Understanding and shaping the future of work with self-determination theory

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Abstract | Self-determination theory has shaped our understanding of what optimizes worker motivation by providing insights into how work context influences basic psychological needs for competence, autonomy and relatedness. As technological innovations change the nature of work, self-determination theory can provide insight into how the resulting uncertainty and interdependence might influence worker motivation, performance and well-being. In this Review, we summarize what self-determination theory has brought to the domain of work and how it is helping researchers and practitioners to shape the future of work. We consider how the experiences of job candidates are influenced by the new technologies used to assess and select them, and how self-determination theory can help to improve candidate attitudes and performance during selection assessments. We also discuss how technology transforms the design of work and its impact on worker motivation. We then describe three cases where technology is affecting work design and examine how this might influence needs satisfaction and motivation: remote work, virtual teamwork and algorithmic management. An understanding of how future work is likely to influence the satisfaction of the psychological needs of workers and how future work can be designed to satisfy such needs is of the utmost importance to worker performance and well-being.

The nature of work is changing as technology enables new forms of automation and communication across many industries. Although the image of human-like robots replacing human jobs is vivid, it does not reflect the typical ways people will engage with automation and how technology will change job requirements in the future. A more relevant picture is one in which people interact over dispersed networks using continuously improving communication platforms mediated by artificial intelligence (AI). Examples include the acceleration of remote working arrangements caused by the COVID-19 pandemic and the increased use of remote control operations across many industries including mining, manufacturing, transport, education and health.

Historically, automation has replaced more routine physically demanding, dangerous or repetitive work in industries such as manufacturing, with little impact on professional and managerial occupations[1]. However, since the mid-2010s, automation has replaced many repetitive error-prone administrative tasks such as processing legal documents, directing service queries and employee selection screening[2,3]. Thus, work requirements for employees are increasingly encompassing tasks that cannot be readily automated, such as interpersonal negotiations and service innovations[4]: in other words, work that cannot be easily achieved through algorithms.

The role of motivation is often overlooked when designing and implementing technology in the workplace, even though technological changes can have a major impact on people's motivation. Self-determination theory offers a useful multidimensional conceptualization of motivation that can help predict these impacts. According to self-determination theory[5,6], three psychological needs must be fulfilled to adequately motivate workers and ensure that they perform optimally and experience well-being. Specifically, people need to feel that they are effective and masters of their environment (need for competence), that they are agents of their own behaviour as opposed to a 'pawn' of external pressures (need for autonomy), and that they experience meaningful connections with other people (need for relatedness)[5,7]. Meta-analytic evidence shows that satisfying these three needs is associated with better performance, reduced burnout, more organizational commitment and reduced turnover intentions[8].

Self-determination theory also distinguishes between different types of motivation that workers might experience: intrinsic motivation (doing something for its own sake, out of interest and enjoyment), extrinsic motivation (doing something for an instrumental reason)

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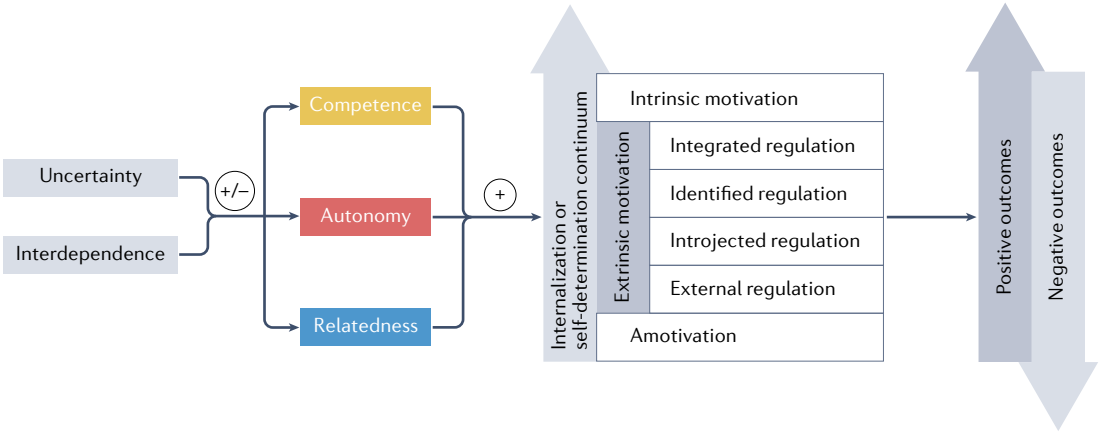

Fig. 1 | **Self-determination theory.** According to self-determination theory, satisfaction of three psychological needs (competence, autonomy and relatedness) influences work motivation, which influences outcomes. More intrinsic and internalized motivations are associated with more positive outcomes than extrinsic and less internalized motivations. These needs and motivations might be influenced by the increased uncertainty and interdependence that characterize the future of work.

and amotivation (lacking any reason to engage in an activity). Extrinsic motivation is subdivided according to the degree to which external influences are internalized (absorbed and transformed into internal tools to regulate activity engagement)[5,9]. According to meta-analytic evidence, more self-determined (that is, intrinsic or more internalized) motivation is more positively associated with key attitudinal and performance outcomes, such as job satisfaction, organizational commitment, job performance and proactivity than more controlled motivation (that is, extrinsic or less internalized)[10]. Consequently, researchers advocate the development and promotion of self-determined motivation across various life domains, including work[11]. Satisfaction of the three psychological needs described above is significantly related to more self-determined motivation[8].

Given the impact of the needs proposed in self-determination theory on work motivation and consequently work outcomes (FIG. 1), it is important to find ways to satisfy these needs and avoid undermining them in the workplace. Organizational research has consequently focused on managerial and leadership behaviours that support or thwart these needs and promote different types of work motivation[12–23] (FIG. 2). There is also substantial research on the effects of work design (the nature and organization of people's work tasks within a job or role, such as who makes what decisions, the extent to which people's tasks are varied, or whether people work alone or in a team structure) and compensation systems on need satisfaction and work motivation[24–37], and how individuals can seek to meet their needs and enhance their motivation through proactive efforts to craft their jobs[38–40].

Importantly, the work tasks that people are more likely to do in future work will require high-level cognitive and emotional skills that are more likely to be developed, used, and sustained when underpinned by self-determined motivation[40–50]. Therefore, if individuals are to be effective in future work, it is important to understand how future work might meet — or fail to meet — the psychological needs proposed by self-determination theory.

In this Review, we outline how work is changing and explain the consequences of these changes for satisfying workers' psychological needs. We then focus on two areas where technology is already changing the worker experience: when workers apply for jobs and go through selection processes; and when the design of their work — what work they do, as well as how, when and where they do it — is transformed by technology. In particular, we focus on three domains where technology is already changing work design: remote work, virtual teams and algorithmic management. We conclude by discussing the importance of satisfying the psychological needs of workers when designing and implementing technologies in the workplace.

