



Article

How Individual Involvement with Digitalized Work and Digitalization at the Workplace Level Impacts Supervisory and Coworker Bullying in German Workplaces

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Abstract: Digitalized work has gained importance across industrialized countries. Simultaneously, research investigating the consequences of digitalized work for workplace relations among employees, supervisors, and coworkers, such as workplace bullying, is largely missing. This study is, to the best of our knowledge, the first to investigate how digitalized work influences supervisory and coworker bullying dependent on individual, job, and workplace characteristics. We use representative linked-employer-employee data from 3612 employees located in 100 large workplaces in Germany across all industrial sectors and apply random effects multilevel linear analyses. Individual involvement in digitalized work is related to less supervisory bullying for all employees, and for lower qualified employees to less coworker bullying. At the workplace level, when digitalization has advanced, supervisory bullying increases for highly qualified employees. Neither the individual nor the workplace effects of digitalization are explained by mediating factors such as job autonomy, routine or machine work, competency, or psychological or physical stress. Competence and job autonomy prevent the occurrence of bullying, while routine work, psychological stress, and physically demanding work are positively related to bullying. All effects are more pronounced for supervisory bullying than for coworker bullying. Individual involvement with digitalized work seems to change relational dynamics within workplaces and to protect employees from bullying. For highly qualified employees, this is probably related to the gathering of key competencies; for lower qualified employees, it might be linked to working with digital devices. In workplaces where digitalization has progressed, digitalized work may disrupt and change the established work processes and relations and increase the necessity for new coordination and, thus, the occurrence of conflicts.

Keywords: workplace bullying; digitalization; job autonomy; routine work; linked employer-employee data; supervisors

1. Introduction

Although the consequences of digitalized work have been disputed in the media and by the public for some time, workplaces have only recently begun to digitalize work. Digitalized work represents a new technology that connects global data networks and physical systems as machines through specific software systems. Digitalized work enables the smooth transfer of information into physical processes, for example, when production is automatically adapted to shifting demands in markets. Real-time regulation of production processes, sometimes over the entire value chain, becomes possible. Moreover, digitalized work leads to better vertical and horizontal integration of work (Nies 2020) and finds application in various areas as the use of machines, logistic or coordination systems and relates

decisions increasingly to information available on the Internet. However, digitalized work systems can also be used to routinize and streamline work processes and allow for meticulous mentoring. For example, when employees receive on-time information describing not only which task to perform but also where and how fast.

The introduction of digitalized work not only alters specific occupations, but also makes it necessary to reorganize entire production processes. The consequences of digitalized work are discussed in a noticeably polarized way (Hirsch-Kreinsen and Ten Hompel 2017). On one side are hopes of less stressful and more interesting jobs, and on the other side are fears of inhuman, alienated, and less autonomous jobs. However, a third position is gaining ground, one that emphasizes the role of workplaces and relations between individual and collective actors in shaping the introduction of digitalized work and its consequences (Rahwan et al. 2019).

Empirical research investigating the consequences of digitalization on jobs, workplaces, and workplace relations is scarce. Particularly lacking is research that goes beyond single case studies, covering larger parts of the overall workforce, and research looking at the possible consequences of digitalization over and above a mere description of digitalized work. We focus on workplace relations and on the under-researched question of whether digitalization goes hand in hand with an increased risk of bullying by supervisors or coworkers.

Workplace bullying has profound and long-standing consequences for employees and the workplaces where it occurs (Hodson 2001; Rainey and Melzer 2019). Workplace bullying refers to a systematic and persistent exposure to negative acts at work, embodied by persistent acts of criticism and negative remarks as well as personal or even physical abuse (Einarsen et al. 2003). It reduces employees' ability to execute daily tasks and to cooperate (Einarsen 2000; Olsen et al. 2017), decreases employees' job satisfaction and commitment (Courcy et al. 2016; Hoel and Cooper 2000), undermines employees' dignity, and destroys the positive meaning people can find in their work (Hodson 2001; Rainey and Melzer 2019). Workplace bullying makes people mentally and physically ill (Bonde et al. 2016; Einarsen and Nielsen 2015; Mikkelsen and Einarsen 2002) with symptoms as severe as burnout (Ali et al. 2019; Deery et al. 2011). At the workplace level, bullying increases costs (Hoel et al. 2003; Kivimäki et al. 2000), boosts absenteeism and turnover rates (Asfaw et al. 2014; Deery et al. 2011; Hoel and Cooper 2000; Vartia 2001), and reduces productivity (Einarsen and Mikkelsen 2003; Hoel and Cooper 2000). Workplace bullying is also a widespread phenomenon. In Germany, approximately 7% of employees have experienced severe bullying and 17% bullying (Lange et al. 2019).

Although many studies convincingly demand that workplace bullying should not be understood as a set of individual acts or dyadic relationships, it must be investigated within the specific social context in which it occurs: the workplace (Berlingieri 2015); for an exception see, e.g., (Medina et al. 2020). The bulk of empirical research on workplace bullying focuses mostly on "who does what to whom; when, where, [and] why" (Einarsen et al. 2003, p. 9) and primarily analyzes individual level data (Berlingieri 2015; Neall and Tuckey 2014; Rainey and Melzer 2019). It emphasizes the importance of individual and job characteristics such as autonomy (Crowley 2014; Einarsen et al. 1994) or individual competence level (McDaniel et al. 2015), which are protective resources against workplace bullying. Among job demands, psychological stress, and physical demands (Hauge et al. 2007; Hauge et al. 2011), working with machines and routine work have proven to be associated with higher levels of workplace bullying (Crowley 2014; Einarsen et al. 1994). But there is still a need for thorough and solid research on workplace bullying nesting individual behavior within the broader institutional context of workplaces and investigating how the occurrence of workplace bullying is influenced by individual as well as organizational characteristics. The lack of research on bullying taking workplace characteristics into account is aggravated by the fact that available empirical evidence is largely restricted to either single case studies or content-coded organizational ethnographies (Berlingieri 2015; Neall and Tuckey 2014; Rainey and Melzer 2019).

Our study advances the existing literature in several respects. First, to the best of our knowledge, this is the first study to investigate how supervisory and coworker bullying is influenced by digitalized work. Second, similar to the research on workplace bullying, research investigating the presence of digitalized work within workplaces and its consequences on working conditions is not only rare but also usually done in single case studies e.g., (Nies 2020). In contrast, we draw on representative linked-employer-employee (LEE) data that provide information on approximately 3538 employees nested within 100 large workplaces across the German industrial structure (Diewald et al. 2014; Melzer et al. 2016). Finally, accentuating the role of workplaces, we differentiate between individual level involvement with digitalized work and the meso-level dispersion of digitalization (i.e., share of employees working with digitalized work).

Our data provide general information on digitalization, as they were designed to describe employees' involvement in digitalized work within workplaces at a time when digitalization is just being introduced. This information does not allow us to distinguish among the many variants of digitalized work in different occupations and branches, but it provides dense information on possible confounders and mediators of the digitalization–bullying relationship: at the level of job characteristics (i.e., occupation, hours worked, teamwork, supervisory responsibility, job autonomy), firm-level characteristics (e.g., within-organization shares of employees working in autonomous or routine jobs), and relevant individual characteristics (i.e., personality traits, education, and training). We are able to isolate the influence of digitalized work from other individual and workplace characteristics that are possibly confounded with the existence of digitalized work or that may mediate the influence of digitalization over a change of defined job characteristics as well as changes at the organizational level related to the introduction of digitalized work.

