooting is a genetic engineering technique used to introduce HR genes into the target crop via microprojectile bombardment. Tiny gold particles coated with two HR-genes are 'shot' into plant cells via a gas-powered 'gene gun'. Although this process damages many cells, a few survive and incorporate the HR genes into their genome. Plants regenerating from these modified cells have copies of the HR genes.

Shooting was considered a suitable activity for close and focused analysis of how useful things are constitutive of performing work in biotech as it: a) plays a pivotal role in initiating the team's work on new HR crop varieties; and b) illuminates how a diverse array of useful things such as plant materials, reagents, algorithms, tools, and machines are integral to shooting. In identifying which things to include in our analysis, we were confronted with a large array of material and intangible things involved in shooting. To initially identify the

possible roles these things may play and how they relate to each other in performing the work, we used two criteria to maximise the range and diversity of useful things included in our analysis: (i) simple (e.g., tweezers) to complex things (e.g., robots), and (ii) things clearly and demonstrably involved in shooting (e.g., plant materials, laboratory equipment, algorithms, reagents etc.), as well as things involved in less immediate ways derived from the broader local/national/international context of the work being performed (e.g., regulatory frameworks).

During analysis, we focused primarily on *things directly embedded in performing the biotechnology work* under investigation. As Hindmarsh and Llewellyn (2018, p. 416) note, when it comes to decisions about which things are relevant in sociomaterial analysis, 'there is a *prima facie* case for privileging only those features that organizational members utilize, invoke or index in producing and coordinating action.' For us, the focus on things directly involved in performing shooting also assisted in achieving clarity on the questions motivating our analysis, i.e., the roles things play in performing work, how things are related to each other, and how useful things and practitioners co-constitute work performance.

Empirical material and analysing 'shooting'. Focused empirical material on shooting was generated through non-participant observation of four members of the HR team shooting in the laboratory: two senior scientists, a junior scientist, and an honours student being taught to shoot by one of the senior scientists. We shadowed these scientists as they prepared in the office, donned a white coat and followed them into the laboratory, and observed their shooting in situ. We used video, field notes, and photographs to capture how the diverse array of tools, machines, plant materials, reagents, algorithms, and experimental protocols actively contributed to shooting performance. We also recorded spatial arrangements and the relationships of these items to the diverse ecology of useful things making up the laboratory (e.g., the humming fridges, the square bulk of the autoclave machine, long benches packed with neatly ordered pipettes, tips, reagents, racks, waste bins and so forth).

Especially important in our dataset were the video recordings of shooting performed by HR team members. These videos recorded multiple iterations of shooting over different days by team members of varied experience and skill level. The videos provided a 'permanent and detailed record of "what happened"' (De Rond, Holeman and Howard-Grenville (2019, p. 1966), allowing repeated examination of material, spatial, verbal, and bodily details in shooting (Smets et al., 2014), thereby enabling us to discern patterns and contrasts in analysis (Gylfe, et al., 2016; Hindmarsh and Llewellyn, 2018).

Analysis involved an abductive process (Klag and Langley, 2013) of iterating between the empirical material, sensitising concepts from Heidegger's ontology of things, and our pre-understanding (Alvesson and Sandberg, 2022) of the focal phenomenon (e.g., one of the authors had experience as a biotechnological scientist). To analyse the videos, photographs, and field notes on shooting, we also adapted two of Gylfe et al.'s (2016) recommendations for working with visual data: specifically, the analytical steps of 'sequencing' and 'patterning', elaborated next. Additionally, our close familiarity with the broader project dataset – including the HR project's aims, activities, and intended outcomes, as well as the agbiotech's culture – provided essential contextual understanding for interpreting the visual data (e.g., Jarrett and Liu, 2018).

First, in *sequencing*, repeated viewings of the videos enabled us to map the participants' bodily performance of shooting within the material environs of the laboratory and offices. Our focus here was to capture an initial chronology of actions, events, and things involved in shooting: from the preparatory office/planning work, through to setting up in the laboratory, and then shooting the plant materials. We developed an extensive table, recording for each video what actions and events occurred, when and where these took place, and what, how, and why different people and things were involved. In doing this, we attended to how participants pointed, touched, manipulated, and referred to things of various kinds – e.g., tools, machines, databases, protocols, regulations, plant materials, and reagents – in ways that were recognizable and meaningful to them (Gylfe et al., 2016). We took extensive notes on the spatial orientations of different items, our preliminary impressions of the role(s) they played in shooting, how they were related to each other, and the ways in which their involvement interleaved with the scientists' movements, timing, judgements, and decisions about what to do next and how to proceed. This sequencing process was particularly useful for generating initial insights into how useful things and practitioners co-constituted shooting performance, as well as how things were related to each other in this process.

Once we had captured a chronology of each video, *patterning* then involved comparing and contrasting across the chronologies. This allowed us to identify regularities and differences in performance across people and useful things, interrogating more closely the different roles useful things performed in shooting. We constructed emergent categories of roles in work performance, that is, what useful things were actually doing in relation to practitioners and other useful things in shooting. This meant going beyond gross observations of function for specific items (e.g., the tweezers move the callus) to considering their *role* in performing shooting, that is, *how* they contributed to shooting (e.g., by *extending* the human body's ability to manipulate small and fragile objects).

This process initially generated a great number of role categories, yielding recognition that particular things could fulfil more than one role in shooting, with roles shifting over time and across practitioners. To manage this complexity and refine our categorisations, we engaged in extensive discussion while making iterative comparisons of tentative categories against the chronologies and relevant video segments. These discussions centred on striking a balance between preserving the differentiation and dynamism of role categorisations, while winnowing categorisations that were less common, less elucidatory of the contribution to shooting, or that could be subsumed into a higher-level role category. We thereby gradually clarified and refined the roles based on their *overall or predominant contributions* to performing the work (e.g., *modifying* other things or *coordinating* people and things etc.) and their central *distinctive features* (e.g., useful things playing a *providing* role are occupied or consumed during work performance). These criteria led to us constructing categories of roles at a broad level, although we recognise these broad roles potentially could be further divided into sub-categories.

In total, we identified seven distinct (but interrelated) roles of useful things in contributing to performing the work: *providing, modifying, extending, substituting, coordinating, framing, and directing.* While we acknowledge the construction of categories is open to interpretation, we present these roles – elaborated in the next section – as credible interpretations with tight connections to our empirical material and explanatory power for how things contribute to performing work.