Future work requirements

The future workplace might evolve into one where psychological needs are better fulfilled, or one where they are neglected. In addition, there is growing concern that future work will meet the needs of people with adequate access to technology and the skills to use it, but will further diminish fulfillment for neglected and disadvantaged groups[51] (BOX 1). To understand how future work might align with human needs, it is necessary to map key work features to core constructs of self-determination theory. Future work might be characterized by environmental uncertainty interdependence, complexity, volatility and ambiguity[52]. Here we focus on uncertainty and interdependence because these features capture core concerns about the future and its implication for connections among people in the changing context of work[53]. Higher levels of uncertainty require more adaptive behaviours, whereas higher levels of interdependence require more social, team-oriented and network-oriented behaviours[54].

We first consider the increasing role of uncertainty in the workplace. Rapid changes in technology and global supply chains mean that the environment is more unpredictable and that there is increasing uncertainty about what activities are needed to be successful. Reducing uncertainty is central to most theories of human

adaptation[55] and is a strong motivational basis for goals and behaviour[56]. If uncertainty becomes a defining and pervasive feature of organizational life, organizational leaders should think beyond reducing uncertainty and instead leverage and even create it[55]. In other words, in a highly dynamic context, it might be more functional and adaptive for employees and organizational leaders to consider more explorative approaches to coping with uncertainty, such as experimentation and improvization. All of these considerations imply that future effective work will require adaptive behaviours such as modifying the way work is done, and proactive behaviours such as innovating and creating new ways of working[54].

Under higher levels of uncertainty, specific actions are difficult to define in advance. In contrast to action sequences that can be codified (for example, with algorithms) and repeated in predictable environments, the best action sequence is likely to involve flexibility and experimentation when the workplace is more uncertain. In this context, individuals must be motivated to explore new ideas, adjust their behaviour and engage with ongoing change. In stable and predictable environments, less self-determined forms of motivation might be sufficient to maintain the enactment of repetitive tasks and automation is more feasible as a replacement or support. However, under conditions of uncertainty, individuals will benefit from showing cognitive flexibility, creativity and proactivity, all behaviours that are more likely to emerge when people have self-determined motivation[40,41,44,46–49,57].

Adaptive (coping with and responding to change) and proactive (initiating change) performance can be promoted by satisfying the needs for competence, autonomy and relatedness, and self-determined motivation[4,58]. For example, when individuals experience internalized motivation, they have a 'reason to' engage in the sometimes psychologically risky behaviour of proactivity[40]. Both adaptivity and proactivity depend on individuals having sufficient autonomy to work differently, try new ideas and negotiate multiple pathways to success. Hence, successful organizational functioning depends on people who can act autonomously to regulate their

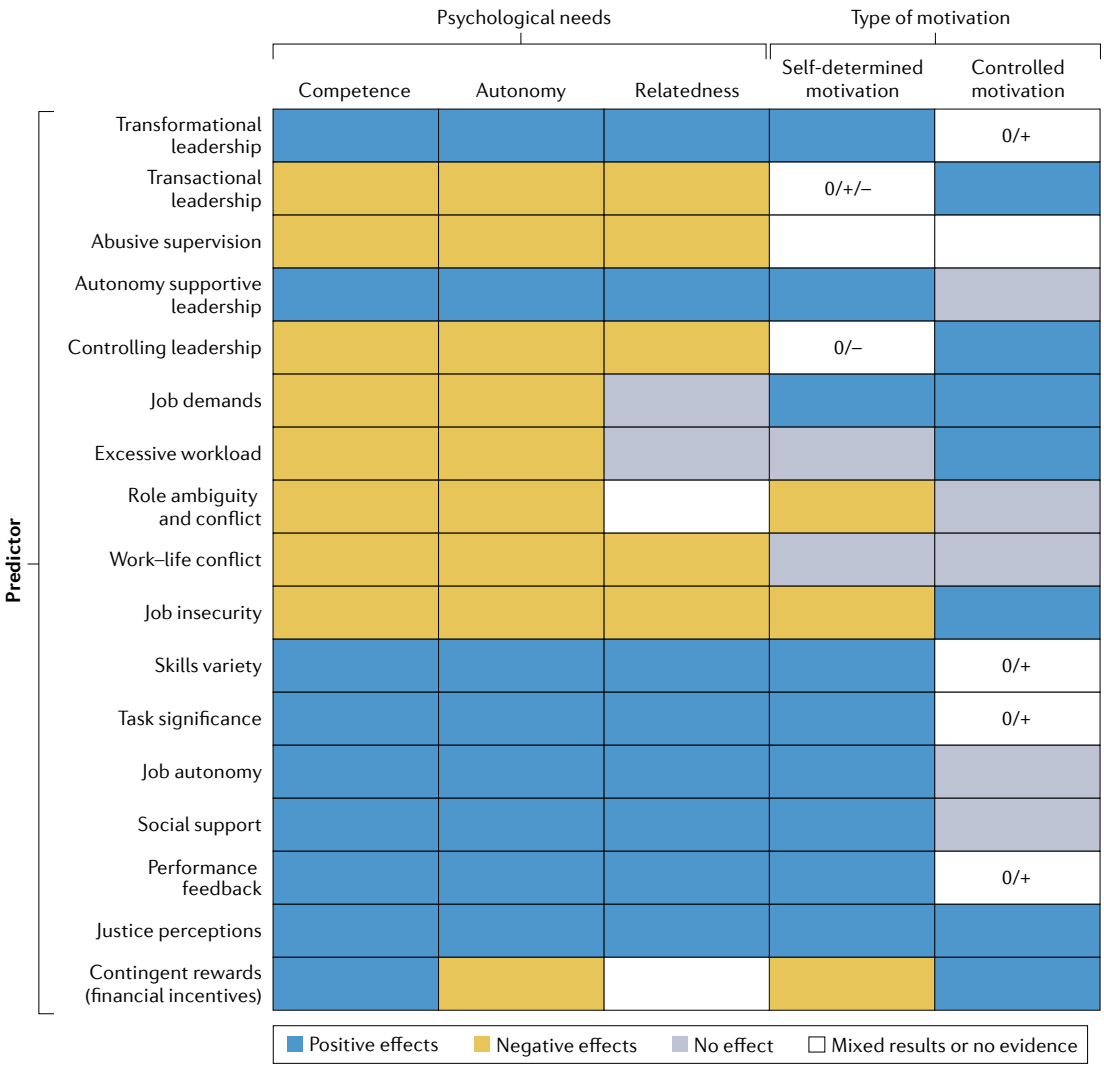

Fig. 2 | **Predictors of need satisfaction and work motivation.** Summary of research findings[5–30] and available meta-analyses[8,10]. In cases where the evidence is mixed, a negative sign indicates a negative correlation, a positive sign indicates a positive correlation, and a zero indicates no statistically significant correlation.

