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Basic human needs and robotization: How to make deployment of robots worthwhile for everyone?

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ABSTRACT

It is in organizations' best interests to support the motivation and wellbeing of their personnel during organizational changes. One example of this is robotizing work in such a way that the employees also perceive the outcome to be worthwhile. This is especially relevant when supporting and augmenting human competences and contributions in service jobs with new-generation robots. The present study examined the realization of work-related material and psychological needs between robotized and non-robotized workplaces, as well as the relationships among robotization, basic needs, and job satisfaction. The population-based study used nationwide Quality of Work Life survey data collected in Finland (N = 4089). The statistical analyses were conducted considering various fields of work. The results show that in robotized work, material needs are met better regarding income, but not necessarily regarding the working environment. Psychological needs (competence, autonomy, and relatedness) were proven to be met more frequently in non-robotized workplaces than in robotized workplaces. Satisfied psychological needs were then positively associated with future-oriented job satisfaction (FJS) in both robotized and non-robotized workplaces. However, there were differences depending on the field of work. In some robotized workplaces, less realization of basic needs even supports FJS. The results demonstrate the importance of acknowledging human factors in robotization and provide valuable information for change management in different industries. Technological changes may not support employees' basic needs by default, and robotization entails distinct qualities dependent on the field of work.

1. Introduction

Contesting the claim that employers introduce robotization purely to improve the cost-effectiveness of operations, new era organizations are coming forward with diverse motivations for technological changes, including social responsibility [1]. This is well in line with new policies that emphasize the importance of socially sustainable technological changes in society and in working life [2]. In addition to the changes in manufacturing industries, the digitalization and robotization of service jobs are topical and important themes in macroeconomy debates concerning the future of work and employment [3]. Robot deployment in service work emphasizes the premise that technological changes are not only about economic values but also about human values, such as the wellbeing and satisfaction of customers (e.g., patients) and personnel (i.e., employees at various levels) [4,5].

For successful socially responsible *robotization*, it is crucial to acknowledge and support employees' needs during and after technological changes. However visible in political and organizational strategies, the actual status of realized human needs in robotized work has not thus far been investigated. In this study, we pause to consider how the realization of material and psychological needs is actually perceived in robotized and non-robotized organizations.

By definition, robotization is a *resource* for work, as it is meant to support physical, psychological, social, and organizational conditions and to lighten the workload [6]. Resources such as robotization play a part in work motivation when they successfully contribute to employees' positive development and foster the basic psychological needs of perceived autonomy, relatedness, and competence [6–8]. Technological changes can be perceived as useful, meaningful, and satisfactory by employees, but this usually requires a high level of motivation [9]. The question is, "What is there in it for me?". This question can be broken down into how basic human needs are met in the workplace after the change and, in this case, after robotization. The question concerns the extent to which new technology and robots serve human needs and, conversely, the extent to which they are detached from human needs. In this study, we investigated the self-reported realization of the basic

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needs of individual workers and analyzed how job satisfaction depends on meeting those needs, as well as the field of work and the status of robotization in the workplace.

The objective of this study was to examine 1) the realization of work-related material and psychological needs in robotized and non-robotized organizations and 2) the association between the realization of basic needs and future-oriented job satisfaction (FJS). We used data from the nationwide Quality of Work Life interview survey collected by Statistics Finland (N = 4089). The correlative study design contributes to the research literature on the psychosocial impacts of robotization on employees.

Research on human factors in robotization usually focuses either on people's attitudes and expectations regarding future robotic assistance or on user experiences in studies introducing new robotic equipment [4,5,10,11]. Rather than identifying hypothetical threats and opportunities in technological changes or factors of robot acceptance, this study utilizes statistical information to investigate the thus-far neglected topic of job satisfaction after robotization [12]. Simultaneously, the aim is to meet the acknowledged need for empirical studies that compare work in the same fields of work and between robotized and non-robotized organizations [12,13]. It is also to provide between-field comparisons *vis-à-vis* earlier findings that demonstrate social responsibility as a context-specific phenomenon [1].

2. Theoretical background

2.1. Corporate social responsibility (CSR)

Understanding human behavior as a part of successful organizations has long been on the agenda of management and social studies. If the early managerial works of the industrial engineer F. W. Taylor are ignored, it was the sociologist Elton Mayo and his team who provided a systematic model for the research of the human aspects of organizations with their famous socio-psychological Hawthorne studies in the late 1920s and early 1930s [14]. One can take a critical stance against the managerial programs of scientific management codified by Taylor or even to the conservative motives of the Human Relations School personified in Mayo [15], yet their efforts were the initial impetuses for emphasizing the role of human qualities in designing mechanized industrial processes.

Since then, factories and the work performed in them have changed considerably. The introduction of computers after World War II not only accelerated automation and new organizational principles in industry, but also quickly led to visions of knowledge and information as the key resources of production and societies at large. For example, Daniel Bell, who labeled the new era of post-industrial society, also distinguished between signal-level computer data, structured information, and processed human knowledge [16].

As societies become tied to technologized information, the increased use of automation in production lines and the emergence of personal computers and other communication technologies all involve a fresh approach to the research and assessment of human competences. The fusion of information and technology generates a broad scope of conceptual constructs, such as knowledge engineering and expert knowledge, including the challenging constructs of artificial intelligence. Toward the 1990s, the acceleration of innovation cycles and increasing interdependence between economic and social development had to also be recognized. In societies that rely on information technology innovations, the cycles of technological revolutions have happened not by centuries or even decades but by a matter of years.

Technology-driven information societies facing rapid and disruptive innovations call for social responsibility. Scholars, moreover, have been forced to take a closer look at the relationships between social development and economic effectiveness and competitiveness and productivity. For example, the famous diamond model developed by Michael Porter in his book, *The Competitive Advantage of Nations* (1990), provided an influential framework for analyzing the synergies of industrial clusters and competitive strengths in the context of society as a whole [17].