Our findings on how things are constitutive of shooting performance are presented next via a composite vignette (Jarzabkowski et al., 2014), which integrates analytical insights from multiple observations of shooting into a single narrative. As data presentation strategy, the vignette demonstrates both the richness and representativeness of the patterns observed across the empirical material (Jarzabkowski et al., 2014); in our case, it reveals the recurring patterns identified in how useful things are constitutive of shooting performance. The vignette portrays a member of our research team observing Heidi, a composite character derived from all four participants, working with the gene gun in the HR lab.

FINDINGS: THINGS AT WORK IN SHOOTING

After months of collective effort, the HR team has devised and optimized a shooting protocol specific to the genes and plant varieties with which they work. The HR team's success here has been hard won; each plant variety imposes its own variation on the protocol, requiring adjustment to both the protocol's reagents and enactment. Every team member has helped with experiments to improve shooting efficiency, trialling numerous permutations (e.g., varying the sources, age, and appearance of the callus or newly formed plant tissue; the settings of the gene gun; the reagents used; the number of shots fired etc.). Now the team has refined their process, I'm keen to observe them in action.

'The gun is free now – we can go if you like'. I look up to see Heidi, one of the HR team's most experienced scientists, standing over my desk. I'm in the downstairs, open-plan office of the agbiotech. It's early in the morning and a few of the team members are still in front of their computers, checking emails, and planning their day. Amelia, on my right, has the team's project database open on her computer screen, and is busy calculating and updating the latest field trial results. Later today, Heidi will update the same database with the shooting work we're about to perform. As I gather what I need, Heidi asks Amelia, 'This batch of callus – its quality?' Amelia nods, barely looking up. 'Yeah, I got ten plants back from the last lot. Not bad'. She continues with her work. Heidi turns back to me, 'All right, let's go'. Together, we leave the office.

Swiping her security card, Heidi pulls open the heavy door and we enter the brightly lit, temperature-controlled laboratory, with its design and access requirements carefully adapted to ensure compliance with gene technology regulations. I survey the terrain before me, taking in the long benches and shelves that partition the room. Numerous devices, instruments, and other inscrutable objects populate the space, many of them maintained by a team of technicians and scientists not currently present. My eye is caught by a movement to my left. Turning, I spy the automated PCR robot busy in its sealed case, its long arm gliding purposefully across the tube arrays executing its precise distribution of reagents. The sight is a reminder: useful things are busy at work here – pipetting, lighting, heating, cooling, spinning – all involved in the array of activities constituting shooting.

Heidi strides to a large, stainless-steel cabinet at the side of the room. This is a laminar flow cabinet, an enclosed bench space designed to minimize contamination. The cabinet's features – its stainless steel and glass construction, irradiating UV lamp, and filtered flow of air – provide a semi-purified space within which the sensitive work of plant tissue culture can be performed. This cabinet, however, stands out from others like it in the lab. Squatting in the

cabinet's back corner is a metallic black and silver box, two pressure gauges and a large plastic tube protruding from its surface. The bulky tube snakes up and out of the cabinet, connecting to a large freestanding canister of gas (See Figure 2). Noting me eye this strange apparatus, Heidi nods, 'Yes, that's the gun'.

Figure 2: The gene gun

I settle myself on a stool to observe. Heidi pulls on her lab coat and gloves, describing the preparatory tasks already completed: 'Before we came up, I turned on the gas, the pumps, the sterilizer, and UV'd it. I also checked the callus [under the microscope]'. Heidi takes her seat, swivelling towards a plastic box on the narrow bench to her left. This is Heidi's 'shooting box.' Inside, neatly labelled and arranged, are all her tools and materials.

Heidi precisely assembles her tools in the cabinet, each item having its place. Twin foil packages are set at the front of the cabinet, tweezers are freed from their wrappings and slid tip-up into the red rack at the back, and two petri dishes find their home adjacent to the gene gun. Before each item passes into the cabinet's sanitized environs, Heidi gives its exterior a liberal spray of ethanol. Contamination from bacteria, fungi, and other unseen enemies is the plant scientist's greatest bane.

Heidi picks up one of the petri dishes and unseals it. The lid is placed, face up, at the back of the cabinet; the empty dish is set to the fore of the cabinet. Heidi then turns towards the gene gun. Opening the chamber door, she reaches in and extracts a ceramic platform on which three chunky, round metal pieces rest. Carefully, she sets the platform on the open petri dish; the dish prevents the platform from touching the cabinet's surface.

The jumble of metal and ceramic pieces must be put together to load the gun. First is the rupture disc holder, host to a small circle of plastic, the 'rupture disc', which allows the build-up of gas providing the power behind shooting. Heidi collects the metal holder, resting it in the palm of her left hand. Taking up her tweezers, she deftly delivers the rupture disc to the holder's centre aperture, before screwing the holder into place at the top of the gun.

Next, the 'bullets' for the gene gun are prepared. This requires several components: the ceramic platform, the remaining metal pieces, a 'macrocarrier' (a small orange disc onto which an HR-genes/gold mix has been loaded), and a 'stopping screen'. Heidi reaches for a yellow

box to her left. A flip of its lid exposes a pile of silver, circular, mesh stopping screens. With the tweezers, Heidi extracts a screen from the box and delivers it to the round metal piece in the centre of the ceramic platform. The tweezers then help Heidi collect a macrocarrier; she nimbly inserts it above the screen, flipping the disc to ensure the correct orientation. The tweezers are returned to their place in the rack. Heidi's gloved hands slot and screw the remaining metal components of the assembly into place.

Heidi turns towards the gene gun and slides the macrocarrier assembly home. The loading of the gun unfolds rapidly, Heidi's movements displaying a smoothness and surety borne of repetition and purpose. Finally, Heidi reaches for one of the foil-wrapped packages. Peeling away the foil, she extracts a sealed petri dish. She looks at it closely, scrutinizing the pale cluster of callus in the centre of the dish. Carefully keeping the dish within the cabinet, Heidi tips it slightly so I can see the callus, pointing out that it looks 'crispy'. Heidi assures me this is good; based on her experience, one gets more modified plants from callus like this. Heidi unwinds the seal on the petri dish, removes the lid and sets the callus onto the bottom shelf of the chamber. She closes the door, sealing the gun's main chamber. After just a few minutes of fluent activity, the gun is ready.

Heidi and the gun begin their well-practiced dance. Heidi flicks the small red 'vacuum' switch and the gun goes to work. First, air is rapidly evacuated from the lower chamber, creating a vacuum. As the air is expelled, Heidi's gaze flits to the pressure gauge set into the gun's side. She watches as the needle gradually moves to the left, showing the internal pressure dropping to about 28psi. At the right moment, Heidi flicks the switch again, holding the vacuum, then quickly triggers the 'fire' switch.