Box 1 | **Inequalities caused by future work**

Future work is likely to exacerbate inequalities. First, the digital divide (unequal access to, and ability to use, information communication technologies)[51] is likely to be exacerbated by technological advances that might become more costly and require more specialized skills. Moreover, the COVID-19 pandemic exacerbated work inequalities by providing better opportunities to those with digital access and skills[210,211]. The digital divide now also includes 'algorithm awareness' (knowing what algorithms do) which influences whether and how people are influenced by technology. Indeed, the degree to which algorithms influence attitudes and behaviours is negatively associated with the degree to which people are aware of algorithms and understand how they work[212].

Second, future work is likely to require new technical and communication skills, as well as adaptive and proactive skills. Thus, people with such skills are more likely to find work than those who do not or who have fewer opportunities (for example, education access) to develop them. Even gig work requires that workers have access to relevant platforms and adequate skills for using them. These future work issues are therefore likely to increase gaps between skilled and non-skilled segments of the population, and consequently to increase societal pay disparities and poverty.

For example, workforce inequalities between mature and younger workers are likely to increase owing to real or perceived differences in technology-related skills, with increased disparities in the type of jobs these workers engage in[210,213]. Older workers might miss out on opportunities to upskill or might choose to leave the workforce early rather than face reskilling. This could decrease workforce diversity and strengthen negative stereotypes about mature workers (such as that they are not flexible, adaptable or motivated to keep up with changing times)[214]. Furthermore, inequalities in terms of pay have already been observed between men and women[215]. Increased robotization increases the gender pay gap[216], and this gap is likely to be exacerbated as remote working becomes more common (as was shown during the pandemic)[217]. For example, one study found that salaries did not increase as much for women working flexibly compared to men[218]; another study found that home workers tended to be employees with young children and these workers were 50% less likely to be promoted than those based in the office[140].

To promote equality in future work and ensure that psychological needs are met, managers will need to adopt 'meta-strategies' to promote inclusivity (ensuring that all employees feel included in the workplace and are treated fairly, regardless of whether they are working remotely or not), individualization of work (ensuring that work is tailored to individual needs and desires) and employee integration (promoting interaction between employees of all ages, nationalities and backgrounds)[213].

behaviour in response to a more unpredictable and changing environment[31,54,59].

The second feature of the evolving workplace is an increasing level of interdependence among people, systems and technology. People will connect with each other in more numerous and complex ways as communication technologies become more reliable, deeply networked and faster. For example, medical teams from disparate locations might collaborate more easily in real time to support remote surgical procedures. They will also connect with automated entities such as cobots (robots that interact with humans) and decision-making aids supported by constantly updating algorithms. For example, algorithms might provide medical teams with predictive information about patient progress based on streaming data such as heart rate. As algorithms evolve in complexity and predictive accuracy, they will modify the work context and humans will need to adapt to work with the new information created[60].

This interconnected and evolving future workplace requires individuals who can interact effectively across complex networks. The nature of different communication technologies can both increase and decrease feelings of relatedness depending on the extent to which they promote meaningful interactions. Typically, work technologies are developed to facilitate productivity and efficiency. However, given that human performance is also influenced by feelings of relatedness[8], it is important to ensure that communication technologies and the way networks of people are managed by these technologies can fulfill this need.

The rapid growth of networks enabled by communication technologies (for example, Microsoft Teams, Slack and Webex) has produced positive and negative effects on performance and well-being. For example, these technologies can be a buffer against loneliness for remote workers or homeworkers[61] and enable stronger connections among distributed workers[62]. However, networking platforms lead some individuals to experience more isolation rather than more connectedness[63]. Workplace networks might also engender these contrasting effects by, for example, building a stronger understanding between individuals in a work group who do not usually get to interact or by limiting contact to more superficial communication that prevents individuals from building stronger relationships.

Both uncertainty and interdependence will challenge people's feelings of competence. Uncertainty can lead to reduced access to predictable resources and less certainty about the success of work effort; the proliferation of networks and media can lead to feeling overwhelmed and to difficulties in managing communication and relationships. Moreover, technologies and automation can lead to the loss of human competencies as people stop using these skills[64–67]. For example, automating tasks that require humans to have basic financial skills diminishes opportunities for humans to develop expertise in financial skills.

Uncertainty and interdependence are likely to persist and increase in the future. This has implications for whether and how psychological needs will be satisfied or frustrated. In addition, because uncertainty and interdependence require people to behave in more adaptive and proactive ways, it is important to create future work that satisfies psychological needs.

The future of employee selection

Changing economies are increasing demand for highly skilled labour, meaning that employers are forced to compete heavily for talent[68]. Meanwhile, technological developments, largely delivered online, have radically increased the reach, scalability and variety of selection methods available to employers[69]. Technology-based assessments also afford candidates the autonomy to interact with prospective employers at times and locations of their choosing[70,71]. Furthermore, video-based, virtual, gamified and AI-based assessment technologies[3,72–74] have improved the fidelity and immersion of the selection process. The fidelity of a selection assessment represents the extent to which it can reproduce the physical and psychological aspects of the work situation that the assessment is intended to simulate[75]. Virtual environments and video-based assessments can better reproduce working environments than traditional 'paper and pencil' assessments, and AI is being used to simulate social interactions in work or similar contexts[74]. Immersion represents how engrossing or absorbing an assessment experience is. Immersion is enhanced by

richer media and gamified assessment elements[75,76]. These benefits have driven the widespread adoption of technology in recruitment practices[77], but they have also attracted criticism. For example, the use of AI to analyse candidate data (such as CVs, social media profiles, text-based responses to interview questions, and videos)[78] raises concerns about the relevance of data being collected for selecting employees, transparency in how the data are used, and biases in selection based on these data[79].

Candidates with a poor understanding of what data are being collected and how they are being used might experience a technology-based selection process as autonomy-thwarting. For example, the perceived job-relatedness of an assessment is associated with whether or not candidates view the assessment positively[69,80]. However, with today's technology, assessments that appear typical or basic (such as a test or short recorded interview response) might also involve the collection of additional 'trace' data such as mouse movements and clicks (in the case of tests), or ancillary information such as 'micro-expressions' or candidates' video backdrops[81]. We expect that it would be difficult for candidates to evaluate the job-relatedness of this information, unless provided with a rationale. Candidates may also feel increasing pressure to submit to employers' requests to share personal information, such as social media profiles, which may further frustrate autonomy to the extent that candidates are reluctant to share this information[82].

