Digitalization of Logistics Work: Ergonomic Improvements Versus Work Intensification

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Abstract Digital technologies are more and more finding their way into logistics. On the one hand, they are associated with positive effects on the ergonomics of logistics work by replacing repetitive, stressful and ergonomically disadvantageous tasks. But, on the other hand, studies indicate that the intensification of work is increasing. According to this discrepancy, we investigate how digital technologies, ergonomic improvements and work intensification are related. We present qualitative-explorative results from different logistics departments and warehouses using digital technologies in order picking. Our aim is to analyze whether opportunities to substitute ergonomically disadvantageous tasks are used to integrate more challenging and attractive activities or whether they give rise to easier tasks. We show that such substitution potentials are almost exclusively used for intensifying work and hence, that possible positive ergonomic effects are eliminated or not at all a crucial aim when digital technologies are implemented in order picking.

1 Introduction

Digitalization and its technologies and solutions are often seen as the answer to cope with the increasing demands for individual products and services, shorter delivery times within dynamic environments and markets [30, 44]. Talking about potential core zones of a digital permeation, systematic networking and structural change, the focus quickly shifts to the segment of logistics: here a wide range of applications for digital technologies is seen, "*which allow organizations to increase efficiency*

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and productivity, whilst also providing greater transparency and accuracy in the movement of goods" [32, p. 176]. According to literature, intralogistics with its diverse fields of activities like warehousing, order picking, packaging, etc. is actually facing a major change in existing logistic structures and processes due to the digital transformation [45, 51].

Digital technologies interfere with the existing socio-technical system of companies and change the conditions of work [20]. Hence, they open up new and diverse possibilities to shape Human-Machine-Interaction. In the debate about digitalization and Industry 4.0 the implementation of digital technologies often refers either to potentials for better working conditions or the loss of jobs through automation [7, 11, 13, 43, 49]. While scholars today are more and more critical regarding the disruptive job loss hypothesis [5, 6, 31, 50], the results regarding better work conditions vary [24].

Better working conditions can arise in two different areas: The first area is linked to a higher degree of self-organization and autonomy and refers to a more fulfilling work experience. The second area are ergonomic improvements for employees by substituting repetitive and/or physically hard work in logistics through hands-free order picking, vital tracking, lifting aids, exoskeletons or reducing hand movements by the use of smart glasses. Against this background, through the substitution of ergonomically disadvantageous tasks we often see in consequence a rise of "easier" tasks. Instead of doing one straining work task, now three easier tasks have to be done. In this context, we analyze how the new digital technologies and ergonomic improvements and an intensification of tasks that follows relate to each other: Are opportunities of the substitution of ergonomically disadvantageous tasks used to integrate more challenging and attractive work or do they give rise to easier tasks? Does the work intensification eliminate ergonomic improvements? Here, we do not only relate the discussion on ergonomics and the discussion on work intensification, but also aim to enrich both debates, which still lack valid empirical results in the context of logistics. Focusing on order picking, which often is characterized by standardization, pre-structuring and physical stress [18], this chapter is structured as follows: In Sect. 2, we provide a short overview over different technologies and specific disorders and illnesses that occur in order picking. Based on that, we present the debates on ergonomics and work intensification in the context of digitalization. In Sect. 3, we present four empirical cases of the BMBF project "Innolab – Hybrid Services in Logistics" to analyze the relation between digital technologies, ergonomic improvements and work intensification. Finally, in Sect. 4 we sum up and discuss our results and draw conclusions.

2 Digital Technologies, Ergonomics, and Work Intensification

2.1 Digital Technologies in Logistics

A strong permeation and diffusion of digitalization on all levels is predicted in logistics [42, 51]. Although digital technologies like Cyber-Physical-Systems (CPS) are associated with increasing automation and efficiency, especially in logistics some obstacles prevent a complete automation of processes. This can be seen, for example, in the still very high proportion of manual activities, such as order picking. Here, the requirements to cope with dynamic and flexibility are very strong and employees play an important role in successfully handling those [18].

Therefore, digitalization projects often focus on "finding" the items rather than automating the picking process itself. Pick-by-Vision systems use for example devices like data glasses or tablets that are connected to the warehouse system via Wi-Fi, from where they receive relevant information for the order picking process. The device provides this information to the worker carrying out order picking tasks. Pick-by-Vision devices display information like contract orders, sequences, number of pieces etc. and guide the employee. Some models have a built-in scanner (e.g. camera) and eliminate the necessity to use an additional handheld-device.

A second technology variant are Pick-by-Voice systems. Instead of a handheld scanner and packing lists, the picker only needs a headset and a terminal when working with Pick-by-Voice. The terminal is connected to the warehouse management system and in most cases attached to the belt of the picker. The warehouse management system communicates the respective orders to him or her by radio. The system first calls a shelf. Once the employee has arrived at the shelf, the article and the quantity thereof are voiced. Once the warehouse worker has picked and loaded these, she or he confirms the process verbally. Then the next order is announced.

Thirdly, monorail systems, where the items are delivered to the picker, eliminate travel times of the worker and are more efficient in terms of picks per hour than the Picker-to-Part systems. Part-to-Picker systems, i.e. monorail systems, lack in flexibility regarding warehouse planning.

