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Corresponding Author	Family Name	**Sartore**
	Particle	
	Given Name	**Mégane**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	SNCF, Innovation and Research
	Address	Paris, France
	Division	
	Organization	Strate Research Strate
	Address	Paris, France
	Division	
	Organization	LINEACT, CESI
	Address	Paris, France
	Email	megane.sartore@sncf.fr
Author	Family Name	**Ocnarescu**
	Particle	
	Given Name	**Ioana**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	Strate Research Strate
	Address	Paris, France
	Email	i.ocnarescu@strate.design
Author	Family Name	**Joly**
	Particle	
	Given Name	**Louis- Romain**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	SNCF, Innovation and Research
	Address	Paris, France

	Email	louis-romain.joly@sncf.fr
Author	Family Name	**Buisine**
	Particle	
	Given Name	**Stéphanie**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	LINEACT, CESI
	Address	Paris, France
	Email	sbuisine@cesi.fr

Abstract	Robots are playing an increasingly important role in very different professional and personal contexts, including that of railway maintenance, which is starting to integrate robotic tools. By confronting industrial robotics part of industry 4.0 and 5.0 with service robotics, we realize that the railway maintenance sector does not refer to industry as manufacturing, nor to service robotics as such but rather as a common space between these two branches of robotics. Our objective is to take advantage of these two types of robotics to introduce a new concept, **ikigai robotics**. This notion reveals and explores the symbiotic relationship between well-being at work and performance. We have conducted a study that specifically highlights the fact that the need for affiliation is a positive factor for both well-being at work and performance in the specific context of railway maintenance. Finally, we provide first guidelines for the design of ikigai robots and open a discussion on how to image this concept beyond our specific context.

Keywords (separated by '-')	Industrial robotics - Service robotics - Railway maintenance - Industry 4.0 - Industry 5.0 - Need for affiliation - Well-being - UX design

Ikigai Robotics: How Could Robots Satisfy Social Needs in a Professional Context? a Positioning from Social Psychology for Inspiring the Design of the Future Robots

Mégane Sartore[1,2,3](✉), Ioana Ocnarescu[2], Louis- Romain Joly[1], and Stéphanie Buisine[3]

[1] SNCF, Innovation and Research, Paris, France
{megane.sartore,louis-romain.joly}@sncf.fr
[2] Strate Research Strate, Paris, France
i.ocnarescu@strate.design
[3] LINEACT, CESI, Paris, France
sbuisine@cesi.fr

Abstract. Robots are playing an increasingly important role in very different professional and personal contexts, including that of railway maintenance, which is starting to integrate robotic tools. By confronting industrial robotics part of industry 4.0 and 5.0 with service robotics, we realize that the railway maintenance sector does not refer to industry as manufacturing, nor to service robotics as such but rather as a common space between these two branches of robotics. Our objective is to take advantage of these two types of robotics to introduce a new concept, **ikigai robotics**. This notion reveals and explores the symbiotic relationship between well-being at work and performance. We have conducted a study that specifically highlights the fact that the need for affiliation is a positive factor for both well-being at work and performance in the specific context of railway maintenance. Finally, we provide first guidelines for the design of ikigai robots and open a discussion on how to image this concept beyond our specific context.

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1 Introduction

Robotics has impacted human labor in many sectors, starting with manufacturing and more recently directly in the home. A robot would be primarily a tool or machine (Ichbiah, 2010; Singer, 2009) capable of perceiving and apprehending the world using sensors (Bonnell, 2010; Gelin, 2015; Ichbiah, 2010). A robot would also be able to understand its environment and make decisions (Chatila, 2014). Like those proposed by The Robot Institute of America and The International Standard Organization (ISO), these definitions shed light on the technological side of the robot without addressing the

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human side, particularly with regard to human-robot interactions (Bartneck & Forlizzi, 2004), human needs, values and well-being, which highlights an important distinction that is the focus of our paper.

Industrial robotics is a category in which robots referring to manipulator arms for the manufacturing industry (Wallén, 2008). This robotics is part of Industry 4.0, a technological-driven approach (Piccarozzi et al., 2018; Xu et al., 2021), focusing on *"the introduction of network-linked intelligent systems, which realize self-regulating production: people, machines, tools and products will communicate with each other continuously"* (Kovács et al., 2019, p. 78). An industrial robot is usually integrated into the manufacturing. It is defined as being *"easily …reprogrammable without physically rebuilding the machine. It shall also have memory and logic to be able to work independently and automatically. Its mechanical structure shall be able to be used in several working tasks, without any larger mechanical operations of the structure"* (Wallén, 2008, p. 5). The term *"reprogrammable"* highlights the utility and adaptability feature. Also, robotics are designed to reduce drudgery and improve the health of operators. New advancements in the psychology of professional fulfillment show that needs are emerging that question the quest for meaning and peoples' relationship to work. Therefore, designing robotics only by taking into account functional aspects is not enough to improve the operators overall experience at work.