2. Digitalized Work

The existing research on the effects of digitalized work is fundamentally divided. On the one hand, the literature accentuates the fact that extensive, profound, fast, and data-driven information provided by digitalized work systems enables employees to reach more informed and efficient decisions related to production or development (Dworschak and Zaiser 2014). Digitalized work systems act as decision-reaching tools. For example, in production, employees no longer just operate machines, but their main task is to bring in their experience, decide, and coordinate the processes. As such, digitalized work systems create new fields of competency and increase employees' autonomy (Neff and Burmeister 2005). Most importantly, digitalization enhances flexible on-time decisions that are better suited to overcome challenges of global, fast moving, and flexible markets.

This “optimistic” viewpoint is contrasted by a growing body of research emphasizing increasing control and a loss of autonomy due to the digitalization of work. Digitalization boosts supervisors' ability to monitor not only the work output but also the entire work process (Briken et al. 2017). Competencies are dislocated away from employees to digital devices or computational algorithms. This “negative” viewpoint can be best subsidized under the keyword “digital Taylorism”, which highlights the use of digitalized work systems to maximize efficiency by providing new digitally supported routines that fragment, standardize, and automate work tasks (Cattero 2018; Nies 2020; Staab and Nachtwey 2016). A prominent example of digital Taylorism is Amazon, where “pickers” deliver items to packing stations. Pickers are equipped with an electronic device, which indicates not only the specific item needed but also its position and the best way to reach it, simultaneously monitoring employees' progress (Cattero 2018; Hodge et al. 2006) and serving as a feedback mechanism to penalize noncompliance with time guidelines and other irregularities.

Both scenarios can find support. In other words, digitalization is a generic clause for many diverse applications between increasingly autonomous robots replacing physical work over computer-aided support systems enabling communication and coordination in networks, or replacing routine cognitive tasks with comprehensive artificial intelligence systems steering complex value creation chains.

2.1. Digitalization and Workplace Bullying: The Role of Job and Workplace Characteristics and Organizational Change

The experiences of employees with digitalized work will differ across workplaces, occupations, or qualifications (Cascio and Montealegre 2016), and the influence of digitalized work on supervisory or coworker bullying will depend on the specific tasks for which those systems are used. Moreover, digitalization might influence the incidence of workplace bullying not only directly but also through job and workplace characteristics that are known precursors of bullying and are simultaneously affected by digitalization. In the following section, we discuss existing research on both the direct and indirect components of the digitalization–bullying link.

2.1.1. Job Autonomy, Individual Competency, and Stress

Digitalized work can increase employees' efficiency, responsibility, and job autonomy (Neff and Burmeister 2005). Job autonomy is the freedom to engage in work tasks at one's own discretion (Notelaers et al. 2010). Autonomous employees have the opportunity to decide how and when to work and sometimes even to set their own goals. Existing research on workplace bullying provides evidence that bullying is less prevalent when employees have job autonomy (Einarsen et al. 1994). The relevance of autonomy for workplace bullying is mostly explained through a stress pathway: a lack of autonomy can contribute to stress and frustration at the workplace (Karasek 1979), and in general, work-related stress increases the occurrence of workplace bullying (Colligan and Higgins 2008; Hoel et al. 2002). For those lacking autonomy, stressful work environments increase conflicts, negativity of the social climate (Einarsen 2000), and even aggressive behaviors, which then increase the probability of workplace bullying (Einarsen 2000; Skogstad et al. 2011). An alternative relation between stress and bullying is described by the social interactionist hypothesis (Felson 1992; Neuman and Baron 2003; Skogstad et al. 2011). Stressful working conditions wear employees out and cause them to react to social encounters in a way that makes them easy targets for bullying.

2.1.2. Control, Physically Demanding Work, Routine Work, and Work with Machines

As already noted, digitalized work is also used to control employees (Briken et al. 2017), not least by routinizing, fragmenting, and automatizing work tasks (Cattero 2018; Nies 2020; Staab and Nachtwey 2016). This is not a case of “persuasive” control, which works through training and participation and can reduce abuse, conflicts, and hostility. Rather, it belongs to “coercive” forms of control, such as direct supervision, task segmentation, automation, and rules. Coercive control promotes abuse and makes workers feel humiliated and infantilized, which, in turn, generates hostility toward management (Crowley 2014; Hodson 2001). It is exaggerated coercive control that can erode workers' self-respect, self-worth, and dignity by diminishing the intrinsic rewards employees find in their work (Crowley 2014; Hodson 1996, 2001). When digitalization goes along with routine, monotonous, and repetitive work, it increases boredom and frustration and, thus, the risk of workplace bullying (Einarsen et al. 1994). Such working conditions can be destructive for social interchange and friendships (Hodson 1996). In addition, high workloads (Hoel and Cooper 2000; Jennifer et al. 2003) are also related to hostility and bullying.

The existing literature accentuates that job requirements change with the digitalization of work, though with partly opposing views regarding the direction of these changes. The central question is how the introduction of digital technologies changes workers' job autonomy, control, and job quality: Does it increase or reduce job autonomy, does it produce more or less routine, more or less stress, and does it enrich jobs and create highly complex responsibilities, or does it do the opposite by fragmenting and routinizing work tasks? We expect that the influence of digitalized work on work relations between employees and their supervisors or coworkers will depend on employees' qualifications.

2.1.3. Education and Training

Highly qualified and specialized employees exercising complex and nonroutinized tasks and having autonomy are most likely to utilize digitalized work as decision-reaching, competence-enhancing tools (Autor and Dorn 2013; Brynjolfsson and McAfee 2014; Hirsch-Kreinsen and Ten Hompel 2017). It is mostly among these employees that digitalized work increases job autonomy and responsibilities, provides job enrichment, and relieves the burden of routine cognitive or physical tasks. Moreover, being responsible for and able to operate such new digitalized technologies should increase employees' prestige and status. Thus, we expect that digitalized work should have positive effects on workplace relations and reduce the likelihood of experiencing bullying for highly qualified employees. Lower qualified employees, in contrast, might have entirely different experiences when faced with digitalized work. For lower qualified employees, digitalized work should externalize work goals and dislocate subjective competencies to digital devices or computational algorithms, as highlighted in "digital Taylorism". Lower qualified employees are likely to experience frustration, boredom, and reduced social and friendly interactions. This should be accentuated by a lack of time to resolve and to react adequately to conflicts when working with digital technologies. Consequently, we expect the following:

Hypothesis 1. *Highly qualified employees working with digitalized technologies are less likely to experience bullying by supervisors and coworkers, whereas less qualified employees working with digitalized technologies are more likely to experience bullying.*

2.1.4. Organizational Change

Aside from the direct effects of working with digitalized work on employees' relations, the introduction of digitalized production processes at the workplace level should even influence workplace relations of employees who are not directly involved with digitalized work. This is especially the case if digitalization is related to a profound and rapid organizational change, i.e., when the digital governing of work makes it necessary to reconsider and reorganize entire production processes or teams. In the process of digitalization, new and unknown situations may raise concerns and even fears among employees (Heath et al. 1993). Bullying should increase especially if the introduced changes are to employees' disadvantages or even if they are only perceived as such (Bryson et al. 2013), e.g., if employees fear not being able to perform well under the new requirements and are concerned about losing their jobs (De Witte 1999; Green 2011).