Eventually the working steps are simplified by the digital technologies and hence logistics is characterized by a large percentage of temporary work and a high level of low skilled work [3, 23]. In this chapter we focus on order picking. Such logistical activities often show a high standardization and pre-structuring and are often physically stressing (e.g. lifting up and loading heavy items, moving long distances) and require disadvantageous body postures [18, 48]. It is not surprising that pickers are often incapacitated by musculoskeletal disorders. In response, more and more companies develop ergonomic tools for order picking, as musculoskeletal diseases account for over 52% of all work-related illnesses in the European Union [17, p. 696]. Hands-free order picking and less travel time are often seen as ergonomically advantageous and are used to sell new technologies.

In general, according to data from Germany's largest health insurance company (AOK), the proportion of mental illness in all cases of incapacity to work has risen sharply [36, p. 447ff.]: It increased by 40% since 2008 and is responsible for about one in ten incapacities to work in 2018. However, most cases of incapacity to work in Germany are still due to respiratory diseases (just under a quarter), although these only account for a good 14% of all days of incapacity to work. Musculoskeletal diseases, on the other hand, are in first place in terms of sick days, which also account for the highest proportion of incapacity to work cases and days in the warehouse management sector. Within this sector, a quarter of the missing days and about 20% of the cases are due to musculoskeletal disorders [37]. This puts the warehouse management sector among the top ten occupational groups with the highest number of absences due to musculoskeletal diseases [36].

A second important factor is stress. Recent studies [2] report numbers for Germany as high as 80% of surveyed works council members indicate rising work intensity. Sick days due to mental disorders have more than doubled since 1994 from 1314 days to 2766 days per 1000 workers by 2012 [9]. While they are still a relatively small factor in comparison to musculoskeletal diseases, mental disorders are on the rise and with an increase in work intensity they are prone to become much more relevant.

Against this background, the implementation of digital technologies influences work in order picking systems. Here, we focus on ergonomic effects on the one side and potential work intensification on the other side. As the base for our further argumentation and our empirical findings, we show the corresponding state of research of the two lines of research which have not been connected to each other very often (see [18].

2.2 Digital Technologies and Ergonomics

Closely linked to the debate about digital technologies are changes in the Human-Machine Interaction and their consequences for work systems [20]. Here, the ergonomics of digital technologies and the shaping of work against this background is an important issue. Ergonomics as part of work research is a

> scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human wellbeing and overall system performance. [21]

The aim of an ergonomic design of work systems is to optimize the workload, to avoid negative effects and instead to foster facilitating effects [1, 47]. The underlying idea is, that human performance, if it is not impaired, improves the effectiveness and efficiency of the system and thus might contribute to realize the goal of an ergonomic design of work systems. Hence, the human being should be regarded as the main factor and as an integral part of the system, its workflow and work environment. The

field of ergonomics is divided into product and process ergonomics with different subareas like physical ergonomics, cognitive ergonomics and organizational ergonomics [1, 39, 42].

- *Physical ergonomics* deals with aspects like anatomy, anthropometry, physiology and biomechanics and the shaping of workplaces in order to avoid impairments of posture and movement.
- *Cognitive ergonomics* deals with human performance and human processing of information at the human-machine interface (e.g. perception, attention, memory, decision, motoric actions). It aims to shape and optimize the cooperation and interaction between human and technical system to enhance the efficiency of the whole human-machine system as well as the satisfaction and well-being of users.
- *Organizational ergonomics* focuses especially on work process related organizational aspects like division of labor, working times, teamwork etc.

Besides or across these three different fields of ergonomics mentioned above, there is also software-ergonomics. It deals with the adaptation of a software to the (mental and physical) characteristics, knowledge, behavior and habits of a user to ensure its usability. Ergonomics-related aspects in the context of technology and digitalization are also usability and user experience. *Usability* can be understood as the *"extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"* [22]. In contrast to this, *user-experience* is defined as the *"users´ perceptions and responses that result from the use and/or anticipated use of a system, product or service"* (cf. ibid).

Many studies dealing with ergonomics in the context of Industry 4.0 and digitalization address software ergonomics with usability and user experience of digital technologies and interfaces [4] or ergonomic requirements in the context of collaborative robots [34, 41]. Surprisingly, the amount of laboratory studies or experiments seems quite high, so many studies do not (or only to a limited extent) take place in or consider the reality of companies with their complex conditions and challenges. The debate of ergonomics and digital technologies lacks long-term studies in the operational experience of companies. Grosse et al. [17, 18] criticize that, although order picking has a particularly high amount of human work and a high proportion of manual processes, a human-oriented and ergonomic design of work has

> often been ignored in management-oriented research (i.e. the production, operations and logistics management literature). Instead, researchers have focused on developing decision support models that help to achieve economic performance goals such as low cost or low order throughput times in the past […], without paying attention to either the impact of system design on the human-in-the-system or the human influences on system performance. [18, p. 1261]

With regard to the implementation of digital technologies improvements in ergonomics and potentials to support employees, to reduce physical and/or psychological strain and to foster cognitive and senso-motoric capabilities are highlighted [14, 42]. In logistics, several stationary and mobile or wearable digital assistance systems already exist and are established in logistic companies.