The term "corporate social responsibility" was introduced to cover the expectations encountered by organizations and institutions. According to this view, value-creating business models and business practices must be sensitive not only to factors like technological change, market share, and consumer preference, but also to common ethical values and human needs. According to Acquier et al., the actualization of this research occurred in the US in the early 1970's, where organizations began to develop new practices to fully commit to social responsibility [[18], p. 224]. According to Hu et al., the rapid development of the Internet and other communication technologies since the mid-1990s has specifically favored business model concepts that not only help "create, deliver, and capture value through the exploitation of business opportunities," but are also seen as an organizational configuration that was used by firms "to differentiate themselves from competitors and create competitive advantages" [[19], p. 1].

The rising need for socially, ethically, and environmentally sustainable business models has led to further development of models of responsible corporate strategies. The concept of creating shared value (CSV), originally introduced by Porter and Kramer, adopted a premise in which the competitiveness of a company and the health of the communities around it are mutually dependent [20]. Seen from the evolving sustainability perspective, the CSV concept has extended the challenge of value creation in society to human needs [21].

Moreover, the "responsibility turn" in corporate strategies has been consonant with the fact that service work has become an important market for digitalized solutions, including robotics. Professional and private use of service technologies has since been a growing field for both new applications of accumulated industrial solutions and novel service innovations. As Wirtz et al. stated, in services, applying robots can be seen as "an inflection point with regard to productivity gains and service industrialization like the industrial revolution in manufacturing that started in the eighteenth century" [[22], p. 907].

After decades of *acknowledging* the importance of human and social factors in technological changes, we now need empirical evidence about how CSR *manifests* in perceived motivation and job satisfaction in the workplace. In this study, the focus is on workers' basic human needs and how these are met in workplaces that either have or lack robots.

2.2. Basic human needs

Committing to the socially responsible principles of robotization, employers strive to support employee motivation and wellbeing during and after work-related changes [23,24]. This includes supporting their livelihood and working conditions as the primary work-related physiological needs of employees [25] as well as feelings of competence, autonomy, and social relatedness, which are the basic psychological needs of all humans [26].

Maslow's hierarchy of needs theory and its famous pyramid of human needs are classics when it comes to understanding how workplace conditions have the means to satisfy employee needs [27–29]. In Maslow's theory, employees move up the hierarchy of needs. If the basic needs of survival and safety are met, an individual is ready to be motivated by social belonging and other psychological needs. In this study, we move from Maslow's theory of motivation and needs to studies that come with more empirical evidence [28] about basic human needs in the workplace.

The satisfaction of basic physiological needs at work has been found to predict both better employee productivity and higher subjective wellbeing [30,31]. Physiological needs include material values, where a paid job is a way to make a living, and the job is evaluated by the perceived balance between monetary compensation and the effort, time, and inconvenience the job requires. Material needs are threatened by deteriorating (physical) working conditions, inadequate earnings in comparison to the effort the job requires or a fear of losing one's job. For workers from various careers and cultural backgrounds, robotization can cause the threat of *technological unemployment* [[32], p. 358–373], where work is viewed as being gradually taken over by machines and artificial intelligence [33]. In these views, new technology threatens the basic needs of individuals by causing unemployment, career deflation, or decreased earnings [34].

Whenever we speak of basic human needs, it includes all people. As a species, our existence and wellbeing require a satisfactory amount of food, shelter, and safety as physiological basic needs. That said, prioritizing basic needs sometimes depends on the context as well as individual attributes, such as the stage of life. Sometimes, psychological needs come before physiological needs. For example, older employees are more often motivated than those of younger age to fulfill their social and emotional needs at work, while younger employees often attach more importance to material needs [35].

Just like physiological needs, our *basic psychological needs* must be satisfied so that we can live our lives as healthy individuals. Apart from working conditions and financial remuneration, employees are motivated by how the job responds to their psychological needs to feel a satisfactory amount of competence, autonomy, and social relatedness [8,26]. Again, cultural and contextual factors contribute to how people prioritize the relevance of different basic needs. However, by definition, they are basic needs common to all human beings.

Universal basic psychological needs motivating people include competence, autonomy, and social relatedness, as emphasized in a series of studies by Deci and Ryan [26]. The basic need for a sense of competence at work refers to the need to feel mastery and proficiency in one's occupation, work description, and the demands of the job, as well as any changes in it. The need for autonomy at work refers to the need to feel a sense of ownership of one's actions and decisions as well as freedom of opinion. The basic need for relatedness at work refers to the need to feel a sense of belonging and connection with peers and other members, including stakeholders, who form the social network of the job.

From the perspective of psychological wellbeing, it is not the most significant in which context or life domain the individuals fulfil their need to feel competence, autonomy, and relatedness [26]. If workers struggle with autonomy at work, they can compensate for this by being firmly in charge of their personal lives. Still, empirical studies show how basic psychological needs are more often met in certain quality contexts. For instance, the need for feelings of competence plays a special role when it comes to the context of working life. A high level of cognitive demands on a job is prone to increase employees' sense of competence while simultaneously challenging their feelings of autonomy [8].

2.3. Basic psychological needs and future-oriented job satisfaction

Job satisfaction refers to an individual's overall view of their job and can be quantified in the form of a subjective satisfaction rating [36]. Employee job satisfaction and readiness for organizational or technological changes have a dynamic relationship that is not always consistent [37–39] and is, therefore, in need of additional research. Likewise, satisfaction with basic psychological needs has a strong positive connection to job satisfaction *per se* [8,24,25,31], but the mechanism has yet to be studied in the context of robotization.