Especially if digitalization is only recently introduced, as is the case in Germany, the responsibilities for the operation and regulation of digitalized work have to be rearranged and negotiated between supervisors and employees as well as between coworkers (c.f., Baillien and Witte 2009). This situation might increase conflicts and even escalate into bullying. Previous research on the introduction of computer-controlled production processes in the US paper industry in the 1990s illustrates similar patterns, showing that conflicts and contradictions are inevitable when new technologies are introduced, even when such introductions are theoretically sound and planned by experienced consulting firms (Vallas 2006). Technological innovations can produce structural tensions, as different occupational groups compete for the key positions and the responsibility to operate new technologies (Vallas 2006). Moreover, the necessity to push innovations through and to restructure work even against the wishes of employees may lead to more authoritarian management styles (Hoel and Salin 2003; McCarthy et al. 1995), which can be perceived as bullying. The more widespread digitalization is, the more employees are confronted with new digitalized work and the more widespread the organizational change related to digitalization is, the more pronounced workplace bullying should be. Following this line of argument, we expect the following:

Hypothesis 2. *Employees in workplaces with higher shares of employees working with digital systems are more likely to experience bullying by supervisors or coworkers.*

Salin (2003) emphasizes that the occurrence of bullying demands factors that enable bullying, such as the presence of workers of different statuses in the workplace, motivating factors such as competition, and triggering factors such as organizational change (see also Hoel and Salin 2003). Thus, the consequences of organizational change related to digitalization might be especially severe in competitive environments where digitalized work enhances workers' efficiency and responsibilities and is understood as something worth competing for. This might be especially the case when the introduction of digitalized work carries organizational and strategic meaning and is highly politicized, as is most likely the case for highly qualified workers, who gain status and prestige from working with digital systems. The increased competition should worsen the existing relationships between employees' supervisors and coworkers and increase the occurrence of bullying. For low qualified employees, for whom work with digital technologies goes hand in hand with higher control and lower autonomy and partly implies a deterioration of working conditions, the competition over work with digital devices should be lower. Thus, we expect that for low qualified workers, organizational changes are less influential on workplace bullying:

Hypothesis 3. *Highly qualified employees in workplaces with higher shares of employees working with digital technologies are more likely to experience bullying by supervisors and coworkers than are lower qualified employees in workplaces with higher shares of digital technologies.*

3. Data, Variables, and Analytical Strategy

3.1. Data

This study uses unique German LEE data that combine administrative information for employers and their employees with surveys at both levels (Diewald et al. 2014; Melzer et al. 2016). The survey data, named LEEP-B3, were collected in 2014 by the Collaborative Research Center "From Heterogeneities to Inequalities" and was financed by the German Research Foundation. Administrative information from the Institute of Employment Research originating from the social security records of the German Federal Employment Agency was linked to the survey data. The collection of the data took place using a two-stage procedure. First, 100 establishments located in Germany with at least 500 employees paying social security insurance were drawn from stratified industries based on the administrative data of the German Federal Employment Agency (Bundesagentur für Arbeit). They comprise companies based on German capital or ownership as well as international companies. However, we have no information about ownership in our data and therefore cannot distinguish between them. In the subsequent step, on average, 65 employees per firm were selected randomly. The employees were contacted per mail and questioned with computer-assisted telephone interviews on different aspects of their work and private life. They are between 22 and 54 years old with an average of 44 years. In our sample, 45% of the employees are women, and 16% are first- or second-generation immigrants. Finally, the sampled employees work full and part-time from 5 to 55 h per week with an average of 35 h per week and on average spent 14 years in education. The sample of employees is representative of employees of large establishments in Germany (Melzer et al. 2016).

Questions regarding the incidence of digitalization in the job were introduced only in the second wave and only for employees who were already questioned in the first wave. This reduces the initial sample in the second wave from 6338 to 4000 employees in 100 firms. The response rate for employees, calculated according to the American Association for Public Opinion Research, was 73.25%, quite high for the targeted employees who were already questioned in the first wave (Melzer et al. 2016). In the first wave, the response rate was 29.8%.

The cross-sectional nature of the data limits the interpretation of the individual level effects to correlational associations. This limitation is less crucial for the interpretation of the influence of workplace attributes on bullying, as organizational characteristics usually change very slowly (DiMaggio and Powell 1983; Stainback et al. 2010), which makes it more plausible to assume that

organizational characteristics influence social relationships within workplaces and not the other way around (e.g., [Avent-Holt and Tomaskovic-Devey 2012](#); [Melzer et al. 2018](#)). Nevertheless, we interpret those effects as relations and not causal effects.

3.2. Variables

3.2.1. Dependent Variables

The two dependent variables of being bullied by a supervisor or coworkers are derived from the questions in the employee questionnaire: “How often do you feel unjustly criticized or bullied by your supervisor?” and alternatively “... by your coworkers?” Both Likert scales range from 1 to 5 and correspond to the following answer categories: “never”, “seldom”, “sometimes”, “often”, or “always”. The questions resemble the definition of bullying as repeated actions that erode the dignity of employees e.g., ([Crowley 2014](#); [Hodson 2001](#); [Rainey and Melzer 2019](#)). The use of self-labeling questions on workplace bullying, which allow the respondent to decide by herself which behavior she considers to be bullying, instead of a range of questions focusing on particular actions, is most common in the research on workplace bullying in European countries (see, e.g., the review by ([Einarsen et al. 2003](#))). The self-labeling questions capture a broader understanding of workplace bullying, including a whole range of harmful interpersonal workplace behaviors ([Rainey and Melzer 2019](#)).

Supervisory bullying is rated at an average of 1.85, and bullying by coworkers is rated at an average of 1.73 on these scales, with standard deviations of 0.83 and 0.77, respectively (see [Table 1](#)). Employees with lower qualifications indicate that they are being bullied slightly more often by supervisors and coworkers than employees with higher qualifications.

3.2.2. Digitalized Work

The variables describe digitalized work at the individual and workplace levels. At the individual level, digitalized work was captured with the following general question: “Now we come to a very specific aspect of working conditions, which applies so far only to a small amount of workplaces, namely, so-called cyber-physical systems or Industry 4.0. Have you been confronted with one of those terms at your workplace so far?” The wording of the variable was designed to measure employees’ involvement in digital work, going beyond employees who were already working full-time with digitalized technologies. This specification was necessary because such technologies are just beginning to be introduced in most workplaces. Thus, our dependent variable also accounts for persons who are involved in the introduction or planning of digital work and not only those already working with digitalized technologies. Despite the cautious wording, only 8% of the employees in our sample work with digitalized work systems, while this form of work is slightly more common among higher qualified employees (9%) than lower qualified employees (7%; see [Tables 1 and A1](#) in the [Appendix A](#) for the creation of the variable). The distribution of digitalized work across workplaces is uneven: there are workplaces that do not have any digitalized work, while there are also some workplaces where 74% of the employees are engaged with such work (see [Table 2](#)). Nevertheless, because of the wording, we might overestimate the share of employees involved in digitalized work. Consequently, we might underestimate the effects that digital work has on workplace relations.

Table 1. Description of individual characteristics for all employees, as well as for employees with and without high school degrees.

	All				Highly Qualified	Lower Qualified
	Mean	SD	Min	Max	Mean	Mean
Dependent variables						
Supervisory bullying	1.85	0.87	1	5	1.81	1.89
Bullying by coworkers	1.73	0.78	1	5	1.68	1.79

Table 1. Cont.