The gun responds immediately. Gas pours into the upper pressure chamber, the needle on the helium gauge jerking to life. As gas builds, the pressure on the rupture disc at the top of the chamber increases. The needle climbs upwards of 1000psi. The rupture disc fractures in less than a minute. A propulsive shock wave of gas bursts through to the lower chamber, hitting the macrocarrier assembly and propelling the macrocarrier disc forward into the mesh stopping screen. The tiny microprojectiles, meanwhile, slip through the mesh screen to bombard the exposed callus. A muted *click* sounds. 'That's it,' says Heidi. The callus has now been 'shot', the gene gun having done its job.

A Nexus of Useful Things in Performing Shooting

The vignette introduces us in a concrete manner to how a specific set of useful things contributes to shooting, while also demonstrating their necessary entanglement with practitioners who make use of them. As we enter the laboratory, we encounter its 'brightly lit and temperature-controlled' spaces, given form and structure by its arrangement of benches, shelves, cabinets and the like. This basic infrastructure is itself teeming with objects, materials, instruments, and machines of various kinds: laminar flow cabinets, gene guns, petri dishes, plant materials, chemicals, tweezers, gloves, lab coats, and so on. These useful things are active, busily carrying out different tasks. The cabin protects, the gene gun shoots, the petri dishes store, the plants provide initial materials, the chemical reagents react, the tweezers grip, the gloves and lab coats protect, and so on. The protocol helps orchestrate how all these different things are bound together when shooting, while the project database similarly coordinates the HR team's work all the way from the lab bench to the field. Table 2 provides

examples of some of the things used in shooting.

Useful Thing	Task(s) performed in shooting	Role in shooting
Protocol	Coordinates and standardises shooting performance	Coordinating
Gene technology regulations	Stipulates laboratory design and construction, how to perform lab work, and skills and training needed to perform lab work	Framing
DNA	Supplies DNA to enable genetic modification of plants	Providing
Gold microprojectiles	Carries/transports the DNA to transform the plant	Modifying
Callus/plant material	Supplies the plant material/cells to be shot and transformed	Providing
Growth medium and hormones	Supplies nutrients for plant growth	Providing
Computer	Runs and displays computer programs	Extending
Email	Sends information electronically across time and space	Extending Coordinating
Project database	Stores and displays information about project activities	Coordinating
Security keycard	Unlocks the door to laboratory	Extending
Laboratory space	Provides suitable space for performing shooting	Providing
Lab benches	Provides suitable surface for work	Providing
Lab coat	Protects clothes	Providing
Gloves	Protects hands and what is handled	Providing
Automated pipetting machine (‘robot’)	Automates (sets up and carries out) PCR tests	Substituting
Laminar flow cabinet	Provides a sterile space	Providing
Plastic shooting box	Stores and protects useful things	Providing
Tweezers	Handles or manipulates small, fragile objects	Extending
Petri dish	Stores and protects other useful things, including gun components	Providing

Table 2: Examples of useful things in gene gun shooting

In keeping with our theoretical perspective, this plenitude of tools, materials, protocol, database, and equipment *belong to a nexus of useful things* in shooting. As highlighted previously, things belonging to this nexus have the qualities of being both suitable and relevant to shooting. For example, the cabinet’s ‘stainless steel and glass construction, irradiating UV lamp, and filtered flow of air’ make it clean and hygienic, and thus suited to working with plant tissue culture. However, this is insufficient to qualify for membership in the nexus, which requires incorporation into a specific activity and relations with other useful things involved in this activity. For example, the gene gun is recognizable and operable as a gene gun – as opposed to an assemblage of metallic objects, rubber tubes, and plastic gauges – in relation to other useful things in shooting, like the callus and genes, the protocol, the laminar flow cabinet, and wider laboratory. From this web of relations (e.g., genes—callus—protocol—gene gun—cabinet—laboratory), established and connected in a specific activity (e.g., shooting), things gain significance and meaning in performing work.

The materials, tools, protocol, and instruments Heidi works with in shooting are intelligible, then, within this nexus, animating her actions in preparing the cabinet and loading the gene gun. Her precise placement and ordering of materials and instruments in the cabinet reflects familiarity with how these different items bear on each other when it comes time to

shoot. In loading, she places the rupture disc into the rupture disc holder, the macrocarrier disc in the macrocarrier assembly, and both the assembly and holder in the gene gun. In other words, Heidi enacts and embodies an understanding of effectively working with the nexus of useful things in shooting.

This comprehension of the nexus of useful things also inheres in Heidi's and the team's setup, daily movements, and interactions in the lab more broadly. For instance, the shared norm of 'working from clean to dirty' (i.e., from sterile to non-sterile conditions) is a principal determinant of what makes a given item suitable and relevant to incorporate into this nexus, as well as how the team engages when working (including during shooting). This principle is writ large in the setup and layout of the lab facilities (the sterile clean rooms are at the front of the facility, the 'dirty' greenhouses at the back), in how the team members structure their day (typically one starts in the lab and finishes in the green houses), and even, as seen in the vignette, in how the scientists organize their tools in the hood (sterile/clean items go in first towards the back of the cabinet, while the comparatively 'dirtier' items are placed last and towards the front). Importantly, the nexus of useful things in shooting is not fixed in its composition and arrangement; rather it is dynamic, shifting across performances, time, and different individuals/groups, as we explain below.

Roles Useful Things Perform in Shooting

Critically, when it comes to shooting, the nexus of useful things is far from marginally or peripherally involved. Rather, as previously highlighted, the nexus is active and integral; useful things perform essential actions in relation – and in response – to each other in shooting. This is readily discernible in the vignette through the actions performed by particular useful things in shooting: for example, the cabinet protects, the gun shoots, the protocol guides, the tweezers grip and move. Yet, useful things are also active in more oblique and auxiliary ways in shooting. The fridges hum away in the background, storing and preserving reagents and samples; the air-conditioning maintains the ambient temperature to precise experimental requirements; national gene technology regulations stipulate how genetically modified plant material is to be handled and managed. The more one looks, the more one sees shooting is impacted by guidelines, objects, tools, and machines with which Heidi does not always directly engage, but which are nonetheless pivotal to accomplishing shooting. Hence, the nexus of useful things is constitutive of shooting as these things perform central tasks in shooting. Importantly, useful things within the nexus impart their own variation on shooting performance. For instance, the qualities of different plant varieties meant the shooting protocol had to be adapted in terms of reagents used (e.g., addition of different hormones) and timing of certain activities (e.g., age of the callus when shot), yielding different shooting outcomes (e.g., some varieties tended to give rise to more new GM plant lines than others). Changes to individual elements making up the nexus have to be considered in terms of their likely impacts on the whole.