Hypothetically, one may feel an inadequate amount of autonomy at work if a robot dictates the working pace. Additionally, preferring not to use robots is typically assuaged when people are anxious about robots [11], which makes mandatory robot use a possible encroachment on one's autonomy. On the other hand, autonomy can be supported by new technology if it brings about better opportunities to organize and schedule one's job. Similarly, new technology has its pros and cons in moderating feelings of competence. Perceived competence may be reduced if technological changes are perceived as difficult to adopt and learn. Competence is especially challenged in robotization through proletarianization, where certain occupations now have a ceiling effect on the skills to develop [40]. The ceiling effect refers to robotized processes that change the roles and skill demands of human workers, for example, by changing manual work into monitoring work. This blurs the differences between junior and more experienced workers and can be viewed as a risk to feelings of competence. Nevertheless, robots can also support feelings of competence if they manage to change their work in such a way that individual workers have greater opportunities to use their skills, creativity, and expertise. Finally, social relatedness may suffer from technology, for example, when meetings are changed into online meetings. However, technological solutions also enable more opportunities for social participation, especially for people who are physically challenged or for whom it is difficult to travel daily.

Robotization entails mechanisms that can be supporting or frustrating when it comes to the perceived realization of psychological needs, therefore affecting job satisfaction. In addition to the present-tense question of "how satisfied one is with their work," job satisfaction has the dimension of future prospects, where the opportunities to develop in the job are evaluated. Future-oriented job satisfaction is especially relevant regarding robotization owing to the robots' gradual diffusion into a wider range of industries, where not only are the functionalities of pure technological systems present, but also the dynamisms of mutual interactions and individual behaviors. Subjective future-oriented job satisfaction also includes assessing the opportunities the job will offer in the months and years to come. The psychological basic need for autonomy plays a particular role in future-oriented job satisfaction. In addition to the effects on job satisfaction, a perceived high level of autonomy has been found to predict employees' innovative mindsets and performance [41].

2.4. Hypotheses

We made a few assumptions concerning the realization of basic human needs and job satisfaction in both robotized and non-robotized workplaces. Regarding physiological needs, we know that robotized workplaces have a history of relatively high salaries [42]. We hypothesized that this would be reflected in a higher realization of physiological needs among respondents in robotized workplaces.

H1. Material basic needs are better met in robotized workplaces.

On a general level, we hypothesized a higher level of realized psychological needs among respondents in non-robotized workplaces than among respondents in robotized workplaces. With the literature including evidence both for and against this assumption, we set these hypotheses on the grounds of the attributes that seem to make robotization stand out from other technological changes, namely user anxiety and proletarianization of skills [11,40].

H2. Feelings of a) competence, b) autonomy, and c) relatedness are more frequent in non-robotized workplaces.

Next, we hypothesized that respondents who report more material and psychological basic needs as being met in their work also have higher FJS [8,24,25,31]. Furthermore, because the mere risk of a job being automated is associated with poorer job satisfaction [12], we hypothesized that the reported level of FJS depends on whether the workplace is robotized.

H3. Unrealized basic needs at work are associated with poorer FJS.

H4. FJS is higher in non-robotized workplaces compared with non-robotized workplaces.

3. Method

This study uses the Finnish Quality of Work Life survey data collected in 2018. This survey, undertaken by Statistics Finland, yielded national interview data and provided a nationally representative sample of Finnish workers, more specifically, wage earners (N = 4089; 52%

female; average age 44.22).

A series of nationwide working life surveys has been conducted since 1977. In this study, we used the most recent data that includes a module regarding the potential robotization of work. The data consisted of a sample of wage-earners in robotized workplaces (n = 535) and wage-earners in non-robotized workplaces (n = 3554). This means that slightly more than one tenth of all respondents worked in a robotized workplace. Less than half (44.7%) of the respondents working in robotized organizations and more than half (52.5%) in non-robotized organizations had university-level education. The age and gender distributions are described by field of work in Table 1.

Our objective was to compare the actualization of basic needs, depending on whether the workplace had gone through robotization. Because of the cross-sectional data, we had no access to measurements before and after robotization; hence, the study design was constructed in such a way that same-field work was compared between robotized and non-robotized organizations. The election of fields of work used in the analysis is based on categorizing fields that also include robotized organizations.

3.1. Variables

FJS as the dependent variable was measured by summing the two items tested and repeated over several years of collecting Finnish Quality of Work Life Surveys: 1) “How satisfied are you with your current job?” and 2) “How satisfied are you with the opportunities to develop in your current job?” The responses were provided on a Likert scale from 1 to 5, and higher scores of the aggregate variable indicate a higher level of FJS (scale 2–10; M = 7.87; SD = 1.49; α = 0.67; ρ = 0.68). The new two-item variable was tested for its reliability and in addition to Cronbach's alpha (α), the internal consistency was estimated using the Spearman–Brown split-half coefficient (ρ). However, as a parallel examination, the FJS items were also analyzed in separate models with respect to the multivariate analysis of the associations between job satisfaction and psychological needs.

Work-related material needs were operationalized as separate items of *equality of salary* (scale 1–4), *financial incentives received* (yes/no), *threat of technological unemployment* (yes/no), and *perceived quality of the working environment* (scale 1–5). Higher scores indicate unrealized material needs.

While correlating moderately with each other (see Appendix A), the basic psychological needs for competence, autonomy, and relatedness were tested and used as separate explanatory factors instead of as an aggregate variable of “need satisfaction,” as this has been previously rationalized and recommended [31].