	All				Highly Qualified	Lower Qualified
	Mean	SD	Min	Max	Mean	Mean
Job characteristics						
Digital technologies in job (%) ¹	7.97	27.09	0	1	9.05	6.71
Works with machines (sum index)	1.55	1.50	0	4	1.39	1.74
Competence (%) ¹	88.21	32.26	0	1	88.75	87.55
Job autonomy	0.04	0.76	−2.15	1.16	0.13	−0.07
Routine work	2.57	1.18	1	5	2.30	2.90
Psychological stress	−0.05	0.96	−1.49	2.22	0.03	−0.15
Physical demanding work	2.47	1.07	1	5	2.29	2.69
Supervisory responsibility (%) ¹	35.13	47.75	0	1	38.39	31.30
Hours worked	35.21	7.15	5	55	35.34	35.07
Works in a team (%) ¹	88.12	32.36	0	1	89.67	86.28
Occupational change (%) ¹	19.55	39.66	0	1	22.39	16.19
Improved occupational position (%) ¹	12.85	33.46	0	1	14.83	10.51
ISCO-1-digit occupations						
Legislators, senior officials, managers (%) ¹	3.99	19.57	0	1	5.78	1.87
Professionals (%) ¹	26.69	44.24	0	1	43.46	6.89
Technicians, associate professionals (%) ¹	33	47.03	0	1	31.39	34.86
Clerks (%) ¹	12.32	32.87	0	1	11.96	12.75
Service workers, shop, market sales (%) ¹	5.45	22.71	0	1	2.56	8.88
Skilled agricultural, fishery workers (%) ¹	0.30	5.51	0	1	0.15	0.48
Craft, related trades workers (%) ¹	8.64	28.10	0	1	3.07	15.23
Plant, machine operators, assembler (%) ¹	5.20	22.22	0	1	0.97	10.21
Elementary occupations (%) ¹	4.40	20.52	0	1	0.66	8.82
Demographic characteristics and personality						
Age	43.91	8.10	22	54	43.39	44.52
Woman (%) ¹	45.29	49.78	0	1	45.50	45.02
Immigrant (%) ¹	16.17	36.82	0	1	16.21	16.13
Extraversion	−0.02	0.78	−3.04	1.55	−0.02	−0.01
Conscientiousness	−0.01	0.69	−3.65	1.43	−0.06	0.05
Neuroticism	−0	0.69	−1.90	2.40	−0.06	0.07
Compatibility	−0	0.62	−3.08	1.36	−0.02	0.02
Openness	0.02	0.61	−2.31	1.73	0.05	−0.02
Qualifications						
Education in years (centered at 9 years)	5.05	2.79	−2	9	7.20	2.50
Tenure in years	9.91	7.74	0	36.93	8.79	11.23
Workplace characteristics						
Share of employees working with digital technologies (%) ¹	7.84	11.25	0	74.42	7.93	7.74
Share of women (%) ¹	46.59	27.02	0	100	47.91	45.02
Share of immigrants (%) ¹	16.50	9.33	0	62.07	16.81	16.13
Share of employees with high school degrees (%) ¹	54.47	23.49	6.25	98.18	64.64	42.44
Employees working with machines ²	1.55	0.65	0.09	2.69	1.50	1.61
Share of competent employees (%) ¹	88.06	6.42	71.43	100	88.13	87.97
Employees having job autonomy ³	0.03	0.25	−0.79	0.48	0.08	−0.02
Employees working in routine jobs ⁴	2.58	0.39	1.82	3.87	2.47	2.70
Employees having psychological stress ³	−0.05	0.21	−0.53	0.50	−0.03	−0.08
Employees working in physically demanding jobs ⁴	2.47	0.33	1.82	3.41	2.40	2.56
Industry						
Manufacturing (%) ¹	34.50	47.54	0	1	27.25	43.08
Trade, hospitality, and transportation (%) ¹	7.34	26.08	0	1	4.45	10.76
Banking and insurance (%) ¹	22.20	41.57	0	1	29.55	13.53
Social, private, and public services (%) ¹	35.96	48	0	1	38.75	32.63
N	3612				1956	1655

¹ To display those values in percentages, the ordinal dummy variable was multiplied by 100; ² aggregated sum index; ³ aggregated factor variable, ⁴ measured at a scale from 1 to 5 and aggregated to the workplace level.

Table 2. Description of organizational characteristics for the analysis sample of large German workplaces.

	Mean	SD	Min	Max
Share of employees working with digital technologies (%) ¹	7.34	10.88	0.00	74.42
Share of women (%) ¹	46.03	26.98	0.00	100.00
Share of immigrants (%) ¹	16.93	10.08	0.00	62.07
Share of employees with high school (%) ¹	52.24	23.57	6.25	98.18
Employees working with machines (sum index) ²	1.55	0.65	0.09	2.69
Share of employees being competent (%) ¹	−0.00	0.07	−0.19	0.14
Employees having job autonomy ³	−0.02	0.27	−0.48	0.79
Employees working in routine jobs ⁴	3.38	0.40	2.13	4.18
Employees having psychological stress ³	0.06	0.20	−0.44	0.52
Employees working in physically demanding jobs ⁴	2.50	0.33	1.82	3.41
Manufacturing (%) ¹	23.00	42.30	0	1
Trade, hospitality, and transportation (%) ¹	8.00	27.27	0	1
Banking and insurance (%) ¹	17.00	37.75	0	1
Social, private, and public services (%) ¹	24.00	42.92	0	1
N	100			

¹ To display those values in percent, the ordinal dummy variable was multiplied by 100; ² aggregated sum index; ³ aggregated factor variable, ⁴ measured at a scale from 1 to 5 and aggregated to the workplace level.

3.2.3. Other Job Characteristics

Other forms of human–machine interface and other work that includes machines, which might be regulated by advanced computer-aided technologies, are accessed by an index from four dummy variables similar to the question: “I have to deal with technologies and machines at my workplace, which take away decisions concerning their regulation and to which I have to respond”; responses range from 0 to 4 with a mean of 1.5 (Tables 1 and A1 in the Appendix A) and a Cronbach’s alpha of 0.78. Another question asks whether employees perceive their work as difficult or overwhelming, or whether they feel competent when working with new technologies: “Sometimes I feel overwhelmed because of the work with technologies at my workplace” was used reverse-coded. Only 11.9% feel overwhelmed from technology (Table 1).

The measurement of job autonomy is based on three questions that are answered on a Likert scale ranging from 1 (completely disagree) to 5 (completely agree) (see Table A1 in the Appendix A for the variable description). Those questions are included in the estimation, following the Kaiser rule, as a single factor (Cronbach’s alpha 0.71). Routine work is based on a single question: “My job mainly includes routine tasks, I rarely learn something new” with similar response categories (1~completely disagree to 5~completely agree) and a mean of 3.4.

Psychological stress was measured using five items (see Appendix A, Table A1) of the effort-reward-imbalance scale developed by Siegrist (2000) (Cronbach’s alpha of 0.78), and physical stress was measured with only one item (“How often does it happen that you have to go to the limits of your physical capacity at your work? Would you say ...?”; reverse-coded.). All six items are answered on a scale from 1 to 5, where 1 corresponds to “always”, 2 to “often”, 3 to “sometimes”, 4 to “rarely”, and 5 to “never”.

All job characteristics described above, including those for digitalization, were aggregated to the workplace level. This allows for accessing contextual measures in addition to the individual job characteristics. Table 2 displays the means and the distribution of these characteristics.