Pick-by-Vision systems have recently become more sophisticated and comfortable [33]. Data glasses for example display relevant information dynamically and directly in the employees' field of vision.

Compared to paper- or tablet-based processes AR-technologies can support palletizing tasks and reduce palletizing errors [29]. Such logistic digital assistance systems providing packing information and instructions can reduce the risk of overloading (e.g. caused by damaging or forgetting articles), lower mental strain and frustration, and might have a positive impact on the motivation, satisfaction and performance of employees as well as on sickness rates [33]. Exoskeletons can support strenuous physical movements (e.g. lifting and picking heavy things) and reduce physical strain. In this context, Kinne et al. [26] show ergonomic potentials of using passive exoskeletons in palletizing activities where the palletizing task itself, the workload and task difficulty was rated lower by the test persons. Thus, the ergonomics of digital assistance systems highly depend on their specific usability and user experience, which influence the employees' rating of ergonomics and technology acceptance.

Despite these mostly positive reports and findings concerning the relationship of digital technologies and ergonomics in logistic work systems and especially in order picking, the following aspect should not be forgotten: usually, the main objectives of those digital assistance systems are, first of all achieving maximum picking performance, minimizing the error-ratio (e.g., wrong quantity or article type) and boosting the learning curve [33]. Hence, ergonomic improvements seem to be of a lower importance. Digital technologies can substitute physical demanding activities in logistics, have the potential to improve ergonomics and make work more interesting and varying. Nevertheless, some empirical findings show that in the course of implementing digital technologies an intensification of work often takes place.

This gap is also reflected in the current debate on the digitalization of work. Here, different scenarios of industrial and logistic work are discussed [19]. A positive scenario predicts rising employment effects, high-order tasks and qualifications, extended autonomy and all in all "*better jobs – jobs that at every level would be enriched by an information technology*" [52, p. 159]. A contrary, rather dystopian scenario assumes the emergence of negative effects that substitute and devalue industrial and logistic work especially on the low-skilled-level with a high degree of routine and restrict the autonomy of employees [13]. Work systems have a high degree of division of work and digital technologies like Cyber-Physical Systems (CPS) substitute human decision-making and crucial control functions of processes and work. This might also be called "*digital taylorism*" ([10, p. 15 ff., 46]). A third scenario group combines positive and negative effects and argues that a polarization of work occurs. Partial substitution processes and an erosion of work on the middle-level of qualifications take place and a shift to more complex tasks with high-order qualifications on the one side and a shift to easier tasks with low-order qualification on the other side might happen [15]. Hence, according to Goos and Manning [15], a differentiation of work into "*lousy and lovely jobs*" emerges. The concrete realization of this ideal-typical scenario depends on many aspects like the specific intention of the use of technology, market and customer requirements, wage levels or path-dependencies.

2.3 Digital Technologies and Work Intensification

Work intensity and intensification is not a new topic. Numerous studies have already shed light on it (for an overview see e.g. [40]). High work intensity is defined as the unbalanced ratio of the work result to be achieved (quantity/requirements) to the effort (time/resources). According to Ahlers [2] work intensification is the subjective perception of increasing work demands. Work intensification does not only appear in the form of increased workloads but can also be encountered as more complex performance requirements or more multi-tasking.

Reasons for work intensification can be manifold. Changing working conditions such as higher customer and market orientation, project work, mobile work or constant availability are all associated with higher work intensity [28]. Furthermore, staff shortages, technological innovations and changes in work organization, e.g. lean management, results-oriented work or target agreements [16] can cause work intensification.

High work intensity is a widespread phenomenon: More than 50% of the employees state that they work under strong deadline and performance pressure [8, 12]. Ahlers [2] conducted multiple analyses with the WSI Works Council Survey of 2018, a representative survey of ca. 2300 works council members in the private sector. 80% of the works council members report an increase in work intensity over the last two years in their respective companies. This varies with the specific employee group: 90% of skilled workers are affected, but only 44% of unskilled workers. 77% of the works council members think that work intensification has led to an increase in health problems, 68% think that the working atmosphere has deteriorated as a result. They see the main reason in thin staffing, which is not necessarily a consequence of illness or high order levels (which are also contributing factors) but is often described as normal and a rather conscious management decision. In addition, it is reported that vacancies are very difficult to fill. "Bad" management is often cited as a reason for unfavorable working conditions, such as permanent staff shortages, which in turn cause absences due to illness and result in declining work satisfaction.