In response to manufacturing, a separate category of particular interest to us are the service robots. A. service robot was defined as *"a robot which operates semi or fully autonomously to perform services useful to the* ***well being*** *of humans and equipment, excluding manufacturing operations"* (Bartneck & Forlizzi, 2004, p. 592). In many areas such as healthcare, robotics seems to mark a new form of social interaction. The robot interacts directly with humans, trying to understand and respond to needs according to the degree of knowledge it has acquired. Becoming more than just a machine, the robot allows for the reinvention of social interaction, previously thought of only between humans or between animals and humans. By reinventing social interaction, service robotics seems to stand out. However, this form of robotics promises to be more useful in a personal context than in a professional one (Bartneck & Forlizzi, 2004).

We are interested in the field of railway maintenance, which would intuitively be attached to industrial robotics, but this is not the case. In the context of maintenance, users are interacting with tools and their experience while interacting with these tools is extremely important for their work, collaboration, engagement and well-being. These notions are in the vein of service robotics to bring a better quality in the operators' work. Therefore, this paper introduces the new concept of ikigai robotics for well-being and performance as a meeting place of industrial and service robotics in an environment involving robotic tools and humans: industrial robotics (as an automatization technology) and service robotics. Ikigai robotics could become a wonderful field of innovation leveraging the best of both approaches and sublimating the result while considering humans and machines as a system. Ikigai is a Japanese philosophy of life that is commonly used in Japanese culture to refer to a sense of *"life worth living"* (Kotera et al., 2021; Mathews, 1996; Shirai et al., 2006; Weiss et al., 2005). It is a comprehensive concept describing subjective well-being (Shirai et al., 2006) that can be translated as *"purpose in life"* or *"reason for living"* (Mathews, 1996; Mori et al., 2017; Sone et al.,

2008) and is usually defined as *"a feeling obtained by a person who is doing something useful for someone else or society and, consequently, feels that life is worth living"* (Fukuzawa et al., 2018, p. 1).

Our aim is to integrate original dimensions from psychology in the design of a new type of robotics that would increase users' ikigai. In order to discuss the attributes of this kind of robotics, the next section presents the benefits of taking into account human experience and well-being in industrial robotics and service robotics. Further on we present first results in terms of human needs for ikigai robotics in the railway maintenance and first guidelines for their design.

2 Human Needs in the Current Design of Robots

A robot is designed like any industrial product or tool that is going to be used by a certain type of population. Users' needs are essential requirements of a design process (Yannou & Petiot, 2002). Actually, industrial robots are essentially designed for their functional benefits especially in terms of safety and efficiency to perform repetitive tasks (Heyer, 2010; Lasota et al., 2014). Research is particularly documented regarding industrial robotics in terms of utility and productivity in the industry (Heyer, 2010; Lasota et al., 2014). Indeed, the arrival of robotics in the manufacturing industry has made it possible to produce quickly, at low cost, and in large quantities (Buchner et al., 2012; Heyer, 2010, e.g., Unimate). In 2012, the literature reported the non-existence of the human-robot relationship for safety reasons (Buchner et al., 2012). Since, the implementation of cobotics (a form of collaborative robotics with human operators) has made the human-robot relationship possible (Pauliková et al., 2021). Now we can talk about a full-fledged human-machine system. Within the context of railway maintenance and embracing a new approach in which people interact with industrial robotics and the human-robot interaction is central to a specific task, how to go beyond the functional aspects of professional tools?

Several researchers question the security aspect in favor of the human-robot relationship by integrating users' comfort (Heyer, 2010; Lasota et al., 2014). But behind this notion of comfort there are essentially ergonomic rather than psychological aspects. Finally, industrial robots are designed to meet certain needs, but these needs are still functional ones, like showing a particular *"usefulness"* (Buchner et al., 2012, p. 115) with the objective of productivity in economic, temporal, and quantitative terms.

On the contrary, the development of new forms of robotics, such as service robotics, has paved the way for studying user experience of industrial robotics (Buchner et al., 2012). Researchers showed the importance of the time factor in appropriating a robot (Buchner et al., 2012) in terms of overall user experience especially regarding user-friendliness and cooperation with the robot (Buchner et al., 2012). Moreover, service robots are designed to support human work on the professional scale (professional service robotics, e.g., Tidy-Bot, the industrial vacuum cleaner robot) and the personal scale (personal service robotics, e.g., Roomba, the vacuum cleaner robot). Service robots perform tasks in the human environment that serve human needs (Sprenger & Mettler, 2015).

In psychology, a central and recent research of the theory of motivation distinguishes functional needs from fundamental needs referring to motivation (Deci & Ryan, 2000).

The authors highlight three fundamental needs: the need for competence, the need for autonomy and the need for affiliation. To our knowledge it seems that little research has been done in taking into account these fundamental needs in the design process of robots interacting with people at work.

An approach based on fundamental needs is an example of an original way to develop the tomorrow's robots. In line with notions like collaboration and pleasure at work we want to promote teamwork between humans and robots (Buchner et al., 2012; Weiss et al., 2005) through an approach focusing on human fundamental needs and maximize well-being in the design of industrial robotics. More precisely, we wish to offer the possibility of designing a robotic tool that will positively influence ikigai.