3.2.4. Controls at the Individual Level

As the experience of workplace bullying might be related to employees’ personalities (Nielsen et al. 2017), the most important control variable measures the “Big 5” personality traits (see Appendix A). Additional controls measure demographic characteristics such as immigrant status based on country of birth outside of Germany, gender, age in years and age squared, and level of qualifications (education in years centered at nine years corresponding to low secondary degree (Hauptschule), tenure in years) (see Table 1). As workers might change their occupational position

within workplaces, we use dummy variables to control for occupational changes in the last year and whether the changes accompanied an improvement in the occupational position. A whole range of variables is used to describe the job, controlling for International Standard Classification of Occupations-1-digit occupations, supervisory responsibility, and working on a team.

3.2.5. Controls at the Workplace Level

Organizational research highlights the importance of workplace composition along the lines of gender, race, and immigrant status as the basis for social interactions within workplaces (DiTomaso et al. 2007; Reskin 1993). Therefore, we include controls for workplace composition regarding gender and immigrant status using shares of immigrants and women within workplaces. Moreover, we control for the share of employees with high school diplomas. To account for possible cultural differences in the treatment of employees across industries, we use dummy variables differentiating among (1) manufacturing, including energy, (2) trade, hospitality, and transportation, (3) banking and insurance, and (4) social, private, and public services (see Table 2).

3.3. Analytical Strategy

The influence of individual digitalized work and the dispersion of digitalization within workplaces on supervisory and coworkers' bullying are estimated with multilevel linear analysis (MLA), also called hierarchical linear models. The random-effects (RE) models employ random intercepts and random slopes. MLA models are able to account for the nonindependence of workplace bullying within firms and are superior to ordinary least squares regressions, which may underestimate the standard errors and simultaneously overestimate the effects of variables at the workplace level (Hox 2002). Thus, OLS regression might provide biased results. RE models estimate bullying by relying on between-firm and within-firm variance simultaneously and are able to show how workplace attributes influence workplace behavior. Fixed-effects models are not appropriate to investigate the underlying research questions, as no main effects of workplace attributes on bullying can be estimated with fixed-effects for those data. Thus, utilizing RE MLA, we are able to show how the dispersion of digitalized work within workplaces might encourage or hinder workplace bullying. One drawback of RE models in comparison to the fixed-effects models is that they require an additional assumption regarding the structure of unobserved heterogeneity involved, assuming that the unobserved factors are not correlated with the explanatory factors (Wooldridge 2009, p. 496). This assumption might be violated. However, if the assumption holds, RE models are not only consistent but also more efficient than fixed-effects models.

In the first step of the analyses, we assess the degree to which sorting into workplaces and digitalized work impinges on bullying by estimating the intraclass correlation and integrating variables stepwise into the models (see Supplementary Material, Tables S1 and S2).

To investigate the varying impact of digitalized work on highly and lower qualified workers, the sample is divided. We define highly qualified workers as those who completed upper secondary education and finished a university degree (general university or university of applied sciences) or have a master craftsman certificate (comparable to a bachelor's degree). Following Hirsch-Kreinsen and Ten Hompel (2017), we accounted for the peculiarity of the German dual vocational systems and included highly specialized workers who completed upper secondary education and vocational training, as in Germany specialists such as mechatronics engineers obtain their qualifications in dual vocational training.

4. Results

Tables 3 and 4 display the RE MLA investigating supervisory and coworker bullying, respectively, with all individual and workplace level variables for the full sample (Models I and IV) as well as separately for highly qualified (Models II and V) and lower qualified (Models III and VI) employees. The central individual level variables are additionally displayed as percentages and using 95% confidence bands in Figure 1.

Working with digital systems is negatively related to supervisory bullying for all employees. Employees in the pooled sample working with digitalized work show 13.5% lower levels of bullying (see Figure 1), which is a strong effect. Although the relation between digitalized work and supervisory bullying seems to be slightly stronger for highly qualified employees and the effect is only statistically significant at a 10% level for lower qualified employees, the differences between both groups of employees are not statistically significant. Moreover, while working with digitalized work is also negatively related to coworker bullying for lower qualified employees (10% significance level), the effects are not significantly different from those of higher qualified employees. As highly qualified employees involved with digitalized work are not less likely to experience bullying by supervisors and coworkers than less qualified employees, Hypothesis 1 has to be rejected.

Table 3. Influence of digitalized work and other job characteristics at the individual and workplace level on bullying from supervisors (workplace level random effects regressions).

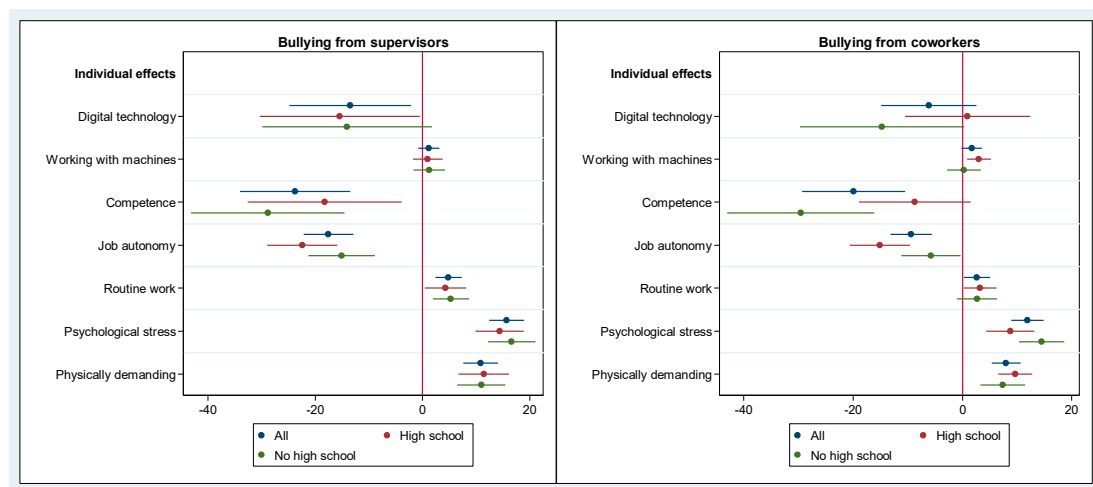
	All		Highly Qualified		Lower Qualified	
	b	se	B	se	b	se
Job characteristics						
Digitalized work	−0.135 *	0.058	−0.154 *	0.076	−0.141 +	0.081
Machines operator	0.012	0.010	0.010	0.014	0.013	0.015
Competence	−0.237 ***	0.053	−0.183 *	0.073	−0.288 ***	0.073
Job autonomy	−0.175 ***	0.024	−0.224 ***	0.033	−0.150 ***	0.032
Routine work	0.048 ***	0.012	0.043 *	0.020	0.053 **	0.017
Psychological stress	0.157 ***	0.017	0.144 ***	0.023	0.166 ***	0.023
Physically demanding work	0.109 ***	0.017	0.114 ***	0.024	0.110 ***	0.023
Supervisory responsibility	0.070 *	0.029	0.015	0.044	0.135 **	0.043
Hours worked	0.004	0.003	0.003	0.004	0.006	0.004
Works in a team	−0.109 *	0.047	−0.114 +	0.063	−0.095	0.067
Occupational change within the last year	0.107	0.075	0.118	0.089	0.120	0.103
Improved occupational position within last year	−0.232 **	0.089	−0.240 *	0.108	−0.239 *	0.119
Workplace characteristics						
Share of employees working with digitalized work/100	0.139	0.191	0.420 *	0.164	−0.154	0.271
Employees working with machines	−0.021	0.039	0.015	0.044	−0.077	0.056
Competent employees/100	0.331	0.242	0.444	0.279	0.129	0.339
Employees having job autonomy	−0.076	0.065	−0.051	0.088	−0.117	0.096
Employees working in routine jobs	0.080	0.071	0.165 *	0.080	−0.008	0.081
Employees having psychological stress	0.059	0.074	0.197 *	0.086	−0.082	0.112
Employees working in physically demanding jobs	−0.056	0.070	−0.192 *	0.076	0.079	0.091
Controlled for:						
Demographic characteristics and personality	Yes		Yes		Yes	
Qualifications	Yes		Yes		Yes	
ISCO-1-digit occupations	Yes		Yes		Yes	
Workplace composition	Yes		Yes		Yes	
Industries	Yes		Yes		Yes	
Constant	0.631	0.468	0.478	0.559	0.558	0.688
Variance (random effects)						
Individuals	−2.916 ***	0.469	−18.410	31.503	−3.755	4.563
Workplaces	−0.220 ***	0.014	−0.271 ***	0.021	−0.181 ***	0.018
N employees	3612		1932		1680	
N workplaces	100		100		100	