Meyer et al. [38] conclude in their study that the introduction of new technologies is associated with an increase in work intensity but is also associated with opportunities and risks for both the work situation and the well-being of employees. Ittermann et al. [25, p. 160] show, on the basis of representative survey data, that in logistics there can be – and in comparison with other industries also above average – positive trends in the sense of workload reduction through digitalization (see Fig. 1). In their overview "The Intensification of Work" Paškvan and Kubicek conclude that

> [i]n many organizations, downsizing has been seen as a quick move to reduce costs, but the associated improvements are probably only temporary. In the long run, employees have more work to do, causing work intensification […], stress-related illness and occupational accidents […]. [40, p. 38]

Relating the results concerning the debate on digital technologies and ergonomics with the debate on digital technologies and work intensification, the following contradiction appears: On the one side, digital technologies have a high potential to

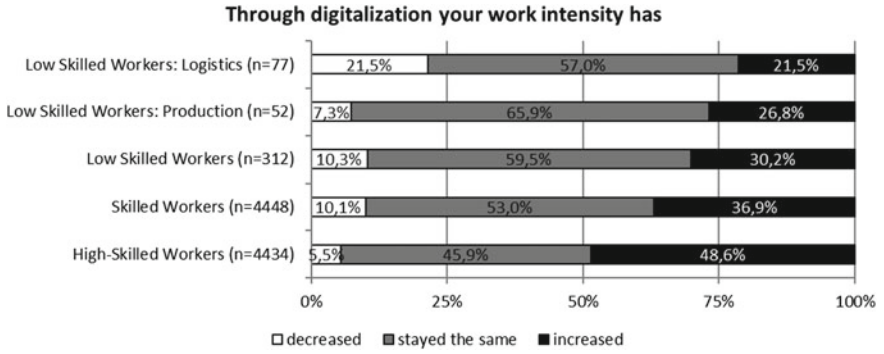

Fig. 1 Digitalization and work intensity. Source Ittermann et al. [25]

support employees, reduce physical and/or psychological strain and improve work ergonomics. On the other side, due to progressing digitalization, the work intensity has increased. This leads to the assumption that the intensification of work eliminates potential improvements in work ergonomics. Furthermore, emerging opportunities for the integration of more challenging and attractive tasks, due to the substitution of ergonomically disadvantageous tasks, might not be realized in companies. Against this background, we present our empirical findings in the following section to examine how digital technologies, ergonomic improvements and work intensification relate to each other in order picking. We also investigate whether opportunities of the substitution of ergonomically disadvantageous tasks are used to integrate more challenging and attractive work, whether they give rise to easier tasks and whether the work intensification eliminates ergonomic improvements.

3 Empirical Cases

The empirical cases our argumentation is based on stem from a research project called "Innolab – Hybrid Services in Logistics"[1] at the TU Dortmund and the Fraunhofer Institute for Material Flow and Logistics (IML) Dortmund. We conducted case studies including qualitative interviews, observations/warehouse tours, and the analysis of documents and websites in different companies, especially in order picking. For the evaluation of the interviews we followed a qualitative content analysis according to Mayring [35]. For this article, we selected four case studies where we analyzed 20 qualitative interviews with managers, works council members and employees. The interviews with the managers and works council members lasted from 90 to 120 min. Topics were consequences of the digitalization, ergonomics, and implementation of Industry 4.0-solutions (i.e. assistance systems). Interviews with employees were conducted during warehouse tours and lasted only a few minutes.

[1] https://www.innovationlab-logistics.com/

Table 1 Overview of empirical cases and interviewees

	Industry	Size	Interview Partners			Digitalization Solution		
			Management	Works Council	Employees	Pick-by-Vision	Pick-by-Voice	Monorail
1	Tools	600	1	2	1	X	–	–
2	Automotive	1000	3	2	1	X	X	–
3	Furniture	2200	2	2	2	X	-	X
4	Food	700	–	2	2	–	X	–

They consisted mainly of pointed questions regarding their own work experience and their use of the assistance systems. We chose the companies to present an overview of the different circumstances under which order picking is performed. From a tool manufacturing company in the steel sector with a small warehouse, to a local retail distribution center, an international distribution center, and an automotive supply warehouse, typical cases for order picking with varying plant sizes were chosen (see Table 1).

Case 1: Tool Manufacturer Warehouse
The company produces different high-quality tools (e.g. spanners, screwdrivers, torque tools and tester) with more than 600 employees. In the order picking area of the company work 10 pickers per shift. A Pick-by-Vision solution was implemented. Here, smart glasses are used in order picking processes. This case not only shows ergonomic effects and potentials of work intensification associated with a digital assistance system, but it also illustrates problems why the technology is not used by the employees in their daily work.

Case 2: Automotive Supplier Warehouse
The company has more than 1,000 employees and is working in contract logistics offering full-service-logistics and the material supply for assembly. As a service partner of the automotive industry almost all of its services (e.g. material supply of the vehicle final assembly, assembly of chassis modules, production of tank modules) focus on a single costumer. Order picking of products for production and assembling according to just-in-sequence and executing outsourced assembling processes for its customer are the core competences of the company. In different buildings different technologies are used in order picking to minimize error-rates: Pick-by-Vision and Pick-by-Voice .

Case 3: Furniture Retail International Distribution Center
Another case is a distribution center for an international furniture retail company. In the distribution center there are 2,200 workers employed (1,600 directly at the company and 600 via service partners). Work in the warehouses is done with forklifts or pallet trucks. Additionally, there is a monorail system where parts are delivered to the picker.