Our analysis suggests that specifying what roles useful things are performing within the nexus helps clarify these interrelations. Our analysis reveals useful things within the nexus performed seven key roles, namely, 'providing', 'modifying', 'extending', 'substituting', 'coordinating', 'framing', and 'directing' (See Table 3; see also Table 2).

Role	Key attributes	Examples of useful things
Providing	• Supplies necessary elements and environs, e.g., raw materials, protective clothing, suitable temperature	• DNA, plant materials, gloves, laboratory
Extending	• Augments and enhances practitioners' bodily abilities, such as handling, perceiving, monitoring, calculating	• Tweezers, microscope, software program
Modifying	• Changes and transforms other useful things	• Gene gun, ethanol
Substituting	• Stands in for practitioners, largely performing tasks instead of them	• PCR robot
Coordinating	• Links and synchronizes actions of practitioners and useful things across tasks over space and time	• Protocol, project database
Framing	• Stipulates contextual conditions and requirements for performing tasks	• Gene technology regulations
Directing	• Guides actions of practitioners and useful things, while emerging	• GM callus

Table 3: Roles of useful things in shooting

Some useful things in shooting are *providing* – that is, supplying – the elements necessary for shooting. Here 'elements' can refer to things like raw materials, components, and ingredients, protection for plant materials and practitioners, as well as environment or milieu. In this sense, the lab space, the surfaces offered by benches and shelves, the lights and air-conditioning provide a suitable environment to carry out shooting. Useful things performing a providing role thus supply the necessary space, ingredients, energy, and protection for a given activity. For example, in the vignette, the HR-gene coated microprojectiles and the plant material directly provide the necessary ingredients for the creation of GM plants. More indirectly, the spray bottle provides by storing and transporting ethanol for use during shooting. When providing, useful things are occupied or consumed as part of shooting performance, either temporarily or permanently. For example, when the laminar flow cabinet provides during shooting, no other activities can take place within its 'sanitized environs' until shooting is complete. Likewise, the gas powering the gene gun is consumed in the act of shooting.

The vignette also shows that useful things are *modifying* other useful things, changing or transforming them during shooting, commonly by performing tasks that humans cannot readily perform by themselves. This modifying role can extend from bringing about minor changes to complete transformations of other useful things, varying from temporary to permanent. For example, the gene gun, rupture discs, and stopping screen together insert HR genes into plant materials, thereby modifying the DNA of the plant. Similarly, ethanol modifies by sterilizing other useful things it is sprayed on in shooting. Moreover, modifying things in the nexus alter properties of other things and, thereby, their performance. In our case, by inserting new DNA, the gene gun modifies the genome of the crop to be more resistant to herbicide. We can

therefore talk about a dual modification effect: modification of properties (change in genes), which modifies the plant's performance (it now resists herbicide).

As shown in the vignette, several useful things are *extending* – in the sense of augmenting or enhancing – bodily abilities as shooting is performed. This includes bodily abilities both physical and cognitive in nature, such as manipulating, perceiving, and calculating. For example, the sterile tweezers allow Heidi to physically handle (but not change) the fragile callus, illustrating how useful things can enhance the body's ability to handle or manipulate matter. Likewise, the microscope allows Heidi to perceive the callus in rich detail when checking it for suitability, showing how useful things may augment the senses. Useful things can augment the ability to compute or calculate too, as seen at the beginning of the vignette, when a software program extended Amelia's ability to analyse field trial results.

Closely related to extending, a fourth role useful things take on in shooting is *substituting* for practitioners. In performing a substituting role, useful things largely (although not completely) take the place of or stand in for practitioners, which frees them up to attend to other activities. For example, the PCR robot stands in for the scientists in testing how many copies of the HR genes had been inserted into the plantlets through shooting, performing with great precision the large number of replicates of PCR tests required. As noted, the robot doesn't completely substitute for the scientists, as it is programmed and maintained by the team.

A fifth role useful things take on in shooting is *coordinating*. For instance, the gauges on the gene gun coordinate the points at which Heidi performs specific actions in shooting. In the laboratory itself, schedules attached to the main instruments coordinate their use across the team; warning signs indicate hazards to be avoided or processes to be activated in emergencies; color-coded bins and instructions direct disposal procedures for waste products to ensure regulatory compliance. At the project-level, the project database synchronizes the team's activities over the life of the project. The database records the creation, treatment, and progress of each novel plant line, tracing its transitions from lab to paddock, with each database entry corresponding to a living GM plant line. This enables team members to visualize the project as a whole or drill down to specific activities, connecting the past to the present and future. For instance, the database indicates current project status (e.g., how many plant lines and which are performing best so far), offers a historical record that enables traceability, and even enables (some) prediction, such as planning field trials based on progress of plant lines. Later, this database will become a major artefact in de-regulation and commercialisation processes.

A sixth role performed by useful things is *framing*. Useful things play a framing role derived from the broader context of the work being performed, for example regulatory frameworks, corporate policies, incentive systems, and surveillance technologies. Things of this kind stipulate, or at least influence, the contextual conditions and requirements for performing the work. They can be distinguished from other conditions or requirements that are not useful in performing the work but may even obstruct or distract from it (e.g., see Van Beurden, Van De Voorde and Van Veldhoven, 2021), including bureaucratic requirements not conducive to completing the work. In shooting, useful things with a framing role include legal regulations that specify permissible conditions for manipulating genes and preventing 'escape' of genetically modified organisms (e.g. stipulating laboratory design, access and field trial requirements). In addition, policies for ensuring workplace health and safety for the scientists influence procedures for safe handling of equipment and disposal of waste products.

Together, the roles performed by useful things in providing, modifying, extending, substituting, coordinating, and framing in shooting ultimately enable performance of a seventh role, namely, *directing.* This role is performed by useful things produced through shooting. Specifically, as shooting proceeds, useful things begin to appear/manifest, such as genetically-modified callus. These emergent useful things perform a key directing role as practitioners and other useful things in the nexus adjust their ongoing performance in response to their appearance. For example, the way in which the team works with the emerging GM callus will depend on the qualities it manifests as it regenerates. It should be noted that other things can also emerge, such as waste materials as a shooting by-product, which are neither directing nor useful in shooting. They may, however, be incorporated into – becoming useful in – other activities, including those designed to reduce negative impacts on the environment.

Importantly, the role specific useful things perform in the nexus is not fixed, but can shift across circumstances and time. For example, the simple spray bottle Heidi used in the vignette plays different roles in shooting at various times, for example, *providing* when storing the ethanol and *extending* when dispersing it. Following shooting, the GM callus will shift from a directing role to subsequently *providing* the raw material for other lab members to select, regenerate, propagate, and characterize. Indeed, the emergent GM plant itself will eventually provide in farming practice.