Dependent variables supervisory and coworker bullying; LEEP-B3 data. Clustered robust standard errors. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4. Influence of digitalized work and other job characteristics at the individual and workplace level on coworker bullying (workplace level random effects regressions).

	All		Highly Qualified		Lower Qualified	
	b	se	B	se	b	se
Job characteristics						
Digitalized work	−0.061	0.045	0.009	0.059	−0.147 +	0.077
Machines operator	0.017 +	0.010	0.030 **	0.011	0.003	0.016
Competence	−0.199 ***	0.048	−0.087 +	0.052	−0.296 ***	0.069
Job autonomy	−0.094 ***	0.019	−0.151 ***	0.028	−0.057 *	0.028
Routine work	0.026 *	0.012	0.032 *	0.015	0.027	0.019
Psychological stress	0.119 ***	0.015	0.088 ***	0.022	0.145 ***	0.021
Physically demanding work	0.080 ***	0.014	0.096 ***	0.016	0.074 ***	0.021
Supervisory responsibility	0.041	0.027	0.010	0.041	0.080 *	0.040
Hours worked	0.002	0.002	0.001	0.003	0.004	0.003
Works in a team	−0.008	0.040	−0.001	0.050	0.010	0.065
Occupational change within the last year	0.056	0.064	0.037	0.069	0.091	0.090
Improved occupational position within last year	−0.158 *	0.070	−0.101	0.079	−0.239 *	0.105
Workplace characteristics						
Share of employees working with digitalized work/100	−0.016	0.125	−0.230	0.185	0.024	0.167
Employees working with machines	−0.025	0.039	0.057	0.044	−0.122 *	0.054
Competent employees/100	0.138	0.270	0.469 +	0.263	−0.201	0.367
Employees having job autonomy	0.116 +	0.062	0.134	0.092	0.047	0.092
Employees working in routine jobs	0.086	0.060	0.085	0.074	0.044	0.061
Employees having psychological stress	0.013	0.073	0.003	0.091	0.031	0.102
Employees working in physically demanding jobs	−0.041	0.059	−0.093	0.069	−0.019	0.087
Controlled for:						
Demographic characteristics and personality	Yes		Yes		Yes	
Qualifications	Yes		Yes		Yes	
ISCO-1-digit occupations	Yes		Yes		Yes	
Workplace composition	Yes		Yes		Yes	
Industries	Yes		Yes		Yes	
Constant	1.949 ***	0.502	1.559 *	0.656	2.277 ***	0.639
Variance (random effects)						
Individuals	−2.801 ***	0.465	−16.281	36.969	−22.052	27.594
Workplaces	−0.319 ***	0.016	−0.392 ***	0.019	−0.266 ***	0.022
N employees	3612		1931		1681	
N workplaces	100		100		100	

Dependent variables supervisory and coworker bullying; LEEP-B3 data. Clustered robust standard errors. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

**Figure 1.** Coefficients estimating the influence of digitalized work and other job characteristics at the individual level on supervisory and coworker bullying with 95% confidence bands (workplace level random-effects regressions displayed in Tables 3 and 4).

Our second hypothesis concerned employees' experience of supervisory and coworker bullying when digitalization has advanced within the workplace. We expected that employees in workplaces with higher shares of employees engaged with digitalized work are more likely to experience bullying by supervisors or coworkers. We are not able to confirm this hypothesis for all employees, as the estimated effects are mostly not statistically significant. We find, however, that for highly qualified employees, the likelihood of experiencing bullying by supervisors increases in workplaces where digitalization is advanced (see Figure 2). For those employees, a one-standard-deviation-higher share of employees working with digitalized work is related to 4.5% higher levels of bullying. For lower qualified employees, the effect shows the inverse direction but is statistically insignificant. This finding is in line with the expectations of Hypothesis 3, assuming that highly qualified employees in workplaces with higher shares of employees working with digitalized work are more likely to experience bullying than less qualified employees. As all of the results for coworker bullying regarding the dispersion of digital technologies within workplaces are statistically insignificant, Hypothesis 3 can be confirmed only for supervisory bullying.

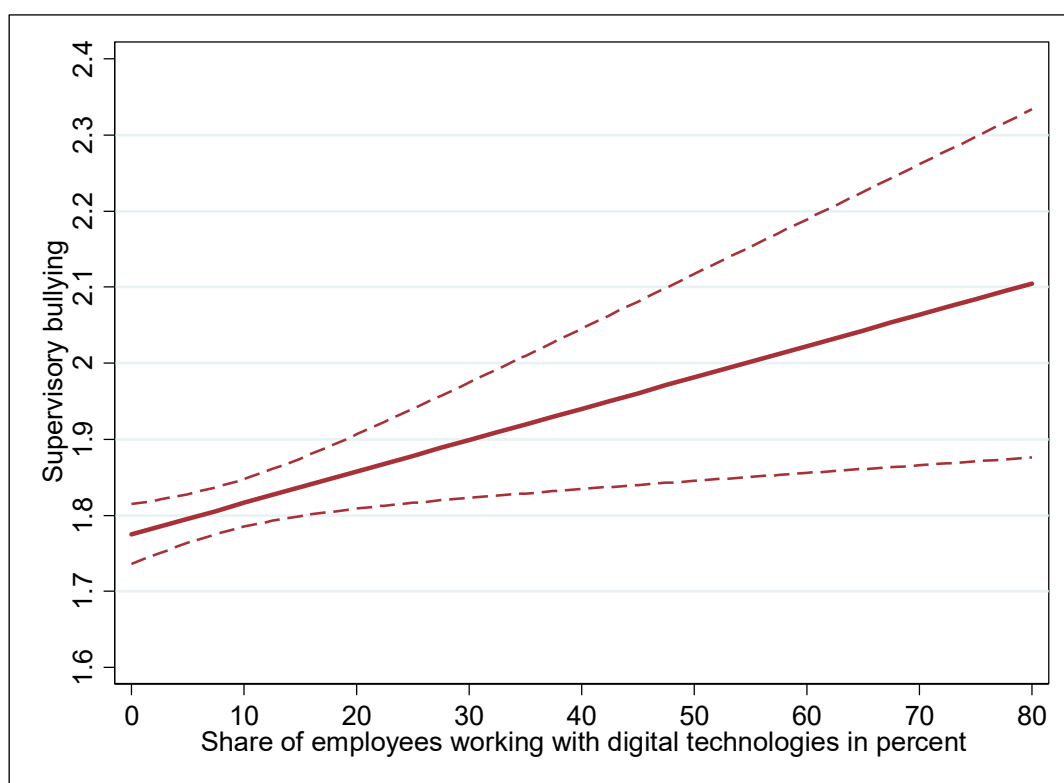


Figure 2. The influence of the workplace level shares of employees working with digital work on supervisory bullying for employees with high school degrees, with 95% confidence bands (workplace level random-effects regressions displayed in Table 3).