Case 4: Food Retail Local Distribution Centre
The company is active in food retailing. In the visited warehouse, articles from the dry and frozen product ranges are picked according to the principle “person to goods”.

The employees in the warehouses work with a Pick-by-Voice system, which has been in use for about five years at the time of the survey, and use forklifts. A total of 700 order pickers are employed at the location, 80% of them are unskilled or lateral entrants from other professions.

In the next subsections we highlight how each digital solution is implemented in the respective firms and what consequences for ergonomics and work intensification arise.

3.1 Pick-by-Vision

Case 1: Tool Manufacturer Warehouses
The observed tool manufacturer uses a smart glasses Pick-by-Vision solution. The main purpose of implementing this Pick-by-Vision system was to enhance the efficiency in order picking, generate time savings in scan processes and increase the picking rate. This was planned because of the spatial restrictions of the warehouse: The order volume made an additional picker necessary, but the warehouse was too small to accommodate another picker with a palette truck.

Ergonomic improvements have not been addressed and have not been a crucial reason for implementing this technology. Even though the works council members mention some potential positive effects like reducing premature wear of employees by hands-free order picking, less physical bending, and fewer movements to reach back and overhead. Furthermore, an employee reports that the glasses improve the presentation of information.

> Well, I like the glasses. I prefer the glasses. Because it's just more comfortable on the eye. We've just got some parts which you have to search. You simply have the advantage that you don't have to go back to the terminal to look again: What was that again? Or something like that. I think that's quite pleasant, to see it straight out of the eye. (Employee order picking)

Overall, however, the company and most of the employees are very disappointed with the smart glasses. Before implementing the Pick-by-Vision system many employees doubted potential positive ergonomic effects. The smart glasses cause headaches and earaches due to the weight of the glasses. Due to this, many employees do not work with the glasses but with the old order picking technologies (tablets and handheld scanners). According to a works council member, against the background of potential physical strain (e.g. headaches, earaches, eye problems and fatigue), rest and break times for the users are important to prevent rising error rates in order picking that might occur in consequence of wearing the smart glasses over a long time and cause fatigue and psychological strain.

Additional problems arose with the use of the integrated camera for scanning labels and barcodes. The Pick-by-Vision solution had problems with old labels at storage locations that were difficult to scan. Hence, a time consuming and costly replacement process of a large number of labels was necessary to increase legibility of barcodes. The warehouse is characterized by narrow alleys causing jam problems

for the order picking vehicles. Little space between the racks impedes and prevents the use of large labels and barcodes, sometimes there is also only a small distance between the individual barcodes themselves making scan processes for the employees with the glasses difficult and uncomfortable. Furthermore, the camera of the glasses is rigidly installed and does not correspond to the actual viewpoint of the employees. They have to perform specific head movements and postures to aim directly and precisely onto the barcode to be able to successfully scan it. An employee says, if he wants to scan a barcode, he has to force himself sometimes to *"look past on the left so I can hit the right"* (Employee warehouse). This affects ergonomics negatively because employees need to perform unnatural and unusual movements and physical bending. The result is a high frequency of errors because wrong labels of storage locations might be scanned. This can cause or strengthen time pressure and physical stress. Because of this, employees usually do not use the Pick-by-Vision glasses or only one function, namely the presentation of picking information. They rather continue using the old handheld scanning devices because they are easier to use and more comfortable.

The ERP-System provides the employees with orders, their priorities and their sequence of processing. "*It is also pre-set. The employee has no influence on what he gets. It's set up in advance. […] And then he's guided through the warehouse*" (Employee warehouse). On the condition that the Pick-by-Vision system would work, it could facilitate training processes for new and unskilled employees: "*Because the work steps are so beautifully broken down means that only what is necessary, is displayed*" (Head of logistics). All in all, the scope of action and decision remains relatively small or "*is equally zero*" (Head of logistics) and did not improve due to the implementation of the Pick-by-Vision system—even if it would work. The main reason for the smart glasses was work intensification and ergonomic benefits came not into fruition. In the end, the glasses were rejected because of their ergonomic disadvantages.

Case 2: Automotive Supplier Warehouse

In order picking the automotive supplier uses a Pick-by-Vision solution via a tablet. Usually the order picking process with the tablet is organized as follows: The employee drives with an order picking vehicle through the alleys of the warehouse and the installed tablet on the vehicle displays the picking order consisting of a male or female first name and a number of pieces. The names correspond to specific storage compartments and replace the complex and error-prone handling of different numbers at the compartments. The storage compartments are ordered alphabetically per male and female names. The tablet visualizes the right storage compartment in form of the relevant name and also shows the relevant number of pieces to be picked for the sequence. After scanning the barcode of the compartment with a handheld scanner, the connector system on the vehicle shows an exact position and orientation for the pieces in the production sequence. A new scan shows, if the order picking has been carried out correctly by the employee, who then confirms this on the tablet. The order of the sequence is structured and automated by the transport control system and the Pick-by-Vision system. The usability of the tablets is very good and does not

require specific technological knowledge, a "digital affinity" is sufficient. "*That's not a menu you have there. Instead you really see where you have to go and a confirmation. And then you scan something. And the scanning confirms it*" (Works council deputy chairman).