Furthermore, if candidates do not understand how technology-driven assessments work and are not able to receive feedback from assessment systems, their need for competence may be thwarted[83]. For example, initial research shows that people perceive fewer opportunities to demonstrate their strengths and capabilities in interviews they know will be evaluated by AI, compared to those evaluated by humans[83].

Finally, because candidates are increasingly interacting with systems, rather than people, their opportunities to build relatedness with employers might be stifled. A notable exemplar is the use of asynchronous video interviews[70,71], a type of video-based assessment where candidates log into an online system, are presented with a series of questions, and are asked to video-record their responses. Unlike a traditional or videoconference interview, candidates completing an asynchronous video interview do not interact directly with anyone from the employer organization, and they consequently often describe the experience as impersonal[84]. Absent any interventions, the use of asynchronous video interviews removes the opportunity for candidates to meet the employer and get a feel for what it might be like to work for the employer, or to ask questions of their own[84].

Because technologies have changed rapidly, research on candidates' reactions to these new selection methods has not kept up[69]. Nonetheless, to the extent that test-related and technology-related anxiety influences motivation and performance when completing an online assessment or a video interview, the performance of applicants might be adversely affected[85]. Furthermore, candidate experience can influence decisions to accept a job offer and how positively the candidate will talk about the organization to other potential candidates and even clients, thereby influencing brand reputation[86]. Thus, technology developments offer clear opportunities to improve the satisfaction of candidates' needs and to assess them in richer environments that more closely resemble work settings. However, there are risks that technology that is needs-thwarting or is implemented in a needs-thwarting manner, will add to the uncertainty already inherent in competitive job applications. In the context of a globally competitive skills market, employers risk losing high-quality candidates.

The future of work design

Discussion in the popular press about the impact of AI and other forms of digitalization focuses on eradicating large numbers of jobs and mass unemployment. However, the reality is that tasks within jobs are being influenced by digitalization rather than whole jobs being replaced[87]. Most occupations in most industries have at least some tasks that could be replaced by AI, yet currently there is no occupation in which all tasks could be replaced[88]. The consequence of this observation is that people will need to increasingly interact with machines as part of their jobs. This raises work design questions, such as how people and machines should share tasks, and the consequences of different choices in this respect.

Work design theory is intimately connected to self-determination theory, with early scholars arguing that work arrangements should create jobs in which employees can satisfy their core psychological needs[89]. Core aspects of work design, including decision-making power, the opportunity to use skills and do a variety of tasks, the ability to ascertain the impact of one's work, performance feedback[90], social contact, time pressure, emotional demands and role conflict[91] are important predictors of job satisfaction, job performance[92] and work motivation[93]. Some evidence suggests that these motivating characteristics (considered 'job resources' according to the jobs demands–resources model)[94] are especially important for fostering motivation or reducing strain when job demands (aspects of a job that require sustained physical, emotional or mental effort) are high[93,95]. For example, autonomy and social support can reduce the effect of workload on negative outcomes such as exhaustion[96].

Technology can potentially influence work design and therefore employee motivation in positive ways[1]. Increasing workers' task variety and opportunities for more complex problem-solving should occur whenever technology takes over tasks (such as assembly line or mining work). Leaving the less routine and more interesting tasks for people to do[97] increases the opportunity for workers to fulfill their need for competence. For example, within manufacturing, complex production systems in which cyber-machines are connected in a factory-wide information network require strategic human decision-makers operating in complex, varied and high-level autonomy jobs[98]. Technology (such as social media) can also enhance social contact and support in some jobs and under some circumstances[86,87]

(but see REF.[63]), increasing opportunities for meeting relatedness needs.

However, new technologies can also undermine the design of motivating work, and thus reduce workers' need satisfaction[1]. For example, in the aviation industry, manual flying skills can become degraded due to a lack of opportunity to practice when aircraft are highly automated[99], decreasing the opportunity for pilots to meet their need for competence. As another example, technology has enabled the introduction of 'microwork' in which jobs are broken down into small tasks that are then carried out via information communication technologies[100]. Such jobs often lack variety, skill use and meaning[101], again reducing the opportunity for the work to meet competence needs. In an analysis of robots in surgery, technology designed purely for 'efficiency' reduced the opportunities for trainee surgeons to engage in challenging tasks and resulted in impaired skill development[102], and therefore probably reduced competence need satisfaction. Thus, poor work design might negatively influence work motivation through poor need satisfaction, especially the need for competence, owing to the lack of opportunity to maintain one's skills or gain new ones[2].

As the above examples show, the impact of new technologies on work design, and hence on need satisfaction, is powerful — but also mixed. That is, digital technologies can increase or decrease motivational work characteristics and can thereby influence need satisfaction (FIG. 3). The research shows that there is no deterministic relationship between technology and work design; instead, the effect of new technology on work design, and hence on motivation, depends on various moderating factors[1]. These moderating factors include individual aspects, such as the level of skill an individual has or the individual's personality. Highly skilled individuals or those with proactive personalities might actively shape the technology and/or craft their work design to better meet their needs and increase their motivation[1]. For example, tech-savvy Uber drivers subject to algorithmic management sometimes resist or game the system, such as by cancelling rides to avoid negative ratings from passengers[103].

More generally, individuals proactively seek a better fit with their job through behaviours such as idiosyncratic deals (non-standard work arrangements negotiated between an employee and an employer) and job crafting (changing one's work design to align one's job with personal needs, goals and skills)[39,40] (BOX 2).

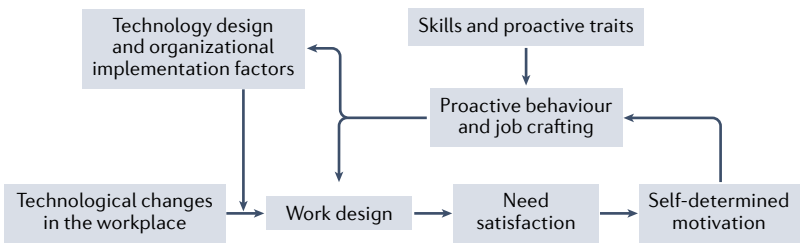

Fig. 3 | **Effects of technology on work design and work motivation.** The causal relationships among the possible (but not exhaustive) variables implicated in the influence of technology on work design and work motivation discussed in this Review.

Consequently, although there is relatively little research on proactivity in work redesign through technology, it is important to recognize that individuals will not necessarily be passive in the face of negative technologies. Just as time pressure can stimulate proactivity[104], we should expect that technology that creates poor work design will motivate job crafting and other proactive behaviours from workers seeking to meet their psychological needs better[105]. This perspective fits with a broader approach to technology that emphasizes human agency[106].