Work that involves handling machines generally does not have statistically significant effects on supervisory or coworker bullying, except for coworker bullying of highly qualified employees (see Figure 1). Being competent is, in turn, negatively related to supervisory and coworker bullying for all employees regardless of educational qualifications. However, the effect is not statistically significant for highly qualified employees.

Job autonomy is negatively related to both forms of bullying. Routine work, in turn, is positively related to supervisory and coworkers' bullying but not statistically significant for all samples when analyzing coworker bullying. Psychological stress and physically demanding work show a positive correlation with supervisory and coworkers' bullying. A one-standard-deviation-higher level of psychological stress is related to 16.3% higher levels of bullying from supervisors and to 11.4% higher

levels of bullying from coworkers for all employees. Similarly, a one-standard-deviation-higher level of physically demanding work is related to an 11.6% higher likelihood of supervisory bullying and an 8.6% higher likelihood of being bullied by coworkers for all employees. Having a supervisory position is at least partly related to a higher exposure to bullying, while working in a team seems to correlate lower with bullying. Finally, improved occupational position in the last year is negatively related to bullying. However, the mere change in occupational position does not provide similar correlations. The controls for demographic characteristics, personality traits, and qualifications display the expected relations, although the effects are weak and often not statistically significant (see Table S5 in the Supplementary Material for all variables). Personality traits seem to play a higher role in the occurrence of coworker bullying than in supervisory bullying, perhaps because social interactions are more common among coworkers than among employees and their supervisors. Moreover, immigrants seem to experience less bullying from supervisors but not from coworkers.

To compare the relation between digitalized work and bullying with the impact of other job characteristics that are highlighted in the existing literature, such as job autonomy, routine work, and stress, we integrate job and workplace characteristics stepwise into the models (Tables S1 and S2 in the Supplementary Material for supervisory and coworker bullying, respectively). Models 0 in both Tables S1 and S2 display intercept-only estimations and show that supervisory and coworker bullying varies significantly not only between individuals employed within the same workplace but also between workplaces. Six percent of the total variance in supervisory bullying and 11% of coworker bullying can be explained by sorting into different workplaces (values are estimated with the intraclass correlation (ratio of variance between individuals working in the same workplace to the total variance)).

When no controls are included, digitalized work is related to 11.3% lower levels of supervisory bullying, as displayed in Model 1 (Table S1 in Supplementary Material). The effects remain generally stable when controls at the individual and workplace level are introduced. Notably, the effect of digitalized work increases in magnitude and significance when variables measuring other forms of work with machines and competency in handling machines are accounted for in Model III. The differentiation between digitalized technologies and other more established forms of work with machines—as well as feeling competent—helps to isolate the diminishing effect digitalized work has on supervisory bullying. This is true, even though digitalized work is only weakly correlated with either working with machines (positively) and competency in working with machines (negatively) (see Table S3 and S4 in Supplementary Material). The relative stability of the effect of digitalized work on supervisory bullying indicates that digitalized work influences supervisory bullying directly, has a genuine impact on the relation between employees and their supervisors and is not related to unmeasured mediators. The impact of digitalized work on coworker bullying, in turn, is not only generally weaker but also not statistically significant in most of the estimated models (see Table S2).

For highly qualified employees, supervisory bullying is higher when higher shares of employees work in routine jobs or more employees have psychological stress. A one-standard-deviation increase in the share of employees with psychological stress is related to 4.1% levels of higher supervisory bullying. In turn, supervisory bullying for highly qualified employees is less common when more employees have physically demanding jobs.

Although we have no information on coercive forms of control such as direct supervision or on rules, which might promote abuse and hostility between employees and their supervisors (cf. [Crowley 2014](#)). The lack of the variable should be especially problematic for the relation between employees and supervisors, as supervisors are those who control employees. In the event that digitalized work would be positively related to supervisory bullying (increases the occurrence of bullying), the lack of those controls would blur the results, as it would remain unclear whether digitalized work or the increased control related to digitalized work was driving the positive relation between digitalized work and workplace bullying. However, when the relation between digitalized work and supervisory bullying

is negative—as this is the case for our study—the lack of control measurements would only lead us to underestimate the impact of digitalized work on supervisory bullying.

We conducted several robustness tests to check the plausibility of our results. For example, we contrasted the impact digitalized work has on workplace bullying in manufacturing, a sector where digitalization should be most advanced, with the public administration, education, and health sectors, where digitalization should be least advanced (Tables S6 and S7 in Supplementary Material). The results are stronger for the manufacturing sector and nonsignificant for the public administration, education, and health sectors. Moreover, we ran analyses in which we dropped workplaces where no employees are involved with digitalized work and those with the highest levels of digitalization (Table S8 in Supplementary Material). Our results remain stable.

5. Discussion and Conclusions

Our results, estimated with linked employer–employee data and random effects models nesting individuals within workplaces, indicate that for all employees, digitalized work is negatively related to supervisory bullying, and for lower qualified employees, it is also negatively related to coworker bullying. These negative effects of digitalized work cannot be explained by other job characteristics, which might be related to digitalized work such as handling machines, competency, job autonomy, or routine work. Similarly, the effects are not related to psychological stress and physical demands, as we control for all those factors not only at the individual level but also at the workplace level. In other words, it is less explained by the layout of work, as it may be inevitably induced by technological change. Rather, the ways in which supervisors and coworkers cope with the usually fast technology-induced change at the workplace—a classical source of bullying in the literature—seem to trigger conflicts in workplace relationships.

The literature on bullying emphasizes the imbalance of power between victims of bullying and perpetrators as a precondition for the occurrence of bullying. Such an imbalance of power is present between employees and their supervisors, as employees are dependent on supervisors' decisions in many aspects of their careers. Digitalized work seems to change the relational dynamics and intervene in the learned balance of responsibilities and of what supervisors and subordinates expect from each other. For highly qualified employees, digitalized work seems to shield from bullying, as employees working with digitalized work gather key competencies crucial for the future of the workplace. Moreover, involvement with digitalized work will probably serve as a positive signal, at least for highly qualified employees' skills, prestige, and status. Moreover, experience with digitalized work might also serve as an important signal in the labor market.

The influence of digitalized work on coworker bullying is less distinctive. The protective effect seems to be present only for lower qualified employees. However, digitalized work has diverse applications, and the experiences of employees with digitalized work differ not only between workplaces and highly and lower educated employees, as we have shown, but probably also between occupations and the specific tasks the employees execute. We assume that the mechanisms that reduce bullying for highly qualified employees are related to the gathering of key competences, status, and prestige. In turn, the mechanisms that reduce bullying for lower qualified employees might be related to the work with digital devices, as described for the example of “pickers” working for Amazon. As employees hurry from one task to the next dictated by the digital device, positive but also negative social interactions among supervisors and coworkers seem to be diminished. Another interpretation is that lower-skilled employees—all of whom may be in an inferior and perhaps threatening situation—may develop and receive more solidarity in coping with newly introduced and abstract digital devices, which might also reduce bullying. However, more research, distinguishing between the specific occupations and tasks related to digitalization, is needed to investigate the specific mechanisms reducing bullying for different groups of employees.