In the course of the implementation of the tablet, the error rate in order picking significantly decreased, but the throughput did not increase significantly. While the order picking work was already tayloristic and structured before, due to the Pick-by-Vision system via tablet, work in order picking became more tayloristic, i.e. much easier, more structured and time-bound. Due to this extended standardization of the work process, the scope of action and decision for the employees became highly restricted. Against this background, a rotation of work tasks is practiced to enhance the variety for employees in sequence order picking with the Pick-by-Vision system at least on a low level.

> We just want people to do a kind of group work. […] And we simply assume that it doesn't happen, that the stronger person takes the best jobs, but that they organize themselves in their group and then practically get the orders. Everyone still does everything, provided that he or she is physically able to do it. (Head of business unit logistic)

Especially the works council refers to a huge control potential of processes and work in order picking, enabled and enhanced by the Pick-by-Vision system and the transport control system: "*We are transparent. We are completely transparent for […] [the OEM]*" (Works council deputy chairman). Due to the combination of transport control system and Pick-by-Vision (as well as Pick-by-Voice) sequence errors "*can be traced back to the tip of the nose*" (Works council chairman). Although the interview partners did not mention mental stress, the potential of an increased traceability and transparency of individual performance and errors seems to us to be omnipresent and increases time and performance pressure for the employees and the pressure to comply with the defined error rates. Furthermore, optimization processes were conducted to optimize routes and travel times of the employees in order picking. "*Also for ergonomic reasons the employee should move, but also not walk too much during the day*" (Head of business unit logistic). However, the employees are now order picking more in the course of this optimization, which might overcompensate positive ergonomic effects.

Case 3: Furniture Retail International Distribution Center

In the case of the international distribution center the basic picking routine via tablet is the same as in the case before. The tablets and the accompanying Pick-by-Vision system have long been introduced and widely accepted. Although the tablet increases work intensity, it is under the supervision and control of the works council. They assure that the data generated by the tablets is not used to measure individual worker performances. A newer addition to tablet guided picking is a scan glove which makes the additional work step of confirmation of the picking via handheld scanner obsolete. Here the acceptance is quite good because the freedom of how to use the scan glove is high: The pickers can either use the glove, use a cuff if they do not want to wear a glove, or not use the new scanning tool at all. In the end, most workers are using

the glove, some use the cuff and only very few stick with the old handheld scanner. The hands-free picking process is widely perceived as more comfortable. The aim of the scan glove was to allow for a higher number of pickings per shift. Ergonomic considerations were not taken into account and, as in the previous case, it is highly debatable if the ergonomic advantages are not eaten by work intensification in the long run.

To sum up, and in agreement with Grosse et al. [18], our Pick-by-Vision cases highlight that ergonomic reasons are either not considered at all. They seem to serve merely as a pretended reason for the legitimation to implement digital technologies, which aim to enhance productivity, reduce error-rates and gain more control and transparency of order picking processes. Rather, the empirical findings presented above show that more productivity goes hand in hand with higher work intensification. Ergonomic improvements that emerged where mostly not intended and are probably not enough to offset higher work intensity.

3.2 Pick-by-Voice

Case 2: Automotive Supplier Warehouse
The automotive supplier also uses a Pick-by-Voice system. The order picking process is structured via Just-in-Time and Just-in-Sequence. The system consists of a headset, a microphone, a headphone and a small PC. Due to the implementation of Pick-by-Voice technology, work in order picking became more tayloristic, i.e. simpler, more structured, monotonous, repetitive, and time-bound. Accordingly, the scope of action and decision for the employees have been reduced by using the headsets because the employee is very strictly guided by voice. The training time of the Pick-by-Voice headset for new or unskilled employees is very low. Processes of de-qualification are observable: now, employees require even less training to fulfill order-picking tasks.

Due to the implementation of the Pick-by-Voice system the error picking rate considerably decreased.

> Well, you have to say that this Pick-by-Voice does not necessarily make the employee faster in his work, but he is […] just as fast. […] But we've had an enormously high level of quality with it. […] So for every million picks, we make about three mistakes. (Head of business unit logistic)

But in the course of analyzing and optimizing the routes and travel times of the employees, new potentials for rationalization emerged that have been used to intensify order picking. "*It's increasing. The more travel times are eliminated, the more picking rises*" (Works council). Here, such optimizations are possible because the Pick-by-Voice system allows the recording of moving profiles: "*They do not only see the route they are walking, they also see the time*" (Works council).

Due to analyzing and optimizing routes and travel times, optimizing sequence order picking and improving error rates by the Pick-by-Voice system, a part of the staff was reduced. "*We no longer need so many quality assurance [QA] personnel.*

Well, we've really had to give up two positions in every shift at QA, I think. There are six jobs broken off" (Works council). The face-to-face-interaction between QA-employee and order picking employee in this case ceased and was substituted by a standardization and technological control mechanisms reducing error rates in order picking.