Importantly, mitigating and managing the impact of technology on work is not the sole responsibility of individuals. Organizational implementation factors (for example, whether technology is selected, designed and implemented in a participatory way or how much training is given to support the introduction of technology) and technological design factors (for example, how much worker control is built into automated systems) are also fundamental in shaping the effect of technology on work design. Understanding these moderating factors is important because they provide potential 'levers' for creating more motivating work while still capitalizing on the advantages of technologies. For example, in one case study[107], several new digital technologies such as cobots and digital paper flow (systems that integrate and automate different organizational functions, such as sales and purchasing with accounting, inventory control and dispatch) were implemented following a strong technocentric approach (that is, highly focused on engineering solutions) with little worker participation, and with limited attention to creating motivating work design. A more human-centred approach could have prevented the considerable negative outcomes that followed (including friction, reduced morale, loss of motivation, errors and impaired performance)[107]. Ultimately, how technology is designed and implemented should be proactively adapted to better meet human competencies, needs and values.

Applications

In what follows, we describe three specific cases where technology is already influencing work design (virtual and remote work, virtual teamwork, and algorithmic management), and consider the potential consequences for worker need satisfaction and motivation.

Virtual and remote work. Technologies have significantly altered when and where people can work, with the Covid-19 pandemic vastly accelerating the extent of working from home (BOX 3). Remote work has persisted beyond the early stages of the Covid-19 pandemic with hybrid working — where people work from home some days a week and at the workplace on other days — becoming commonplace[108]. The development of information communication technologies (such as Microsoft Teams) has enabled workers to easily connect with colleagues, clients and patients remotely[105], for example, via online patient 'telehealth' consultations, webinars and discussion forums. Technology has even enabled the remote control of other technologies, such as manufacturing machinery, vehicles and remote systems that monitor hospital ward patient vital signs

Box 2 | **The future of careers**

Employment stability started to decline during the 1980s with the rise of public ownership and international trade, the increased use of performance-based incentives and contracts, and the introduction of new technologies. Employment stability is expected to continue to decline with the growth of gig work and continued technological developments[219,220]. Indeed, people will more frequently be asked to change career paths as work is transformed by technology, to use and 'sell' their transferrable skills in creative ways, and to reskill. The rise of more precarious work and new employment relationships (for example, in gig work) adds to these career challenges[221]. The current generation of workers is likely to experience career shocks (disruptive events that trigger a sensemaking process regarding one's career) caused by rapid technological changes, and indeed many workers have already experienced career shocks from the pandemic[222]. Moreover, rapid technological change and increasing uncertainty pushes organizations to hire for skill sets rather than fitting people into set jobs, requiring people to be aware of their skills and to know how to market them.

In short, the careers of the current and future workforce will be non-linear and will require people to be more adaptive and proactive in crafting their career. For this reason, the concept of a protean career, whereby people have an adaptive and self-directed career, is likely to be increasingly important[223]. A protean career is a career that is guided by a search for self-fulfillment and is characterized by frequent learning cycles that push an individual into constant transformation; a successful protean career therefore requires a combination of adaptivity skills and identity awareness[224,225]. Adaptivity allows people to forge their career by using, or even creating, emerging opportunities. Having a solid sense of self helps individuals to make choices according to personal strengths and values. However, a protean career orientation might fit only a small segment of the labour market. Change-averse individuals might regard protean careers as career-destructive and the identity changes associated with a protean career might be regarded as stressful. In addition, overly frequent transitions might limit deep learning opportunities and achievements, and disrupt important support networks[221].

Nonetheless, career-related adaptive and proactive behaviours can be encouraged by satisfying psychological needs. In fact, protean careers tend to flourish in environments that provide autonomy and allow for proactivity, with support for competence and learning[223,226]. Moreover, people have greater self-awareness when they feel autonomous. Indeed, self-awareness is a component of authenticity and mindfulness, both of which are linked to the satisfaction of the need for autonomy[227,228]. Thus, supporting psychological needs during training, development and career transitions is likely to assist people in crafting successful careers.

through AI[1]. However, even when people are working on work premises (that is, not working remotely), an increasing amount of work in many jobs is done virtually (for example, online training or communicating with a colleague next door via email).

Working virtually is inherently tied to changes in uncertainty and interdependence. Virtual work engenders uncertainty because workplace and interpersonal cues are less available or reliable in providing virtual employees with role clarity and ensuring smooth interactions. Indeed, 'screen' interactions are more stressful and effortful than face-to-face interactions. It is more difficult to decipher and synchronize non-verbal behaviour on a screen than face-to-face, particularly given the lack of body language cues due to camera frame limitations, increasing the cognitive load for meeting attendees[109–112]. Non-verbal synchrony can be affected by the video streaming speed, which also increases cognitive load[109–112]. Virtual interactions involve 'hyper gaze' from seeing grids of staring faces, which the brain interprets as a threat[109–112]. Seeing oneself on screen increases self-consciousness during social interactions, which can cause anxiety, especially in women and those from minoritized groups[109–112]. Finally, reduced mobility from having to stay in the camera frame has been shown to reduce individual performance relative to face-to-face meetings[109–112]. Research on virtual interactions is still in its infancy. In one study, workers were randomly assigned to have their camera either on or off during their daily virtual meetings for a week. Those with the camera on during meetings experienced more daily fatigue and less daily work engagement than those with the camera off[113].

Lower-quality virtual communication between managers and colleagues can leave individuals unclear about their goals and priorities, and how they should achieve them[114]. This calls for more self-regulation[115] because employees must structure their daily work activities and remind themselves of their work priorities and goals, without relying on the physical presence of colleagues or managers. If virtual workers must coordinate some of their work tasks with colleagues, it can be difficult to synchronize and coordinate actions, working schedules and breaks, motivate each other, and assist each other with timely information exchange[115]. This can make it harder for employees to acquire and share information[53].

Virtual work also affects work design and changes how psychological needs can be satisfied and frustrated (TABLE 1), which has implications for both managers and employees. Physical workplace cues that usually guide work behaviours and routines in the office do not exist in virtual work, consequently demanding more autonomous regulation of work behaviours[116,117]. Some remote workers experience an increased sense of control and autonomy over their work environment[118–120] under these circumstances, resulting in lower family–work conflict, depression and turnover[121,122]. However, managers and organizations might rob workers of this autonomy by closely monitoring them, for example by checking their computer or phone usage[123]. This type of close monitoring reflects a lack of manager trust in individuals' abilities or intentions to work effectively remotely. This lack of trust leads to decreased feelings of autonomy[124], increased employee home–work conflict[105] and distress[125,126]. Surveillance has been shown to decrease self-determined motivation[127]. It is therefore important to train managers in managing remote workers in an autonomy-supportive way to avoid these negative consequences[128]. The negative effects of monitoring can also be reduced if monitoring is used constructively to help employees develop through feedback[129–133], and when employees participate in the design and control of the monitoring systems[134,135].