How Things and Practitioners Co-Constitute Shooting Performance

Useful things acting in concert with practitioners co-constitute shooting performance. In other words, useful things and practitioners are inevitably entangled in shooting; one is insufficient for shooting, as they perform in concert. This co-constitution is evident: a) when useful things are *ready to hand* for practitioners in performing the task of shooting; and b) through specific *teleological structures*, or a hierarchy of purposes, for biotechnology practice.

The meaning of useful things as ready to hand in shooting is illustrated in the vignette through comparing the observer's and Heidi's (i.e., the practitioner's) experience of the gene gun. In the vignette, the observer experiences the gene gun only as an object with specific properties, such as a 'metallic black and silver box'. In contrast, the gene gun is accessible to Heidi as *ready to hand.* She 'smoothly and surely' puts it to use in shooting HR-genes into plant cells. Heidi is thus able to set the gun 'free' to do what it is for. Her attention is focused on using the gun (e.g., loading the 'bullets', checking the gauges) in producing what emerges (e.g., the GM-callus she creates through shooting). For Heidi, performing the task of shooting comes to the fore, with the gene gun 'withdrawing' in its use, thereby contributing to shooting. Also apparent from our analysis, there can be degrees of readiness-to-hand. For instance, when a senior scientist was teaching a student how to shoot, we observed more hesitant, slower movements by the student compared to the experienced scientist. The scientist also demonstrated a 'good fit' of gene gun components (e.g., correct angles and nesting of parts), intervening at critical moments when the student hadn't reacted in time or fully completed an action (e.g., turning off helium gas). These differences in awareness, fluidity, and pace reveal the nexus of useful things is more contracted/limited for some (in this case, the novice) and more expansive for others (i.e., they have greater awareness of its constituents and their connections, with larger capacity to intervene).

Among experienced scientists, too, there were clear variations in how they worked in

concert with the nexus of useful things, bringing individual preferences and insights to bear in optimising performance or dealing with breakdowns. For instance, the scientists used varying heuristics to identify when the callus looked 'ready' to shoot, such as appearance of the callus (e.g., its 'crispiness'). Some would 'double-shoot' the callus to prevent wastage of the DNA/gold mix. Many of these variations reflect differences in shooting quality, as evident in achievements recognized by their colleagues.

As well as readiness to hand, useful things perform in concert with practitioners, co-constituting shooting, through *a hierarchy of purposes* for biotechnology practice. This hierarchical chain of purposes imbues Heidi's and the HR team's actions with meaning and significance, identifies possible ways to do things, and indicates what can be produced. For example, the point and significance of the biotechnology practitioners' work is enhancing crop yields and sustainability. This provides direction for the HR team's activities towards producing genetically-modified plants that can resist herbicides, and be de-regulated and commercialised. The team's choice and deployment of specific useful things are aligned to these overarching purposes. For instance, the HR team chooses biolistics (i.e., the gene gun), rather than other genetic techniques, because biolistics is suited to the plant they work with. Similarly, the team works with plant varieties most likely to succeed commercially. They also optimize protocols/algorithms for how they deploy useful things (e.g., reagents, the gun etc.) to ensure shooting is effective, reliable, efficient, and complies with regulations. Thus, the teams' shared understanding of a chain of purposes for biotechnology practice undergirds their collective performance of shooting, organises (configures) the nexus of useful things, and enables routine deployment of these useful things over time.

Finally, the materials, algorithms, tools, objects, and instruments (i.e., the nexus of useful things) that practitioners invent, design, and refine through their activities can give rise to varying ways of performing shooting, as well as to new or refined patterns of activity. For example, Heidi and the team spent many months creating and optimizing shooting protocols specific to the particular genes and plant varieties they worked with. As each team member engaged in shooting over time, they developed various ways of arranging and handling equipment that optimized the economy and speed of their movement. The smoothness and flow of Heidi's actions in shooting, and her repeated success in creating GM-plants, builds on the HR team's careful preliminary work in trialling and refining shooting protocols. Therefore, in creating and using new useful things as part of the nexus, Heidi and the HR team have also transformed their collective performance of shooting, including knowledge and skills integrated with useful things.

DISCUSSION

In this article we investigated how things are constitutive of work performance, presenting new and refined distinctions. While existing entanglement theories show things are integral to performing work, they generally lack specificity about *how* things are constitutive of work performance. This study makes an original contribution to the entanglement literature by providing a systematic account – empirically and theoretically – of how things are constitutive of work performance in three distinct, interrelated ways: (1) by belonging to a nexus of useful things (2) through performing interlinked roles (3) while co-constituting work performance in concert with practitioners. Figure 3 provides an overview. In striving for clarity, the figure may

appear overly neat or self-contained. However, as the findings demonstrate and we elaborate below, in practice this entanglement is complex and dynamic, integrating past, present, and future endeavours.