The sum variable of unrealized competence was constructed through seven questions, including perceptions of work productivity and meaningfulness and whether respondents felt that they were valued and able to use their skillsets in their jobs. Satisfactory internal consistency among the items (α = 0.73) would have increased further if feelings of appreciation from peers and customers had been excluded. The item was, however, included for theoretical reasons to balance the question concerning perceived appreciation from management.

The sum variable of unrealized autonomy was constructed through 16 questions on how the respondents perceived their opportunities to impact their own work, organization of work, timely resources, and job description. They were also asked whether they worked in an autonomous team and if management was perceived as a facet prone to sharing leadership with employees. The measure that included completely subjective and less subjective thus more factual items proved internally consistent (α = 0.83).

The sum variable of unrealized relatedness was constructed through five questions about social relationships, emotional support, and solidarity. The sixth initially planned item on acknowledging other people's feelings as a part of the job was excluded to reach a satisfactory internal consistency for the relatedness measure (α = 0.80).

Control variables chosen alongside age and gender included *value of work as a life domain* (Very important/Quite important/Not that important) and *prioritizing the content of work over monetary compensation* (scale 1–4). The items in the Finnish Quality of Work Life Surveys have been widely used over the decades, and the survey has been repeated in the population of Finnish wage earners [43,44].

3.2. Statistical procedures

Descriptive results are reported in percentages, means (*M*), standard deviations (*SD*), and Spearman's correlation coefficients (r_s). Group comparisons were conducted using parametric *t* tests, analyses of variance (*F*), nonparametric *U* tests, and Kruskal–Wallis tests (*H*), depending on the distributions. Categorical comparisons were made using Chi square (χ^2) tests. Multivariable analyses consisted of linear regression models for predicting job satisfaction, where standardized betas, effect sizes (*d*), and predictive power of the model (adjusted R^2) are reported. To illustrate moderation effects, continuous variables of basic psychological needs were dichotomized using median figures.

4. Results

4.1. Basic needs depending on the field of work (Testing hypotheses 1 & 2)

Material needs: In robotized organizations, the employees were more satisfied with their salaries ($M = 2.1$, $SD = 0.75$ vs. $M = 2.0$, $SD = 0.78$; $U = 1006699$, $p < .05$) and were likelier to receive financial incentives (75% vs. 69%; $\chi^2(1) = 4.06$, $p < .05$) than were the employees in non-robotized organizations. However, in robotized organizations, people were less satisfied with the working environment and its infrastructure ($M = 3.7$, $SD = 1.12$) than were the employees in the non-robotized organizations ($M = 3.8$, $SD = 1.06$; $U = 1003568$; $p < .05$). Among the non-robotized organizations, respondents in clerical office work or retail trade perceived a greater threat of technological unemployment (12.4%) than did respondents from other fields (4.6%; $\chi^2(1) = 69.18$, $p < .001$).

Competence: Unrealized feelings of competence ($M = 15.07$, $SD = 3.91$) were more frequently found among those working in robotized organizations ($M = 15.96$, $SD = 4.14$) than among employees in non-

Table 1
Distributions based on a field of work (percentages in respect of robotized/non-robotized workplaces), age and gender (%).

Field of work	N	Robotized workplaces			Non-robotized workplaces		
		Percentage	Age mean	Male-%	Percentage	Age mean	Male-%
Technical/Scientific	682	18	42.8	85	82	43.5	77
Healthcare	687	8	42.9	17	92	45.1	11
Education/Legal/Social work	600	6	48.1	60	94	45.5	25
Office/Retail trade	1150	10	41.6	45	90	43.7	36
Industrial/Construction	495	31	44.2	82	69	43.8	89
Other (e.g., transport)	475	12	40.1	61	88	45.2	73
Total	4089	13	43.0	65	87	44.4	46

robotized organizations ($M = 14.94$, $SD = 3.86$; $U = 766755$; $p < .001$). Regarding the field of work, unrealized competence was most reported by respondents working in manufacturing industries or construction ($M = 16.42$, $SD = 3.84$), differing most significantly from high-competence healthcare ($M = 14.51$, $SD = 3.49$), education, legal or social work ($M = 14.53$, $SD = 3.82$), and science or technology ($M = 14.99$, $SD = 3.65$; ($H(5) = 94.98$, $p < .001$). Consistently, the lowest level of competence was reported by industrial or construction workers in robotized organizations ($M = 17.13$, $SD = 3.72$).

Autonomy: Unrealized feelings of autonomy ($M = 33.36$, $SD = 7.00$) were more frequent among those working in robotized organizations ($M = 34.27$, $SD = 7.20$) than among those working in non-robotized organizations ($M = 33.21$, $SD = 6.95$; $t = 3.08$, $p < .005$). Regarding the field of work, unrealized autonomy was reported most frequently in healthcare ($M = 36.38$, $SD = 6.58$) and least frequently in science and technology ($M = 30.61$, $SD = 6.11$; $H(5) = 251.51$; $p < .001$).

Relatedness: Unrealized feelings of social relatedness ($M = 10.23$, $SD = 3.55$) were more frequent in robotized organizations ($M = 10.94$, $SD = 3.69$) than in non-robotized organizations ($M = 10.13$, $SD = 3.52$; $U = 794505$, $p < .001$). Regarding the field of work, fewer differences were found. Perceptions of relatedness differed only between the manufacturing industries/construction, where unrealized feelings of relatedness were reported most frequently ($M = 10.64$, $SD = 3.56$), and the science and technology workers, who reported unrealized relatedness least frequently ($M = 9.96$, $SD = 3.22$; $H(5) = 12.13$; $p < .05$).