Information communication technology might satisfy competence needs by increasing access to global information and communication and the ability to analyse data[136]. For example, online courses, training and webinars can improve workers' knowledge, skills and abilities, and can therefore help workers to carry out their work tasks more proficiently, which increases self-efficacy and a sense of competence. Furthermore, the internet allows people to connect rapidly and asynchronously with experts around the world, who may be able to provide information needed to solve a work problem that local colleagues cannot help with[136]. This type of remote work is increasingly occurring whether or not individuals themselves are based remotely, and can potentially enhance performance.

Box 3 | **The 'great resignation'**

'The great resignation' refers to the massive wave of employee departures during the COVID-19 pandemic in several parts of the world, including North America, Europe and China[229,230], that can be attributed in part to career shocks caused by the pandemic[222]. In the healthcare profession, the shock consisted of an exponential increase in workload and the resulting exhaustion, coupled with the disorganization caused by lack of resources and compounded by health fears[231]. In other industries, the pandemic caused work disruptions by forcing or allowing people to work from home, furloughing employees for varying periods of time, or lay-offs caused by an abrupt loss of business (such as in the tourism and hospitality industries).

Scholars have speculated that these shocks have resulted in a staggering number of people not wanting to go back to work or quitting their current jobs[232]. For example, the hospitality and tourism industries failed to attract employees back following lay-offs[233]. Career shocks can trigger a sensemaking process that can lead one to question how time is spent at work and the benefits one draws from it. For example, the transition to working from home made employees question how and why they work[234]. Frequent health and financial concerns, juggling school closures and complications in caring for dependents have compounded exhaustion and disorganization issues. Some have even renamed 'the great resignation' as 'the great discontent' to highlight that many people reported wanting to quit because of dissatisfaction with their work conditions[235].

It might be helpful to understand 'the great resignation' through the lens of basic psychological need satisfaction. Being stretched to the limit might influence the need for competence and relatedness when workers feel they have suboptimal ways to connect with colleagues and insufficient time to balance work with other life activities that connect them to family and friends[128,236]. The sensemaking process that accompanies career shocks might highlight a lack of meaningful work that decreases the satisfaction of the need for autonomy. This lack of need satisfaction might lead people to take advantage of the disruption to 'cut their losses' by reorienting their life priorities and career goals, leading to resignation from their current jobs[237,238].

Alternatively, the experiences gained from working differently during the COVID-19 pandemic might have made many workers aware of how work could be (for example, one does not have to commute), emboldening them to demand better work design and work conditions for themselves. Not surprisingly, barely a year after 'the great resignation' many are now talking about 'the great reshuffle', suggesting that many people who quit their jobs used this time to rethink their careers and find more satisfying work[239]. Generally, this has meant getting better pay and seeking work that aligns better with individual values and that provides a better work–life balance: in other words, work that better meets psychological needs for competence, autonomy and relatedness.

At the same time, technology might thwart competence needs, and increase fatigue and stress. For example, constant electronic messages (such as email or keeping track of online messaging platforms such as Slack or Microsoft Teams) are likely to increase in volume when working remotely, but can be distracting and prevent individuals from completing core tasks while they respond to incoming messages[136]. The frustration of the need for competence can increase if individuals are constantly switching tasks to deal with overwhelming correspondence and failing to finish tasks in a timely manner. In addition, information communication technology enables access to what some individuals might perceive as an overwhelming amount of information (for example, through the internet, email and messages) which can lead to a lot of time spent sifting and processing information. This can be interpreted as a job demand that might make individuals feel incompetent if it is not clear what information is most important. Individuals might also require training in the use of information communication technology, and even then, technology can malfunction, preventing workers from completing tasks, and causing frustration and distress[136,137].

Finally, remote workers can suffer from professional isolation because there are fewer opportunities to meet or be introduced to connections that enable career development and progression[138], which could influence their feelings of competence in the long run. Although some research suggests that those who work flexibly are viewed as less committed to their career[139] and might be overlooked for career progression[140], other research has found no relationship between remote working and career prospects[119].

Virtual work can also present challenges for meeting workers' need for relatedness[141]. Remote workers can feel isolated from, and excluded by, colleagues and fail to gain the social support they might receive if co-located[142,143], weakening their sense of belonging to a team or organization[144] and their job performance[145]. This effect will probably be accentuated in the future: if the current trend for working from home continues, more people will be dissociated from office social environments more often and indefinitely. Office social environments could be degraded permanently if fewer people frequent the office on a daily basis, such that workers may not be in the office at the same time as collaborators, and there might be fewer people to ask for help or talk with informally. We do not yet know the long-term implications of a degraded social environment, but some suggest that extended virtual working could create a society where people have poor communication skills and in which social isolation and anxiety are exacerbated[146]. Self-determination theory suggests that it will be critical to actively design hybrid and remote work that meets relatedness needs to prevent these long-term issues. When working remotely, simple actions could be effective, such as actively providing opportunities for connecting with others, for example, through 'virtual coffee breaks'[147]. Individuals could also be 'buddied' up into pairs who regularly check in with each other via virtual platforms.

Hybrid work seems to offer the best of both worlds, providing opportunities for connection and collaboration while in the workplace, and affording autonomy in terms of flexible working. Some research suggests that two remote workdays a week provides the optimum balance[148]. However, it is likely that this balance will be affected by individual characteristics and desires, as well as by differences in work roles and goals. For example, Israeli employees with autism who had to work from home during the COVID-19 pandemic experienced significantly lower competence and autonomy satisfaction than before the pandemic[149]. Yet remote workers high in emotional stability and job autonomy reported higher autonomy and relatedness satisfaction compared to those with low emotional stability[120]. These findings suggest that managers and individuals should consider the interplay between individual characteristics, work design and psychological need satisfaction when considering virtual and remote work.

Virtual teamwork. Uncertainty and interconnectedness make work more complex, increasing the need for teamwork across many industries[150]. Work teams are groups of individuals that must both collaborate and work interdependently to achieve shared objectives[151]. Technology has created opportunities to develop work teams that

operate virtually. Virtual teams are individuals working interdependently towards a common goal but who are geographically dispersed and who rely on electronic technologies to perform their work[152,153]. Thus, virtual teamwork is a special category of virtual work that also involves collective psychological experiences (that are shaped by and interact with virtual work)[154]. This adds another layer of complexity and therefore requires a separate discussion.