From an ergonomic point of view, the Pick-by-Voice solution enables a hands-free order picking and hence facilitates order picking work by providing only relevant information that are required to fulfil the sequence. The employees can adjust the speed and acoustic signal or voice of the Pick-by-Voice headset. Due to the reduction of information and complexity as well as to the significantly decreased risk, that employees make mistakes in order picking potential overstraining in some cases could successfully be prevented.

Nevertheless, many employees have to cope with increasing psychological strain, despite the reduction of complexity, technological support and instructions of the Pick-by-Voice system. Some employees report a higher strain caused by the necessity to pay attention at any time wearing the Pick-by-Voice headset and listen to its instructions which might be perceived by the employees as a permanent acoustic irritation. In doing so, the employees need to keep an overview of their working surroundings to prevent accidents, for example with vehicles driving around. Although the headsets only have a speaker on one side, so that the order pickers are not completely shielded or isolated from their environment and its events, they need to stay alert all the time. This is aggravated by a huge degree of structuring, monotony and repeatability of order picking with the Pick-by-Voice headset. "*If you hear seven and a half hours: 'Go to point X. Extract […] Please confirm.' If you hear that 200 times a day, you'll snap. Right?*" (Works council chairman). In case of malfunctions of the Pick-by-Voice system mental/cognitive stress might occur: *"And then malfunctions, right? Because the Pick-by-Voice doesn't run smoothly. Then you have to repeat it a thousand times. You're going crazy"* (Works council deputy chairman).

Another cause of increasing psychological stress is that every pick in the sequence order picking can be assigned to the corresponding logistical employee via his personnel number. According to a works council member, order picking in sequencing in combination with Pick-by-Voice allows for a huge control potential of work. Indeed, according to the interview partners an evaluation for performance and behavior control is possible, but they point out that it is not conducted in the company. The works council is implementing a works agreement that contains guidelines and information on how to deal with the introduction of new technological systems and data privacy requirements. Despite these negative effects according to a works council member, the acceptance of the employees of the Pick-by-Voice solution is quite high.

Case 4: Food Retail Local Distribution Center

In the case of the local distribution center, the Pick-by-Voice solution has a substantial effect on the physical and psychological well-being of the employees. On the one hand, the physical work increases. In this case, the picking volume has increased by 50% (in comparison to picking with paper lists). The ergonomic improvements resulting from hands-free order picking are thus countered by an increased picking

volume and, as a result, a higher total lifting weight per shift. The reduction of "idle times" (like walking to the office to get the next picking list) is an additional factor. Although the work council attempted to counteract the work intensification by increasing the recovery time from five to ten percent, employees repeatedly pointed out the lack of breaks. This is summarized by a works council member as follows:

> The work itself, especially in the picking area, has been reduced to the most stressful activities. Because all the things you used to have, such as: I'm going to the office, what should I do next are no longer necessary. Because I have everything right here. And the proportion of this so-called picking, that is, this grasping and lifting, is of course considerably increased. That's physical, yes, as I said, the work has become harder, not easier. (Works council member)

The wearing comfort of the Pick-by-Voice solution also affects physical well-being. The headsets are perceived as uncomfortable by some of the staff and have led to headaches. However, it has improved since the system was introduced because the pickers have been equipped with the latest generation of headsets.

According to the employees, the psychological stress has also increased considerably. Many people find processing the announcements of the Pick-by-Voice system cognitively challenging.

"So, the biggest problem we have is the psychological pressure. Like I said, we get the headset on the head and they bombard us with numbers." (Works council member).

Another stress factor was, especially in the beginning, the disturbance of the system. These included Wi-Fi failures, unclear announcements, and not understood confirmations of the picker by the system. However, due to improvements by the employer, these disturbances have been reduced to a minimum.

The issue that was most often raised, apart from the aspect of increasing work, was "communication". On the one side, workers complain about psychological problems resulting from the fact that they have to communicate almost exclusively with a "monotonous computer voice" during their entire working hours.

> Because just this stupid wearing [of the headset] and this getting used to it, to hear a voice. Some people say 'Hey, I repeat that at night, right?'. Because all they're saying is a number, a check digit. She says, 'Take three, take three'. You say: 'Okay, okay'. Or: 'confirm' or whatever. And some even repeat it at home. (Works council member)

On the other side, as already mentioned in the previous section, the possibility of compensation is limited, as communication with colleagues is much less frequently due to the Pick-by-Voice system.

> [The communication is] decreasing. There are still some who can articulate, but that is not much anymore. They used to communicate more with each other. That's over. (Works council member)

By contrast, the limited possibilities for action are judged much more ambivalently. Thus, most of the employees have no problems with the "externally controlled navigation" through the warehouse. Some are even happy about the decreasing responsibility. Only a few workers prefer to pick on their own.

A last aspect concerns the transparency of work performance, which is also indirectly related to the Pick-by-Voice system. Due to the coupling of this form of paperless picking with the warehouse management system, the work of the employee can be tracked much better, because the picker must confirm each step of the picking process (naming the check digit on the respective shelf, confirming each individual picking process). This creates a feeling of permanent supervision among the employees and additionally reduces the willingness to communicate with colleagues or otherwise take a short break. It is not even decisive whether their data is used by the employer. According to the works council, this company only checks certain data if a picker's performance is noticeably poor over several days and weeks, which is related to the strong limitations by the "General Data Protection Regulation" (GDPR) in Germany.