Psychological needs and FJS in robotized and non-robotized workplaces (Testing hypotheses 3 & 4)

The most relevant correlations among FJS, perceived satisfaction of basic needs and control variables, are presented in Appendix A. Job satisfaction correlated with both satisfaction with material and psychological needs at work, but the correlations with material needs were weak and did not reach statistical significance in the multivariable analysis. Because FJS was not as dependent on material basic needs as it was on psychological basic needs in the data, regression analyses were conducted on the latter. We examined how the perceptions of psychological needs being met in robotized and non-robotized workplaces were related to FJS when age, gender, and valuing work as a life domain were controlled for.

FJS was found to be somewhat higher in non-robotized workplaces ($M = 7.90$; $SD = 1.47$) than in robotized workplaces ($M = 7.66$, $SD = 1.62$; $F(1) = 12.22$, $p < .001$). However, a more detailed analysis showed that this achieved statistical significance only in the categories of “office/retail trade,” “industrial/construction,” and “other.” Then, instead of using robotization as a covariate, it was natural to continue with separate analyses between non-robotized and robotized workplaces, as well as to make between-field comparisons.

All three types of unrealized psychological needs were found to be associated with FJS in robotized and non-robotized workplaces (Table 2). This finding was repeated when the FJS was returned into two separate measures of: 1) “How satisfied are you with your current job?” and 2) “How satisfied are you with the opportunities to develop in your current job?” The results in Appendix B show that both items had consistent associations with unrealized psychological needs. The predictive power, however, was higher in models using the aggregate FJS ($R^2 = 0.42$–0.47) than in those using single items separated from the FJS ($R^2 = 0.31$–0.39).

There were some inconsistencies across the fields of work. Among science and technology workers, higher FJS was associated with all basic psychological needs, apart from perceived autonomy in non-robotized workplaces. In fact, the science and technology working context was the only field in which all three psychological needs were important factors regarding FJS in robotized workplaces.

Regarding robotized work independent of field of work, competence was the most important factor in FJS, whereas relatedness emerged as an explanatory factor only in science and technology. In healthcare, a higher FJS was associated with a satisfied feeling of competence, but not with relatedness, and with autonomy only in non-robotized workplaces.

In office/retail trade work, all psychological needs were associated with FJS apart from relatedness, which proved to be nonsignificant in robotized workplaces. In manufacturing industries and construction, higher FJS was associated with satisfied feelings of competence, but not with autonomy, and with relatedness only in non-robotized workplaces.

In *post hoc* analyses, interactions between robotization and unrealized (vs. satisfied) psychological basic needs that predicted FJS were modeled. Significant interactions were found regarding the basic needs of autonomy and relatedness. Although robotization generally correlated negatively with job satisfaction, the effect was the opposite in low-autonomy healthcare work. Notably, the deviant finding concerned healthcare work, which was the context in which the least autonomy was reported. In healthcare, robotization decreased FJS in high-autonomy jobs and increased FJS in low-autonomy jobs (Table 3; Fig. 1).

The results for relatedness are presented in Table 4. Deviating from the aggregate data, there was a partial interaction between robotization and relatedness in the field of manufacturing/construction. Consistent with the preliminary findings, FJS was lower in robotized workplaces. The drop in FJS was, however, steeper among those who perceived higher relatedness. Distinctive to manufacturing/construction workers was how they reported unrealized feelings of relatedness more commonly than did respondents in other fields, and also how unrelatedness seemed to buffer the threatened job satisfaction after robotization.

There was no interaction between robotization and realized or

Table 3
Autonomy in healthcare work predicting FJS (N = 525).

	Beta	t	Sig.
(Constant)		2.52	0.01
Age	0.02	.66	0.51
Gender	−0.06	−1.63	0.10
Work content over monetary values	−0.17	-.46	0.65
Robotized workplace	0.58	2.44	0.02
Unrealized competence	−0.50	−10.32	<0.001
Unrealized autonomy	0.56	1.94	0.05
Unrealized relatedness	−0.02	-.48	0.63
Robotized workplace*Autonomy	−0.85	−2.38	0.02
Adjusted R^2	0.34		

Table 2
Psychological basic needs in future-oriented job satisfaction (FJS) (N = 4089).

	Non-robotized workplaces				Robotized workplaces			
	Beta	t	Sig.	d	Beta	t	Sig.	d
(Constant)		83.078	<.001			31.059	<.001	
Age	0.000	−0.017	0.986	–	0.055	1.606	0.109	0.16
Gender	−0.046	−3.141	0.002	0.14	0.024	0.682	0.495	0.07
Value of work as a life domain	−0.053	−3.670	<0.001	0.16	−0.043	−1.234	0.218	0.13
Unrealized competence	−0.491	−24.799	<0.001	1.67	−0.450	−8.984	<0.001	1.49
Unrealized autonomy	−0.101	−6.004	<0.001	0.30	−0.143	−3.487	<0.001	0.43
Unrealized relatedness	−0.128	−7.132	<0.001	0.38	−0.197	−4.371	<0.001	0.60
Adjusted R^2	0.42				0.47			

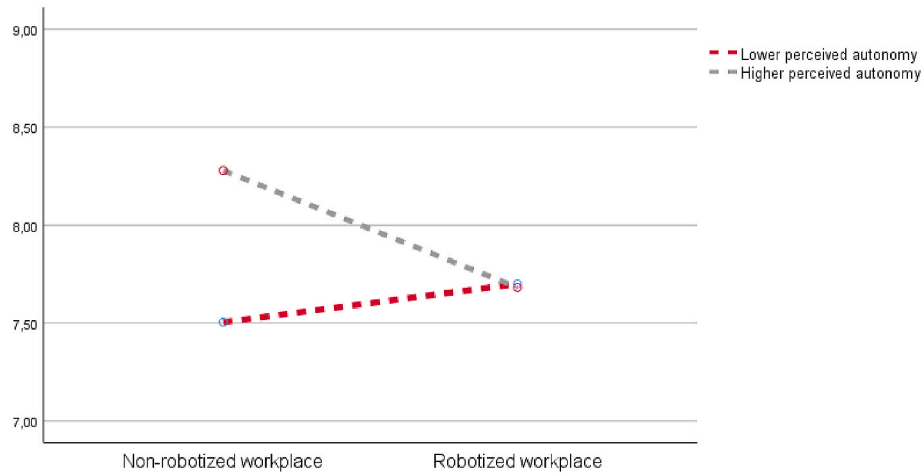

Fig. 1. Autonomy in non-robotized and robotized healthcare work predicting FJS.