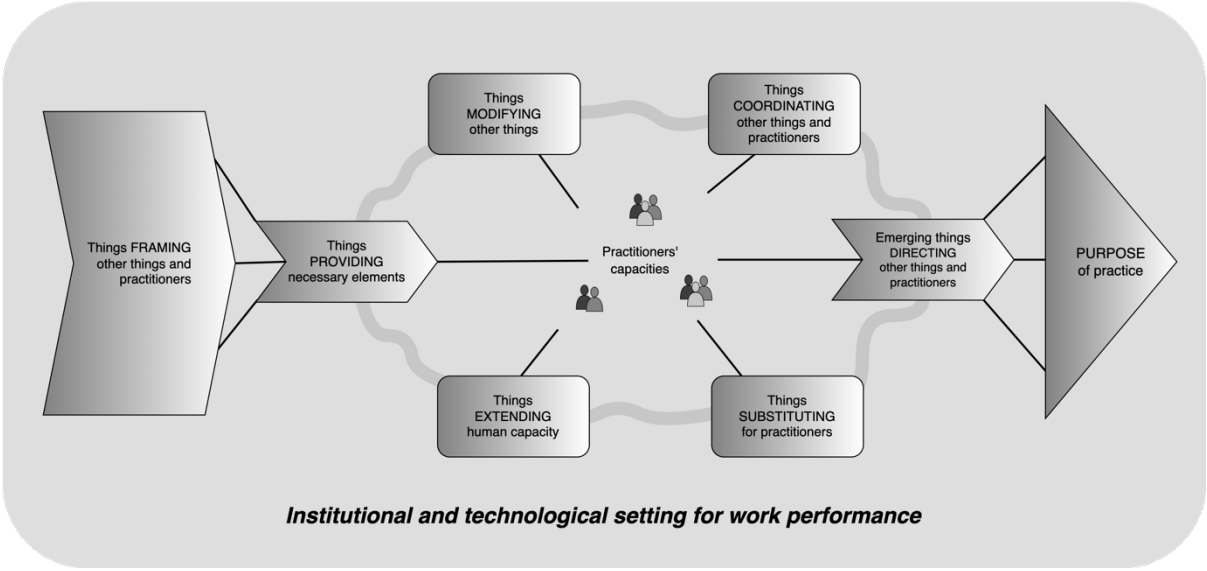

Figure 3: How things are constitutive of work performance

Things belong to a nexus in performing work. As empirically demonstrated by our findings and supported by many entanglement studies, both things and practitioners actively shape and define – that is, are constitutive of – work performance. However, not all 'things' are constitutive of performing work. Our theoretical and empirical account suggests only *useful things* – whether tangible or intangible – are constitutive of work performance. To qualify as a useful thing, three interrelated features must be present. First, it must possess *specific properties* that make it suitable and relevant to performing the activities. Second, it must be bound up in a *nexus*, where it refers to other useful things through a chain of interdependent *roles*. Finally, useful things within the nexus must be *ready-to-hand* for practitioners, who use these things to do what they are for in performing work, as shown through the numerous interconnections depicted in Figure 3 and further elaborated below. Importantly, as Heidegger pointed out and we demonstrate empirically in our findings, the nexus to which things belong makes them intelligible as useful things, working in concert with practitioners in constituting work performance, while embedded in a broader institutional and technological setting.

Things take on interlinked roles in performing work. Our findings demonstrate that useful things (belonging to a nexus and depending on their specific properties) are constitutive of work performance through the following *key interlinked roles*: providing, modifying, extending, substituting, coordinating, framing, and directing (as illustrated in Figure 3). Importantly, through these roles useful things are interconnected in distinct ways to each other and practitioners in performing work.

Providing. Useful things that perform a providing role supply materials, protection, and environs necessary for creating, making, or producing things such as cars, computers, movies, legal advice, and health care. For example, in shooting, HR-genes and plant materials provide

central ingredients, while the laboratory provides suitable space for GM plant creation. In teaching, whiteboards, online platforms, and classrooms may provide important elements for delivering courses. On large construction sites, steel and cement provide essential building material, while overalls and steel-capped boots provide necessary protection for workers and their clothing.

Modifying. Useful things that adopt a modifying role change or transform properties and/or performance of other things (and practitioners) within the nexus, usually performing tasks practitioners themselves cannot readily perform. Such modifications range from minor to major, and temporary to permanent. For example, an electric drill modifies timber by boring holes in it, while Bunsen burners modify the temperature of liquid from cold to hot, which practitioners can't readily do on their own.

Extending. Useful things taking on an extending role, augment and enhance the human body's capacities to perform specific tasks, 'by teaming up with the human perceptual, motor or cognitive system' (Heersmink, 2012, p.121). In shooting, this was evident with the tweezers, microscope, and software programs. Similarly, telephone tapping and CCTV devices extend sight and hearing, enabling police to gather intelligence for solving crimes (Rowe, 2014), while artificial intelligence devices such as Chat-GPT and Google Translate extend and 'vastly exceed the cognitive capabilities of humans' (Ashford Lee, 2020, p.xvii). As such, things and practitioners 'are creating whole new agent-world circuits' (Clark, 2007, p.265) in performing work.

Substituting. Useful things that fulfil a substituting role stand in for, and sometimes even largely replace, practitioners. This substituting role is increasingly performed through digitalisation, such as the autopilot that stands in for pilots in flying an aircraft (e.g., Berthod and Müller-Seitz, 2018), robots that stand in for practitioners in various professions (e.g., Cascio and Montealegre, 2016), and AI-enabled recruiting and selection tools that replace the interviewer in job interviews (e.g., Hunkenschroer and Luetge, 2022). However, although AI substitutes for practitioners, it may not replace them altogether, as it also collaborates with practitioners in performing work (Anthony et al., 2023).

Coordinating. Useful things with a coordinating role, arrange and organize performance of practitioners and other useful things in the nexus, such as linking processes with products and enabling patterns of action to be repeated consistently over time. For example, the protocol and project database in shooting coordinate other things in the nexus, as well as shooting activities over time and across practitioners. Things with a coordinating role sometimes act as 'boundary objects' (Star and Griesemer, 1989), enabling groups to collaborate without consensus (Star, 2010). For example, drawings, prototypes, and process maps can help coordinate product development across organizational units (Carlile, 2002), while concept books, design documents, and milestone schedules can coordinate innovation processes (Scarbourgh et al., 2015).

Framing. Useful things with a framing role operate mainly within broader institutional and technological settings, shaping conditions and requirements for performing work. Things with a framing role include legal frameworks establishing rules, regulations, and requirements, which organizations like hospitals must adhere to, framing medical work in distinctive ways. Similarly, corporate policies, such as performance standards and incentive systems, are intentionally designed to shape work performance in specific ways. Furthermore, recent AI-

driven monitoring of workplace communications and productivity also shape and control work performance in significant ways (e.g., Kellogg, Valentine, and Christin, 2020; Vitak and Zimmer, 2023). This broad framing can promote an instrumental way of performing work, based upon a technological understanding of world.

Directing. Emergent useful things that have not-yet-become take on a directing role, orienting the performance of practitioners and other things in the nexus while work is underway (as also noted in activity theory, e.g., Vetoshkina et al., 2015). In our biotech study, the (emergent) herbicide resistant crop directs the performance of the team and useful things in the nexus. Similarly, an emergent building directs the performance of construction workers and of other things in constructing buildings. However, although the emergent thing directs, no-one may know in advance precisely what and how it will be. This is particularly the case for 'epistemic things' (Rheinberger, 1997) in knowledge-oriented practices, such as research, law, and accounting, but also to a large extent in craftwork (Bell and Vachhani, 2020).

Furthermore, our findings show things perform these roles either in the *foreground* or *background* in a nexus of useful things. In the foreground, things are engaged directly in accomplishing tasks, such as when an algorithm coordinates a process of trawling through data. In the background, things assist other things that are directly engaged in accomplishing tasks, such as electrical equipment that allows the computer to run in following an algorithm. Moreover, although their properties limit the roles useful things can perform, these roles are not fixed but can shift over time. For instance, while an emergent building may take on a directing role during construction, on completion it may provide a workplace for a business.