Apart from the importance of individual engagement with digitalized work on workplace bullying, we find that for highly qualified employees, there is a positive relation between supervisory bullying

and the share of employees involved with digitalized work. In workplaces where digitalization has progressed, regardless of whether individually involved in digitalized work, supervisory bullying is more common for highly qualified employees. Digitalization of work may disrupt and change the established work processes and increase the necessity for new coordination and therefore the occurrence of conflicts. As employees worry about the future of their current positions and struggle to occupy positions with perspectives for future conflicts over the distribution of tasks, competencies and responsibilities emerge within workplaces and can lead to bullying. Digitalized work may establish new competency differentials among employees, their colleagues and supervisors, which may lead employees to challenge the existing status hierarchies or be merely viewed as challenging by supervisors (Reimann et al. 2020). For highly educated employees, for whom the power differences towards their supervisors are lower, such challenges, or the simple worry that such challenges might occur, might result faster in tensions or even bullying than for lower qualified employees, where the hierarchies are more distinct. In addition, highly educated employees are the most likely to utilize digitalized work as decision-reaching tools and profit from less stressful and more interesting jobs with promising perspectives for the future when working with digitalized work. The positive utilization of digitalized work might create tensions over access to digitalized work and the approval of competencies related to this kind of work. Similar to the processes described by Vallas (2006) for the US paper industry, employees and their supervisors might be interested in allocating the key tasks in their sphere of competence. On the other hand, the pressure to introduce digitalization may result in more authoritarian management styles, which are viewed as bullying by employees. Highly educated employees, who are more aware of their rights and status and are probably used to less authoritarian and more respectful management styles, might react more sensibly to the changes. We were not able to empirically investigate these theoretically plausible mechanisms. However, since bullying obviously cannot be prevented by changing job characteristics per se and the fast pace of change may contribute significantly to the risk of bullying, firms should place more emphasis on flanking the introduction of digitalized work with training programs designed to address the social implications of digital systems in addition to the technical aspects of digitalized work. More recent publications on the human-machine interface emphasize the need to integrate human emotions and perceptions in the understanding of how digitalization impacts work processes (Frank et al. 2019; Rahwan et al. 2019; Riedl 2019).

Our analyses are not without important limitations. First, the wording of the dependent variable is not ideal, as it accounts for bullying but also for being unjustly criticized. Therefore, the question might overestimate the extent of bullying taking place in the workplace; however, the mechanisms detected between bullying and digitalized work found in the paper should be independent from the actual scope of bullying. Second, the general measurement of digital work prevents us from distinguishing among the very diverse applications of digital techniques in workplaces and provides no measurement for employees' involvement in digital work. In addition, we do not know how long ago these technologies were introduced. Thus, we are not able to distinguish between transitory effects of organizational change and long-standing influences of digitalization. Finally, our analyses are cross-sectional only. This means that we are not able to distinguish between cause and effect, and the same can be said of the mediating work characteristics we included as covariates. In general, research on digitalized work and on workplace bullying is still at the beginning, and many questions, such as the question of which differences exist between occupations and industries, whether the occurrence and perception of bullying, or the impact of digitalization on bullying, differ between occupations and industries are not sufficiently answered. The main contribution of the paper is to draw a connection between two topics that were separated: digitalization of work and workplace bullying. This paper also provides an example for processes related to organizational changes, in this case digitalization, that trigger workplace bullying.

Our analyses raise concerns that the fast-growing implementation of digitalized work in workplaces creates serious challenges for employers and human resource management. If employers want to

avoid serious and productivity-threatening problems with within-firm cooperation and to strengthen commitment to the company, they should keep in mind that the implementation of digitalized work and the organizational changes linked to it might boost bullying. The problem gains importance as employers introduce digitalized work to remain competitive in the global goods markets, but they face other challenges as demographic shifts towards aging societies and skill shortages at the labor markets simultaneously. The changes in the labor market make it essential to create working conditions that retain qualified and productive employees. Higher levels of workplace bullying resulting from restructuring related to the introduction of digitalized work, as we find for highly qualified workers, might demotivate employees and trigger their desire to leave. This process might occur regardless of whether the employees are victims or just witnesses of the bullying and might be a serious obstacle to increasing competitiveness through digitalization. Therefore, employers should be aware of the impact of organizational changes related to the digitalization of work on workplace relations and monitor the introduction of such new technologies carefully. Laws against bullying as well as internal regulations and measurements within workplaces, such as sensibility training for managers, help not only victims or witnesses of bullying but also indirectly bind employees to their workplaces and ensure commitment and productivity in times of organizational changes when digitalization of work is implemented.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2076-0760/9/9/156/s1>, Table S1: Influence of digitalized work and other job characteristics at the individual and workplace level on supervisory bullying; stepwise model (workplace level random effects regressions), Table S2: Influence of digitalized work and other job characteristics at the individual and workplace level on coworker bullying; stepwise model (workplace level random effects regressions), Table S3: Correlation between bullying and other main variables at the individual level. Table S4: Correlation between bullying and other main variables at the workplace level. Table S5: Influence of digitalized work and other job characteristics at the individual and workplace level on bullying from supervisors and coworkers (workplace level random effects regressions). Table S6: Robustness checks: Influence of digitalized work and other job characteristics at the individual and workplace level on bullying from supervisors (workplace level random effects regressions). Table S7: Robustness checks: Influence of digitalized work and other job characteristics at the individual and workplace level on bullying from coworkers (workplace level random effects regressions). Table S8: Robustness checks: Influence of digitalized work and other job characteristics at the individual and workplace level on bullying from supervisors and coworkers (workplace level random effects regressions) dropping workplaces having no digitalized work and very high levels of it.

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Appendix A

Table A1. Variable construction.

Variables	Questions
Machine operator (These 4 dummy-questions were factored into a scale from 0 to 4.)	“I have to deal with technologies and machines at my workplace, which take away decisions concerning their regulation and to which I have to respond.” “I work with intelligent technology, which actively takes part in the regulation of working processes.” “To avoid mistakes with the technology, I need not only technical knowledge but also sense and intuition for the processes and possible risks.” “All technical systems and machines are connected with each other and communicate with each other on their own.”

Table A1. Cont.

Variables	Questions
Job autonomy (scale from 1~completely disagree to 5~completely agree)	“Within my working hours, I have control over the sequencing of my work activities.” “I am allowed to decide how to go about getting my job done.” “I am able to define what my job objectives are.”
psychological stress (scale from 1 to 5, where 1 corresponds to “always”, 2 to “often”, 3 to “sometimes”, 4 to “rarely”, and 5 to “never”)	“Often, I am already thinking about work-related problems when I wake up.” “When I come home, it is very easy to switch off from thinking about work.” (Reverse coded.) “Those closest to me say I sacrifice myself too much for my career.” “Work seldom lets go of me; it stays in my head all evening.” “If I put off something that needs to be done that day, I cannot sleep at night.”
“Big 5” (These 15 questions were factored into 5 scales that measured a respondent’s degree of openness, conscientiousness, agreeableness, extraversion, and neuroticism. Scale from 1~completely disagree to 5~completely agree; Cronbach’s Alpha 0.61)	Examples: “I see myself as someone who worries a lot” “I see myself as someone who is communicative, talkative.” “I see myself as someone who is original, comes up with new ideas.”

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