Table 4
Relatedness in manufacturing/construction work predicting FJS (N = 494).

	Beta	t	Sig.
(Constant)		11.367	<.001
Age	0.019	0.465	0.642
Gender	0.073	1.761	0.079
Work content over monetary values	0.061	1.446	0.149
Robotized workplace	0.316	2.418	0.016
Unrealized competence	−0.393	−7.013	<.001
Unrealized autonomy	−0.080	−1.663	0.097
Unrealized relatedness	0.166	1.154	0.249
Robotized workplace*Relatedness	−0.422	−2.400	0.017
Adjusted R^2	0.45		

unrealized feelings of competence either in the aggregate data or in any of the field subsamples. The correlation between FJS and feelings of competence was so strong that robotization did not reach enough statistical power to play a role.

4.3. Secondary findings

Age and gender: Descriptive Table 1 shows how younger professionals were likelier to work in robotized organizations ($F(1) = 6.43$, $p < .05$). The exception was manufacturing industries/construction, where, on the contrary, an older age was associated with working with robots. We also found that labor markets were mostly divided into female- and male-dominated fields unaffected by the possible robotization of the organization. However, education, legal, or social work organizations employing robots seemed to be male-dominated, whereas non-robotized education, legal, or social work seemed to be female-dominated. This can be partly explained by the broad category of public service work in question and the fact that educational and social work professionals were mostly female, whereas legal services were male-dominated.

Value of work as a life domain: Because basic psychological needs are universal and can be satisfied through several life domains [26], the relative importance of work in a respondent's life was considered. Work was highly appreciated as a life domain among the participants, as most reported that work was "extremely important." Valuing work correlated positively with feelings of competence ($r_s = 0.17$, $p < .001$). The weak correlation mentioned was the only significant result found between valuing work and psychological basic needs or FJS. Thus, valuing work as a life domain passed as a control variable because it did not confound the correlation between basic needs and FJS.

Prioritizing the content of work: Content of work was valued over monetary values in general ($M = 2.61$, $SD = 0.80$) and in non-robotized organizations ($M = 2.64$, $SD = 0.80$) more than in robotized organizations ($M = 2.42$, $SD = 0.78$; $U = 1088282$; $p < .001$). Here, the differences between fields of work were notable. Prioritizing content of work over remuneration was most significant in education and social work both in non-robotized organizations ($M = 2.99$, $SD = 0.74$; $\chi^2(15) = 301.8$, $p < .001$) and in robotized organizations ($M = 2.91$, $SD = 0.66$; $\chi^2(15) = 97.4$, $p < .001$). However, prioritizing remuneration over content of work was most frequent in manufacturing/construction work ($M = 2.09$, $SD = 0.77$; $\chi^2(15) = 417.1$, $p < .001$). Those prioritizing the content of work over remuneration were only slightly more satisfied with their work on average (Appendix A).

5. Discussion

This study explored how work-related material and psychological needs were perceived to be met in robotized and non-robotized workplaces, as well as the association between the realization of basic human needs and job satisfaction. The comparisons and analyses were conducted according to robotization and field of work. Hence, this study contributes insights into how human needs are perceived to be met in robotized and non-robotized workplaces and how the realization of basic needs is associated with job satisfaction in different fields of work.

The results show that, in robotized work, material needs are well-met regarding remuneration, but not necessarily regarding working environment. Our hypothesis (H1) and prior studies were supported by how participants were more satisfied with their monetary compensation if they worked in a robotized organization [42]. The psychological needs of competence, autonomy, and relatedness were met more frequently in non-robotized organizations than in robotized organizations. These findings support hypothesis (H2) and suggest that socially responsible, truly human-centered robotization has not yet achieved a leading position in Finland.

The results supported the hypothesis that unrealized basic needs (H3) and robotized operations (H4) are associated with poorer FJS. However, examining the three factors together produced important additional information about how FJS varied, depending on the basic needs being met in robotized and non-robotized workplaces and in different fields of work. Realized psychological needs demonstrated their consistent importance in people's working lives by being positively associated with job satisfaction in both robotized and non-robotized organizations. Of the three psychological basic needs analyzed, feelings of competence were found to have the strongest association with FJS among Finnish wage-earners. Competence does not typically stand out as the most significant explanatory factor when it comes to psychological needs and wellbeing at work. In fact, it has been suggested that contribution-oriented Finnish workers might respond to feelings of competence more than people in other cultures [45].

Only perceived competence at work had a robust correlation with job satisfaction, regardless of whether FJS was measured in robotized or non-robotized workplaces. This brings complementary knowledge to previous studies, where other psychological needs have been found important to consider in the digitalization of organizations [46]. In the current study, the relationship between FJS and the two other psychological needs, autonomy, and relatedness, depended on robotization. Comparing the results by working field and by robotization status, this study specifically sought to find evidence on which basic needs are particularly valued in terms of job satisfaction, depending on the field of work. Looking at the satisfactory level of basic needs being met at work, jobs in science and technology seemed to be especially gratifying. In that field, perceived autonomy was relatively high, which corroborates what we know about knowledge workers and how they have more opportunities to affect their own work than other occupational groups [47,48].