To sum it up: Pick-by-Voice increases the physical and psychological stress of the employees. On the one side, there is an increased picking volume and a higher total weight per shift, an increase in cognitive effort ("bombardment with numbers"), in the isolation of the individual picker and in the transparency of their work performance. On the other side, there is a lack of compensation possibilities. The work of the employee is reduced to the most stressful activities ("pure picking"), because "more restful activities" are no longer necessary. Furthermore, communication with other employees is only possible to a limited extent. In addition, changes that (also) benefit the pickers (e.g. increase in recovery time, more reliable Wi-Fi network, and new generation of headsets) do not seem to have improved the physical and psychological well-being much.

3.3 Electric Monorail

Case 3: Furniture Retail International Distribution Center

The furniture warehouse uses two distinct systems in their warehouse. One is a traditional Picker-to-Part system which works with pallet trucks and forklifts. The other is comprised of an electric monorail which is directly connected to a fully automated small parts warehouse. The processing of outgoing and incoming goods is operated by a different worker. Of special interest in that warehouse are the electric monorail system as the most advanced one:

> Because EMS is the thing where most […] is done technologically. They also have their own KPI dashboard, where they can see exactly how it works? […]. So there is actually the greatest software support. (Deputy warehouse manager)

The technologically most advanced station proved to be the most ergonomically disadvantageous. The electric monorail system is connected to an automated small parts warehouse and transports goods to the picker where he or she commissions into a station. Workers need to bend down very low when putting the parts into the station which is even aggravated as the first parts to put there are normally the heaviest ones for which they have to bend down the most.

> And the employee stands all the time and then just has to pack up the goods that come by […]. And there we have, and I want to say that, we definitely save order pickers. (Works council chairman)

While these rail systems are responsible for a rise in productivity, workers feel less in control of their work and through the work at the station they feel isolated (to a degree) from their co-workers as they work alone in these stations and any co-worker is at least ten meters away. Also, the work intensity is very high because there is always the next order coming. The workers found several ergonomic improvements themselves and had to insist on their implementation because of a skeptical management. One was to equip the station of the electric monorail with rubber mats. This made standing and kneeling on a step in front of the pallet in the station more comfortable.

4 Conclusion and Outlook

All in all, the presented cases seem to suggest, that all the talk about ergonomic approaches seems to be more of a fig leaf than a wide-spread strategy to solve one of most pressing problems in logistics in Germany today: labor shortage.

Most solutions presented here aim to raise the number of picks per shift, lower error-rates, diminish training time, and eliminate idle times. The foremost solution to this are various assistance systems and advanced software systems in the background. These solutions typically cut away tasks like getting a new order list to pick and planning a route through the warehouse. These tasks get replaced with more picks. The consequences are a higher work intensity and progressing taylorization of tasks, leading to the desired results: More picks per shift without the need to increase the number of employees and a further simplification of work tasks, thereby reducing the needed training time. Hence, we see a mostly digital taylorism scenario in order picking.

While in the short run this strategy seems to alleviate the labor shortage in the logistics sector by increasing the workload, first problems are already occurring. Because it is ignoring long-term consequences, this approach needs a worker surplus on the labor market. The rising work intensification should result in higher absenteeism due to illness and accidents in the long run. Which in turn leads to a higher turnover in the workforce which is counteracted by the shorter training times due to the increased tayloristic organization of work. For this to function, the labor market needs to be filled with job seekers. Otherwise the workers in that segment will seek out more attractive work, because the short-term solution makes this kind of work highly unattractive: It is boring, dull, and not well paid. Technology acceptance will be low due to the constrained scope of action and decision and the resulting low self-efficacy [27]. Since the system is built in its core on the exchangeability of the employees, the employees will not feel appreciated very much. Corporate loyalty will be low and for very minor increases in pay they will change employers. In short,

exchangeability of workers adds bargaining power to the party which has the rarer commodity: Workforce or workplace.

Adding the aging of the German society into account, the labor shortage problem will increase twofold: Firstly, there are less new workers entering the labor market and secondly, the older workforce will have even more problems with the increasing workload. Since the demographic change is a widely known phenomenon by now, it is somewhat surprising that long-term strategies which incorporate ergonomic viewpoints are still relatively scarce and health prevention, corporate loyalty and corporate culture are still overlooked. Often mitigating suggestions (e.g. job rotation, increase in rest periods) come from works councils and have to be incorporated against employers' resistance.

In the light of the Corona pandemic of early 2020 two more contradictory factors have emerged. On the one hand, the increased demand for home delivery of goods instead of buying in a shop creates even more job opportunities in order picking and, as such, should elevate workers bargaining power. On the other hand, an economic recession seems to be nearly certain. Since order picking jobs are mostly low skilled, workers from other industries may seek jobs in order picking, thus changing the power balance yet again.

Logistics and ergonomics research is in dire need of more long-time studies under real working conditions. Even the few survey results which are available for logistics work (see Fig. 1) are based on relatively low numbers of cases.

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