Things co-constitute work performance in concert with practitioners. While useful things are necessary when performing work, they are insufficient. Practitioners and things co-constitute work performance in two interrelated ways. First, things are constitutive of work performance through being *ready-to-hand* for practitioners (as shown through each connection between practitioners and roles of useful things in Figure 3). For Merleau-Ponty (1962, p.143), when things are ready to hand, we are 'transplanted into them, or conversely, incorporate them into the bulk of our own body'. In this way, practitioners and things 'continuously influence each other, co-constitute each other and coevolve' (Heersmink, 2012, p.126) in performing work. Consequently, variations in the co-constitution of practitioners and nexus of things can lead to differences in scope, quality, fluency, and overall effectiveness in performing work as evident in shooting performance in our study.

Second, things are constitutive of work performance through *a chain of purposes* within a practice, which configures practitioners and things into specific ways of performing work. For example, in the biotechnology practice explored in this study, enhancing crop yields and sustainability configures practitioners and the nexus of things into distinct ways of performing biotechnology. Similarly, the purpose of corporate law is to 'advise on legal risks so clients can achieve what they want to achieve' (Sandberg and Pinnington, 2009, p.1154), configuring corporate lawyers and their nexus of things into specific ways of performing corporate law. Hence, the nexus of useful things and practitioners not only co-constitute work performance, but also each other. Practitioners can only be teachers, chefs, or engineers in engaging with a nexus of useful things, just as things are only intelligible as useful in the context of performing work like teaching, cooking, or engineering (Dreyfus and Taylor, 2015, p.161).

Theoretical Contributions

Our account offers several new insights and conceptual advancements to the entanglement literature. It suggests things are constitutive of work performance in the following three interrelated ways: (a) useful things belonging to a nexus (b) take on interlinked roles, either in the foreground or background, (c) while performing in concert with practitioners, by being ready to hand within a chain of purposes for the practice. In this manner, a nexus of useful things in concert with practitioners perform the work. Taken together, we contend our study provides a more *integrative* and *comprehensive understanding* of how things are constitutive of work performance in organizations. Our study thereby enriches and advances the different bodies of research in the entanglement literature in several important ways, which we outline below.

While existing entanglement literature has identified some broad functions of things – such as mediating, affording and enabling or constraining work performance – our account further differentiates and elaborates seven key roles useful things take on in performing work: providing, modifying, extending, substituting, coordinating, framing, and directing. We argue roles of this kind are essential to performing work beyond biotechnology, holding broader relevance across various fields. For example, while architectural drawings of buildings and booking systems in health clinics differ significantly from each other, they perform the same role of *coordinating* practitioners and other useful things in performing the work in question. Similarly, sewing machines in clothing manufacturing and coffee grinders in coffee making perform the role of *modifying* properties of other useful things (i.e., fabric and coffee beans), while calculators in engineering and telescopes in astronomy perform the role of *extending* capacities to perform work. In other words, varied things across diverse fields typically assume similar key roles in performing work. Moreover, the findings indicate each useful thing may perform multiple roles during different phases of work performance. As such, our proposed account can serve as an analytical framework for empirically identifying and theorizing which key roles things play in performing work, how useful things transition between roles, and how key roles are interlinked in contributing to work performance.

Additionally, while the entanglement literature demonstrates things mediate and afford work performance, our account of key roles things play in performing work provides a more precise and differentiated explanation of *how* this mediation and affordance occurs. Our study underlines that things mediate and afford work performance in not only one, but multiple ways, by *providing* specific elements, *modifying* other things, *framing* the work, *extending* capacities, *substituting* for practitioners, *coordinating* and *directing* things and practitioners in specific ways.

Existing theories show work performance is mediated by things in that they shape the knowledge and skill of practitioners (e.g., Miettinen et al., 2009). Our account provides further clarity and precision on this mediation in the sense that the roles things play in performing work shape the knowledge and skills of practitioners in distinctly different ways. Similarly, while most theories of affordance highlight *what* things afford, they are less clear about *how* things afford work performance (e.g., Davis, 2020, pp. 6-11). Our account suggests affordances of things come into play through the roles they perform, such as *providing* necessary elements, *modifying* other things, and *directing* both other things and practitioners in performing work.

Furthermore, the entanglement literature commonly discusses the dependency of humans on things, highlighting humans cannot perform work without things. More particularly, things play a dual role in *enabling* and *constraining* work performance (e.g., Jarrahi and Nelson, 2018, Hodder, 2011). By identifying the specific roles things assume in performing work, we gain a more fine-grained understanding of their enabling and constraining features, as well as our dependency on things.

Moreover, as noted above, two common ways of conceptualizing things in practice theory – as material elements integral to performing practice and material arrangements in which practices occur – do not differentiate the various roles things play in performing practice (Shove, 2017). In particular, while Shove (2017) and Nicolini et al. (2012) offer broad categories of things in social practices (e.g., tertiary, secondary, and primary objects (Nicolini et al., 2012), our identification of seven roles things play in performing work provides a more differentiated and nuanced account. As a result, our account of the varied roles things take on in performing work advances practice theory in important ways.

In addition, through abductive analysis, we identified key roles that useful things play in performing work. Similar forms of these roles, such as extending, substituting, coordinating, and directing, are also present in disparate bodies of literature. For instance, in technology studies an 'extension theory' explores how things enhance human capacity in work performance (e.g., Heersmink, 2012). Another large and expanding body of literature investigates how advanced technologies, such as robots and AI, replace – or substitute for – human workers (e.g., Cascio and Montealegre, 2016). A coordinating role across work domains has been studied in relation to 'boundary objects' (e.g., Star and Griesemer, 1989; Caccamo, Pittino and Tell, 2023), while a directing role has been theorized in terms of 'epistemic things' that structure work performance (e.g., Rheinberger, 1997; Werle and Seidl, 2015). Thus, our account brings together these bodies of literature in a cohesive way. Simultaneously, these previously disparate bodies of literature provide additional evidence for the key roles things play in performing work that we identified in our study.

Taken together, the insights from our theoretical and empirical account offer a more integrative and comprehensive understanding of how things are constitutive of work performance in organizations. Additionally, we provide a framework and specific vocabulary for identifying and theorizing how things are constitutive of work performance. Given virtually all professional practices (such as engineering, policing, teaching), and organizational and managerial practices (like strategy, human resource management, risk management, marketing) involve useful things, it is highly likely this framework has broad application. However, due to the multitude of things involved, and their complex and ever-changing relationships, we do not claim our proposed account encompasses all possible roles things can play, nor that it is the only way to differentiate and conceptualize these roles. As Locke and Golden-Biddle (1997) emphasized, categorizing the world is always a construction and, therefore, open to interpretation. Nevertheless, given the ambiguity and uncertainty surrounding how things are constitutive of work performance, especially the roles they play, we consider our account represents a significant advancement in understanding.

Implications for Performing Work

Our account not only provides researchers and practitioners with a more integrative and comprehensive understanding of how things are constitutive of work performance but also paves the way for several new avenues of research in organization and management studies, particularly in work design, work performance development, and the creation of new tools and technologies.