Regarding employee autonomy, the findings in this study focusing on robotization differed from a previous study that focused on white-collar work digitalization. In our study, employee autonomy played a significant part in wellbeing in robotization, especially among fields of science, office work, and retail trade. For comparison, a study on digitalization in the fields of banking and insurance found no correlation between employee autonomy and wellbeing expectations in a digital workplace [46]. In addition to the difference between computer-centered digitalization and robot-centered robotization, the studies differed in samples. It is safe to say that the research context and the nature of the samples contributed to the results and limit the possible comparisons. However, the inconsistent findings imply that employee autonomy may have a larger effect on wellbeing during robotization than in general digitalization.

In the comparisons among fields of work in the current study, science and technology stood out as a field where prior findings about the positive relation between basic psychological needs and work-related wellbeing were supported [31,45]. Other fields displayed more variance in how psychological needs were met and how they were associated with FJS. For instance, autonomy in healthcare yielded inconsistent findings. First, the combination of high competence and low autonomy was found to be characteristic of respondents in healthcare. Although this may reflect the complexity of the construct of autonomy in highly specialized work [11], it is also a mechanism described in Van den Broeck et al., where jobs with high cognitive demands have the tendency to increase feelings of competence and decrease feelings of autonomy [8]. Hence, it is implied that doctors and other healthcare professionals with high competence and accompanying high cognitive demands may struggle with unrealized feelings of autonomy. Indeed, new technologies and the bureaucracy related to them have been found to negatively impact the work content and direct patient work of physicians [49,50].

Second, in healthcare, robotization was linked to lower FJS in high-autonomy jobs and to higher FJS in low-autonomy jobs. High-autonomy jobs can be considered parallel to jobs in which an individual has larger areas of responsibility. Hence, this result is interpreted as referring to the maturity of today's service robotics. Although care work has been a subject of a wider digitalization, robotic devices have also been introduced as assistive equipment [6]. In healthcare, measures of job performance include human life and wellbeing, and the degree of freedom at work must be seen in relation to the responsibilities of work. The results imply that today's robots have yet to increase work autonomy to the extent of actually improving the quality of work.

Thus, increasing the use of robots in healthcare depends heavily on how the technology is suited to the tasks in the field and how the division of labor between machines and humans develops in terms of cognitive and emotional tasks. Following the categorization by Heberlein [51], the perceived utility of care robots as a resource may be much more in need of a technological fix than a cognitive fix. In other words, for care workers to be motivated to use robots, instead of trying to change their views about robots, the technology must instead meet the social and ethical demands of this specific line of work. We see a kind of cooperative learning demand here, where the designers must dive deeper into the contextual and situational aspects of their technical solutions and, respectively, where the users must become more involved and accustomed to the logics of technical designs.

Proceeding to the most deviating field, it was more common among manufacturing/construction workers to have unrealized feelings of social relatedness. Nevertheless, workers in those fields reporting low relatedness seemed to remain satisfied with their work after robotization. Our interpretation of this finding pertains to the protectiveness of emotional distance [52,53]. If one does not feel close to the workplace and coworkers and rather considers work as something of little importance when it comes to close relationships, such people will not be heavily affected by organizational changes compared with those having more profound ties to their work. This conclusion is supported by our other results, which showed how manufacturing/construction workers prioritized remuneration over work content. If work has a less significant and more superficial role in one's life, it is likely that changes in the job will not affect wellbeing.

This study has limitations regarding its design. First, the sum variables of basic psychological needs were constructed based on theory and tested only by internal consistency measures. Second, the data did not allow us to extend the view of psychological needs, for example, to spiritual and intellectual issues [54]. However, we see these as interesting directions for future research. Third, causal conclusions were not feasible in this study. Psychological basic needs were more often met in non-robotized organizations, yet we cannot conclude that robotization as a technological change caused people to have less gratification in their jobs. Individuals who consider work to have only little significance in their life may be less psychologically drawn to their jobs and not rely on them for social satisfaction. However, jobs that offer competitive external motivators, such as good monetary benefits and clear boundaries between work and free time, may generate strong psychological ties. Robot use at work makes it somewhat harder to bring work home.

The dependent variable of this study, FJS, was theoretically influenced by a variety of individual-, occupational-, and organization-based factors. That said, the explanatory power (R^2) in the models that predicted FJS based on basic psychological needs was notably high, as were some of the measured effect sizes. The study provides novel information on the role of basic needs based on technological changes in the workplace. An important future direction lies in the next wave of the Finnish Quality of Work Life Survey. Repeated cross-sectional study designs will complement the results presented in this study using the first wave of the survey when topics of robotization were included in the questionnaire.

Service work robotization is only just emerging. Knowledge and predictions about its effects on working life are limited. Future research is essential to gain information on this new generation of robotization, but we must also emphasize the importance of active discussion among stakeholders in various industries. Such discussions are particularly relevant when it comes to implementing cumulative evidence in practice. This study, among others, shows how organizations should support their employees' autonomy, competence, and relatedness during organizational changes. This objective is now more apparent, considering the requirements of CSR.

The results of this study provide additional perspectives for assessing the march of "the fourth industrial revolution" [9,20] in workplaces. As a study of human factors in robotization, our approach differs significantly from most studies in human–computer interaction science, namely, studies of robot acceptance and user experiences in innovations [4,5,10,11]. The Finnish Quality of Work Life Survey includes access to old and new work organizations and environments. Statistical methods can only provide answers at a general level; nevertheless, they can shed new light on the issues of structural changes in robotized work contexts. The assessment of job satisfaction was one way to widen the research window from a focus on mere usability of robots.