Most research conceptualizes team virtuality as a construct with two dimensions: geographical dispersion and reliance on technology[153,155]. Notably, these dimensions are not completely independent because team members require technology to communicate and coordinate tasks when working in different locations[156,157]. Virtuality differs between and within teams. Team members might be in different locations on some days and the same location on other days, which changes the level of team virtuality over time. Thus, teams are not strictly virtual or non-virtual. Team virtuality influences how team members coordinate tasks and share information[130], which is critical for team effectiveness (usually assessed by a team's tangible outputs, such as their productivity, and team member reactions, such as satisfaction with, or commitment to, the team)[158].

Although individual team members might react differently to working in a virtual team, multi-level theory suggests that team members collectively develop shared experiences, called team emergent states[159,160]. Team emergent states include team cohesion (the bond among group members)[161], team trust[162], and team motivation and engagement[159,163]. These emergent states arise out of individual psychological behaviours and states[164] and are influenced by factors that are internal (for example, interactions between team members) and external (for example, organizational team rewards, organizational leadership and project deadlines) to the team, as well as team structure (for example, team size and composition). Team emergent states, particularly team trust, are critical for virtual team effectiveness because reliance on technology often brings uncertainties and fewer opportunities for social control[165].

Table 1 | **Impact of virtual and remote work on need satisfaction**

Needs	Positive effects on need satisfaction	Negative effects on need satisfaction
Autonomy	Flexible schedules	Close monitoring
	Less commuting	Home–work conflict
	More time for other activities	Increased demands
Competence	Worldwide access to information and communication	Information overload
	Remote learning opportunities	Requirement to learn and maintain technological skills
	Increased role clarity	Technological hassles
	Increased self-efficacy	
Relatedness	Face-to-face or virtual communication	Social and professional isolation
	Connecting with people across time and space	Lack of social support
		Less meaningful colleague relationships

Team virtuality is likely to affect team functioning via its impact on psychological need satisfaction, in a fashion similar to remote work. However, the need for coordination and information sharing to achieve team goals is likely to be enhanced by how team members support and satisfy each other's psychological needs[166], which might be more difficult under virtual work conditions. In addition to affecting individual performance, need satisfaction within virtual teams can also influence collective-level team processes, such as coordination and trust, which ultimately affect team performance. For example, working in a virtual team might make it more difficult to feel meaningful connections because team members in different locations often have less contact than co-located team members. Virtual team members predominantly interact via technology, which — as described in the previous section — might influence the quality of relationships they can develop with their team members[141,167,168] and consequently the satisfaction of relatedness needs[169].

Furthermore, virtual team members must master electronic communication technology (including virtual meeting and breakout rooms, internet connectivity issues, meeting across different time zones, and email overload), which can lead to frustrations and 'technostress'[170]. Frustrations with electronic communication might diminish the psychological need for competence because team members might feel ineffective in mastering their environment.

In sum, virtual team members might experience lower relatedness and competence need satisfaction. However, these needs are critical determinants of work motivation. Furthermore, virtual team members can also develop shared collective experiences around their need satisfaction. Thus, self-determination theory offers explanatory mechanisms (that is, team members' need satisfaction, which influences work motivation) that are at play in virtual teams and that organizations should consider when implementing virtual teams.

Algorithmic management. Algorithmic management refers to the use of software algorithms to partially or completely execute workforce management functions (for example, hiring and firing, coordinating work, and monitoring performance)[2,123,171,172]. This phenomenon first appeared on gig economy platforms such as Uber, Instacart and Upwork, where all management is automated[173]. However, it is rapidly spreading to traditional work settings. Examples include monitoring the productivity, activity and emotions of remote workers[174], the algorithmic determination of truck drivers' routes and time targets[175], and automated schedule creation in retail settings[176]. The constant updating of the algorithms as more data is collected and the opacity of this process makes algorithmic management unpredictable, which produces more uncertainty for workers[177].

Algorithmic management has repercussions for work design. Specifically, whether algorithmic management systems consider human motivational factors in their design influences whether workers are given enough autonomy, skills usage, task variety, social contact, role clarity (including knowing the impact of one's work)

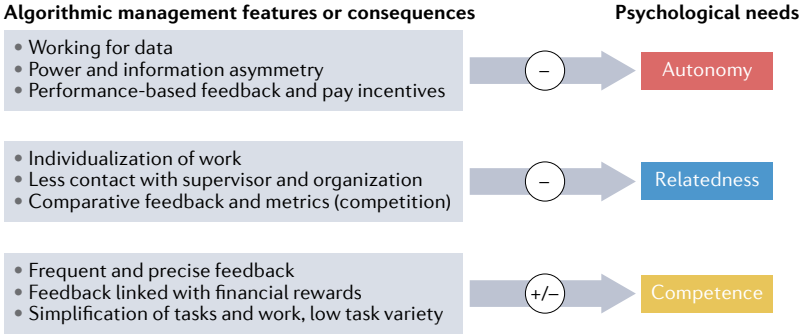

Fig. 4 | **The effects of algorithmic management on need satisfaction.** Summary of the features and consequences of algorithmic management on autonomy needs, relatedness needs and competence needs.

and a manageable workload[123]. So far, empirical evidence show that algorithmic management features predominantly reduce employees' basic needs for autonomy, competence and relatedness because of how they influence work design (FIG. 4).

Algorithmic management tends to foster the 'working-for-data' phenomenon (or datafication of work)[172,178,179], leading workers to focus their efforts on aspects of work that are being monitored and quantified at the expense of other tasks that might be more personally valued or meaningful. This tendency is reinforced by the fact that algorithms are updated with new incoming data, increasing the need for workers to pay close attention to what 'pays off' at any given moment. Monitoring and quantifying worker behaviours might reduce autonomy because it is experienced as controlling and narrows goal focus to only quantifiable results[127,180]; there is some evidence that this is the case when algorithmic management systems are used to this end[172,178,181]. Rigid rules about how to carry out work often determine performance ratings (for example, imposing a route to deliver goods or prescribing how equipment and materials must be used) and even future task assignments and firing decisions, with little to no opportunity for employee input[182–184]. Thus, the combination of telling workers what to do to reach performance targets and how to get it done significantly limits their autonomy to make decisions based on their knowledge and skills.

Some algorithmic management platforms do not reveal all aspects of a given task (for example, not revealing the client destination before work is accepted) or penalize workers who decline jobs[185], thereby severely restricting their choices. This encourages workers to either overwork to the point of exhaustion, find ways to game the system[184], or misbehave[186]. Moreover, the technical complexity and opacity of algorithmic systems[187–189] deprives workers of the ability to understand and master the system that governs their work, which limits their voice and enpowerment[172,185,190]. Workers' typical response to the lack of transparency is to organize themselves on social media to share any insights they have on what the algorithm 'wants' as a way to gain back some control over their work[183,191].