Work design. Our account opens new possibilities for designing quality work. This is of particular importance when increasingly agentic technologies – such as artificial intelligence, automation, robotics, and digitalization, more broadly – are reshaping how, where, when, and, indeed, who or what performs work (Santana and Cobo, 2020). Specifically, our account suggests that in designing work, it is important to treat things and practitioners as one performing unit and to unpack the (shifting) roles things play with practitioners in performing the work in question. At the same time, caution is needed to avoid promoting an instrumental way of relating and potential negative impacts through such a single performing unit.

Moreover, designing quality work means going beyond noting that things mediate and afford work performance to clarifying in a more granular way *how* this happens, that is, through modifying, coordinating, extending, substituting, framing and so forth. For example, a novel AI technology might *substitute* for routine tasks by automating them; or augment a practitioner's cognitive capacity by *extending* their ability to rapidly analyse/process data sets and inform their decision-making; or enable better *coordination* of tasks and communications with geographically- and temporally-distant team members.

Clarifying how things mediate or afford work performance in particular settings would enable sharpened appreciation of implications of the roles things take on for practitioners' experience of autonomy, meaning, and motivation in their work (Parker and Grote, 2022). For example, how do the different roles things play affect employees' autonomy, control, skill variety, and decision-making? What are the impacts of things that frame work, including upon practitioners' skill development and wellbeing? Do things that modify work have a different impact on autonomy than things that substitute for work? Our account also draws attention to how an overall *chain of purposes,* that is, the teleological structure, for specific work can better sensitise work designers to ethical dimensions and professional responsibilities inherent in designing/configuring how practitioners and novel work technologies come together in performing work.

Developing work performance. Our account calls into question much contemporary research and practice on training and development of work performance in organizations, which focuses primarily on enhancing knowledge and skills of individuals and collectives (Martin et al., (2014). In contrast, our account suggests organizations need to place the performance of both humans and things at the centre of their training and development strategies. More particularly, we provide a framework and vocabulary for developing work performance by sensitizing researchers, practitioners, instructors, and organizations to: the different roles things play in performing work; how useful things in a nexus relate to each other over time; and how the specific purposes of a practice configure the nexus of things and practitioners in performing work.

Our account thereby enables organizations to better equip individuals and collectives for skilfully performing work, by understanding the nexus of useful things and the interlinked

(and changing) roles that useful things perform within this nexus. Such understanding can help pinpoint areas of strength, sources of difficulty, and improvements needed in performing work. In doing so, it can throw light on the training and ongoing support needed by practitioners, as they negotiate changes in work design toward developing work performance.

Furthermore, our account makes it possible to investigate more closely how new tools and technologies perform, enabling researchers and practitioners to better understand the impacts upon developing work performance. For example, our account enables researchers and practitioners to articulate the 'ripple effects' of the introduction of new tools and technologies in a specific area of work, such as changing roles of useful things and practitioners, and what is gained or lost in doing so. This is particularly relevant for many digital tools, like computers and software, which possess generative capacities that can often perform tasks beyond those envisioned by their originators (Avital and Te'eni, 2009; Karanasios et al., 2021).

Creating and designing new tools and technologies. In addition, our account can be used as a framework for sharpening the development of new tools and technologies in a work domain. For example, by understanding the roles things perform, designers and manufacturers can develop tools and technologies more precisely suited to the role(s) they are expected to perform within the work in question, while attending to the impacts of these new designs on practitioners. Moreover, and related, understanding the various roles that tools and technologies play in performing work enables a closer examination of the political and ethical dimensions of technological development. This includes analysing how the interests of different groups – such as engineers, designers, and manufacturers – can shape the design and integration of new technologies in work processes. For instance, investigating the framing role could uncover how biases in AI-based algorithms not only reflect the politics of designers, engineers, and companies but also influence and perpetuate societal prejudices and inequalities (Anthony et al., 2023, p. 1681).

Limitations and Further Research

Although our account of how things are constitutive of work performance can be expected to have broad relevance, additional studies in areas outside of biotechnology are necessary to further develop and refine it. For example, to what extent do the main assertions hold in areas other than biotechnology? We identified seven key roles that useful things play in work performance. Are these roles exhaustive or are there more roles in other contexts? Similarly, are these roles present in all types of work performance, or do the roles vary depending on the type of work (e.g., programming versus cooking)? Further research is also needed on how useful things take on different roles in a nexus of things in performing work overtime.

Although we indirectly acknowledged some negative aspects—such as forms of callus less conducive to shooting success, plant lines unsuitable for de-regulation and commercialisation, potential GM 'escapes' into the environment, and emergence of waste products—we primarily featured positive aspects of things in work performance. In particular, we explored how things and roles they assume enable work to be accomplished. However, more attention to the negative aspects, such as how things and their roles can constrain and limit work performance (e.g., Hodder, 2012), warrants further research.

Furthermore, while agency was not the focus of our analysis, our account of things at work provides new avenues for exploring the agency of both things and practitioners in

performing work. For instance, how do the roles things play in performing work (e.g., providing, coordinating, extending, framing) relate to agency? Do these various roles shape the 'negotiation of control between human and machine agents' (Gibbs et al., 2021)? In addition, given the increased degree of algorithmic agency in organizations (e.g., Laapotti and Raappana, 2022) together with the ongoing technologization of the world (e.g., Beyes et al. 2022), a more fundamental question is the extent to which (human) agency becomes technologized, that is, transformed into a mere instrument to achieve (together with things) specific commercial ends.

While we envisage that our account can inform understanding of how things are constitutive of work performance at different levels, such as group and firm performance, further studies are needed in these areas. For example, to what extent could our account assist in identifying and theorizing how things are constitutive of firm performance, such as in a resource-based view of the firm (e.g., Barney et al., 2011), in which performance is typically conceptualized as a combination of things, like equipment, tools, technologies, and human attributes? This appears to be of particular importance when it comes to gaining a deeper understanding of how AI-driven organizational capabilities can establish a 'new foundation for competitive advantage' (Kemp, 2023, p. 2).

Above, we acknowledged the multi-layered setting of biotechnology work in which our research study took place. Future research could explore impacts of this broader setting upon how things are constitutive of work performance, at varying levels of complexity and abstraction. As Heidegger (1977) noted and further elaborated by the emergent technology-centred literature (e.g., Beyes et al. 2022), the instrumental and technological organization of society has become prevalent, exerting a significant impact on practices in numerous industries, including biotechnology. Further investigation is needed into articulating the ways in which this approach shapes how things and practitioners work together in scientific and other organizational and management practices.

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