6. Conclusion

The findings in this study fundamentally beg the question of how to support employees' basic needs during and after robotization. By being sensitive to human needs and individual values during technological changes, organizations practice CSR. Concrete actions seem to lead to the importance of shared decision-making in robotization. A quest for mutual understanding between designers and users should be extended to negotiations between employees and employers. Here, we suggest three actions that are useful in advancing the process and shared decision-making.

Actions supporting *autonomy:* Supporting employee autonomy is important during and after robotizing work, especially for those working in science, office work, or the retail trade. On the one hand, autonomy is a prerequisite for job satisfaction and wellbeing, and on the other hand, job satisfaction and wellbeing are prerequisites for motivation and productivity. Cooperation negotiations between employers and employees are advisable to ensure that the changed work (still) offers employees the opportunity to influence their own work.

Actions supporting *competence:* Among the material and psychological needs of employees, the findings imply that employees' feelings of competence should be the first thing fostered in robotization. Opportunities to acquire new competences and gain additional education are necessary when it comes to technological changes in the workplace. Feelings of competence after robotization, or any changes in one's work, come down not only to personal feelings of competence, but also to the attributes of the new technology and how those two complement each other. Robots should fit into work in a natural and user-friendly way so that employees find technological change a way to maintain their competence in work [55]. Because competence was found to be the most significant predictor of FJS, we emphasize the importance of employee empowerment during robotization and highly recommend shared decision-making in planning and introducing technological changes in the workplace.

Actions supporting *material needs:* The requirement for formal and informal education regarding developments in work also means that the employer should enable this on a concrete level by offering resources and financial support [7]. Among organizations yet to be robotized, respondents working in offices or in business were found to perceive a greater threat of technological unemployment. To pave the way for technological reforms, it is important to ensure that everyone is involved in productivity gains.

Moreover, robotization calls for careful assessment and organizational attention to how work will change after robotization and an understanding of the consequences on the wellbeing of individual employees. A satisfactory level of material needs, competence, autonomy, and relatedness should be ensured after robotization. A socially responsible way to robotize operations will have the goal of making the change everyone's business and pleasure.

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Author statement

Tuuli Turja: Conceptualization; Study design; Data curation; Statistical analysis; Visualization; Writing (original draft and all following versions). **Tuomo Särkikoski:** Conceptualization; Writing (versions following the original draft). **Pertti Koistinen:** Funding acquisition; Supervision, Writing (version following the original draft). **Harri Melin:** Project administration; Supervision; Writing (version following the original draft).

Declaration of competing interest

None.

APPENDIX A

Spearman correlations among future-oriented job satisfaction and their explanatory factors (i.e., unrealized basic needs).

					Unrealized psychological needs			Unrealized material needs	
	1.	*2.*	*3.*	*4.*	*5.*	*6.*	*7.*	*8.*	*9.*
1. Job satisfaction	1	−0.02	−0.03	0.14**	−0.70**	−0.41**	−0.45**	−0.28**	−0.32**
2. Age	−0.02	1	0.05**	−0.12**	0.03	0.02	0.11**	−0.01	0.07**
3. Gender	−0.03	0.05**	1	0.16**	−0.04**	0.15**	0.04*	0.04*	0.20**
4. Work content over remuneration	0.14**	−0.12**	0.16**	1	−0.18**	−0.18**	−0.09**	−0.06**	−0.02
5. Unrealized competence	−0.60**	0.02	−0.04*	−0.17**	1	0.49**	0.59**	0.22**	0.23**
6. Unrealized autonomy	−0.41**	0.02	0.15**	−0.18**	0.44**	1	0.31**	0.22**	0.29**
7. Unrealized relatedness	−0.45**	0.11**	0.04*	−0.09**	0.56**	0.31**	1	0.21**	0.19**
8. Working environment	−0.28**	−0.01	0.04*	−0.06**	0.22**	0.22**	0.21**	1	0.21**
9. Salary	−0.32**	0.07**	0.20**	−0.02	0.23**	0.29**	0.19**	0.21**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX B

Additional models of the associations between the two separate future-oriented job satisfaction items and psychological needs.

	Non-robotized workplaces			Robotized workplaces		
	Beta	t	Sig.	Beta	t	Sig.
(Constant)		0.391	0.696		0.199	0.842
Age	−0.029	−1.897	0.058	−0.075	−1.996	0.047

(*continued on next page*)

(*continued*)

	Non-robotized workplaces			Robotized workplaces		
	Beta	t	Sig.	Beta	t	Sig.
Gender	0.027	1.706	0.088	0.002	0.040	0.968
Value of work as a life domain	−0.060	−3.864	<0.001	−0.100	−2.613	0.009
Unrealized competence	−0.392	18.341	<0.001	−0.333	−6.039	<0.001
Unrealized autonomy	−0.082	−4.528	<0.001	−0.098	−2.259	0.031
Unrealized relatedness	−0.167	−8.608	<0.001	−0.240	−4.855	<0.001
Adjusted R^2	0.32			0.35		

'How satisfied are you with your current job?'

	Non-robotized workplaces			Robotized workplaces		
	Beta	t	Sig.	Beta	t	Sig.
(Constant)		3.312	<.001		0.477	0.634
Age	0.023	1.477	0.140	0.026	0.724	0.469
Gender	−0.049	−3.107	0.002	−0.037	−0.989	0.323
Value of work as a life domain	−0.035	−2.233	0.026	−0.015	−0.398	0.691
Unrealized competence	−0.456	−21.253	<.001	−0.457	−8.523	<0.001
Unrealized autonomy	−0.093	−5.104	<.001	−0.152	−3.471	0.001
Unrealized relatedness	−0.067	−3.422	0.001	−0.122	−2.536	0.012
Adjusted R^2	0.31			0.39		

'How satisfied are you with the opportunities to develop in your current job?'

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