Finally, algorithmic management usually provides comparative feedback (comparing one's results to other workers') and is linked to incentive pay structures, both of which reduce self-determined motivation as they are experienced as more controlling[26,192]. For instance, after algorithms estimated normal time standards for each 'act', algorithmic tracking and case allocation systems forced homecare nurses to reduce the 'social' time spent with patients because they were assigned more patients per day, thereby limiting nurses' autonomy to decide how to perform their work[181]. Because these types of quantified metric are often directly linked to performance scores, pay incentives and future allocation of tasks or schedules (that is, getting future work), algorithmic management reduces workers' freedom in decision-making related to their work, which can significantly reduce their self-determined motivation[123].

Algorithmic management also tends to individualize work, which affects the need for relatedness. For example, algorithmic management inevitably transforms or reduces (sometimes even eliminates) contact with a supervisor[2,182,193], leading to the feeling that the organization does not care about the worker and provides little social support[194,195]. 'App-workers', who obtain work through gig-work platforms such as Uber, reportedly crave more social interactions and networking opportunities[179,185,194] and often attempt to compensate for a lack of relatedness by creating support groups that connect virtually and physically[183,191,195]. Increased competitive climates due to comparative feedback or displaying team members' individual rankings[175,196] can also hamper relatedness. Indeed, when workers have to compete against each other to rank highly (which influences their chances of getting future work and the financial incentives they receive), they are less likely to develop trusting and supportive relationships.

Researchers have formulated contradictory predictions about the potential implications of algorithmic management on competence satisfaction. On the one hand, using quantified metrics, algorithmic management systems can provide more frequent, unambiguous and performance-related feedback, often in the form of ratings and rankings[177], and simultaneously link this feedback to financial rewards. Informational feedback can enhance intrinsic motivation because it provides information about one's competence. At the same time, linking rewards to this feedback could decrease intrinsic motivation, because the contingency between work behaviour and pay limits worker discretion and therefore reduces their autonomy[26]. The evidence so far suggests that the mostly comparative feedback provided by algorithmic management is insufficiently informative because the value of the feedback is short-lived — continuously updating algorithms change what is required to perform well[177,183,185]. This short-lived feedback can undermine feelings of mastery or competence. In addition, algorithmic management is often associated with simplified tasks, and with lower problem-solving opportunities and job variety[123]. However, gamification features on some platforms might increase intrinsic motivation[179,183].

The nascent research on the effects of algorithmic management on workers' motivation indicates mostly negative effects on self-determined forms of motivation, because the way it is designed decreases the satisfaction of competence, autonomy and relatedness needs.

Algorithmic management is being rapidly adopted across an increasing number of industries. Thus, technology developers and those who implement the technology in organizations will need to pay closer attention to how it changes work design to avoid negative effects on work motivation.

Summary and future directions

Self-determination theory can help predict the motivational consequences of future work and these motivational considerations should be taken into account when designing and implementing technology. More self-determined motivation will be needed to deal with the uncertainty and interdependence that will characterize future work. Thus, research examining how need satisfaction and work motivation influence people's ability to adapt to uncertainty, or even leverage it, is needed. For example, future research could examine how different managerial styles influence adaptivity and proactivity in highly uncertain work environments[197]. Need-satisfying leadership, such as transformational leadership (charismatic or inspirational)[15], can encourage job crafting and other proactive work behaviours[198,199]. Transactional leadership (focused on monitoring, rewarding and sanctioning) might promote self-determined motivation during organizational crises[23]. In addition, research on the quality of interconnectedness (the breadth and depth of interactions and networks) could provide insight on how to manage the increased interconnectedness workers are experiencing.

Technology can greatly assist in recruiting and selecting workers; self-determination theory can inform guidelines on how to design and use such technologies. It is important that the technology is easy to use and perceived as useful to the candidates for best representing themselves[200,201]. This can be done by ensuring that candidates have complete instructions before an assessment starts, even possibly getting a 'practice run', to improve their feelings of competence. It is also important for candidates to feel some amount of control and less pressure associated with online asynchronous assessments. Giving candidates some choice over testing platforms and the order of questions or settings, explaining how the results will be used, or allowing candidates to ask questions, could improve feelings of autonomy[70]. Finally, it is crucial to enhance perceptions that the organization cares about getting to know candidates and forging connections with them despite using these tools. For example, enhancing these tools with personalized videos of organizational members and providing candidates with feedback following selection decisions might increase feelings of relatedness. These suggestions need to be empirically tested[202].

More research is also needed on how technology is transforming work design, and consequently influencing worker need satisfaction and motivation. Research in behavioural health has examined how digital applications that encourage healthy behaviours can be designed to fulfill the needs for competence, autonomy and relatedness[203]. Whether and how technology designed for other purposes (such as industrial robots, information communication technology, or automated decision-making systems) can be deliberately designed to meet these core human needs remains an open question. To date, little research has examined how work technologies are created, and what can be done to influence the process to create more human-centred designs. Collaborative research across social science and technical disciplines (such as engineering and computing) is needed.

In terms of implementation, although there is a long history of studies investigating the impact of technology on work design, current digital technologies are increasingly autonomous. This situation presents new challenges: a human-centred approach to automation in which the worker has transparent influence over the technical system has frequently been recommended as the optimal way to achieve high performance and to avoid automation failures[1,204]. But it is not clear that this work design strategy will be equally effective in terms of safety, productivity and meeting human needs when workers can no longer understand or control highly autonomous technology.

Given the likely persistence of virtual and remote work into the future, there is a critical need to understand how psychological needs can be satisfied when working remotely. Multi-wave studies that explore the boundary conditions of need satisfaction would advance knowledge around who is most likely to experience need satisfaction, when and why. Such knowledge can be leveraged to inform the design of interventions, such as supervisor training, to improve well-being and performance outcomes for virtual and remote workers. Similarly, no research to date has used self-determination theory to better understand how team virtuality affects how well team members support each other's psychological needs. Within non-virtual teams, need satisfaction is influenced by the extent to which team members exhibit need-supportive behaviours towards each other[205]. For example, giving autonomy and empowering virtual teams is crucial for good team performance[206]. Studies that track team activities and interaction patterns, including virtual communication records, over time could be used to examine the effects of need support and thwarting between virtual team members[207,208].

Finally, although most studies have shown negative effects of algorithmic management on workers' motivation and work design characteristics, researchers should not view the effects of algorithmic management as predetermined and unchangeable. Sociotechnical aspects of the system[2,209] (such as transparency, privacy, accuracy, invasiveness and human control) and organizational policies surrounding their use could mitigate the motivational effects of algorithmic management. In sum, it is not algorithms that shape workers' motivation, but how organizations design and use them[3]. Given that applications that use algorithmic management are developed mostly by computer and data scientists, sometimes with input from marketing specialists[185], organizations would benefit from employing psychologists and human resources specialists to enhance the motivational potential of these applications.

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