3 Well-Being at Work and the Affiliation Need for Future Designs

As part of a design project, we conducted a questionnaire survey among 46 railway maintenance operators (track and train maintenance). We wanted to know whether robotics tools would make employees feel good about their work and to feel more efficient. One of the aims of this study was to characterize the ikigai of agents and identify the predictors and inhibitors, particularly through the tools they use. To answer these questions, we measured the differences that exist between work situations carried out with a technological (robotic) tool versus a traditional tool. We qualified technological tools as those material resources that had been integrated into the work of operators for less than five years. Traditional tools referred to homologous tools for carrying out the same task, the use of which has been anchored in the work of the agents for at least five years. For example, the inspection of train roofs (task) could be carried out either via a footbridge (traditional tool) or with a drone (technological tool, see Fig. 1).

Fig. 1. Inspection of a box roof via a walkway (left) vs. with a drone (right).

As ikigai seems to be linked to concepts such as self-determination and well-being, we constructed a questionnaire by assembling ten validated scales, such as self-determination, well-being, fundamental needs, and experience with the tool. Given the sample size, the results are not intended to be generalized, but rather to provide an original perspective with regard to the literature on the integration of fundamental needs in industry 4.0 or 5.0. We show elsewhere the results of our questionnaire (Sartore et al., 2022). In this paper, we wish to emphasize two particular results.

First, we have identified the experience with the tool as a predictor of ikigai ($\beta = .499$, $t = 3.067$, $p = .004$, $M = 3.46$). While it is widely recognized that user experience with the tool is a significant predictor of well-being, this approach is still insufficiently implemented in the design of professional tools, particularly in the industrial maintenance sector. They should therefore be created and introduced into the workplace following a design thinking approach (Brown & Katz, 2010), for example by integrating users as early as possible in the design project in order to optimize human experience in interaction with technology (Lallemand & Gronier, 2018).

If this result corroborates current studies in User-Experience (UX) design, the second one appears more original, as it highlights affiliation as another significant predictor of ikigai at work ($\beta = .484$, $t = 3.499$, $p = .001$). Because the need for affiliation is generally not studied or taken into account in current design processes, we wish to make extensive use of this result. Applied to our aim to design robotic tools that could support well-being at work, this result suggests that such solutions should contribute to maintaining or even improving the relationships between employees, their social identity and their feeling of belonging.

In any design process, a crucial phase is devoted to the analysis of users' needs, which is why we believe that introducing the need for affiliation at the very early stages of the design process could be valuable and inspiring for designing robotic tools. The next section defines this specific need and introduces its specificities in the context of railway maintenance.

4 The Need for Affiliation for the Railway Maintenance Context

4.1 What Is the Need for Affiliation?

The need for affiliation refers to the need to belong to a group (i.e., social belonging), the need to feel connected to others, to take care of people vital to oneself with reciprocity (Deci & Ryan, 1985; Ryan & Deci, 2000). Individuals seek to maintain or improve their emotional and social relationships with a person or a group of people. The need for affiliation is not limited to interpersonal relationships, but can also refer to a belief (e.g., belonging to a religious group), to symbols, to objects (e.g., Apple creates a strong sense of belonging to a group) or to an entity such as a company. From a theoretical viewpoint (McClelland, 1987), the intensity of the need for affiliation may vary from one individual to another. Individuals with a strong need for affiliation may act in an affiliative way, intended to nurture social relations, compared to individuals with a low need for affiliation. These acts can take the form, for example, of phone calls, writing letters, meetings with friends, and involvement in social clubs. In the workplace, the need for affiliation may be implemented through the collective dimension of work and projects, the efficiency of teamwork and more generally the social context provided by human organizations.

Some previous studies accounted for the social dimension in methods for designing technologies (Hutchinson et al., 2003), integrating social capital in reference to an economic framework (Coleman, 1988). However, none referred to the idea of strengthening social relationships among users and supporting the feeling of belonging to a group. The authors stress the need to understand *"how technology can be used to support communication with and awareness of the people we care about"* (Hutchinson et al., 2003, p. 17).

4.2 Ikigai Robotics

Technology that would contribute to meeting human need for affiliation should promote users' social identification to a group, emphasize group membership salience, promote teamwork and social laboring, which includes enabling co-workers to communicate seamlessly with one another, support situation awareness as well as group awareness, and promote mutual assistance between teammates. Here the robotic tool can be viewed as a support to affiliation or as a full member of the team and convey the social identity of the group.

For robots' affiliation, on one hand, we imagine a solution that would bring together the robots belonging to the same organization / company / team, and on the other hand, the generation of a family of users. This can be achieved for example through the creation of a label (social identity cue) that would bring together human-robot systems. Some studies show that digital tools can contribute to the loss of social capital by isolating users from social circles and by increasing stress (Kraut et al., 1998, 2001), but they also suggest that technology holds the potential to produce the opposite effect: if it is used to communicate, it can allow individuals to feel *"connected"* to each other during their work time. By extension, we can think that if individuals can experience this feeling of connection to their colleagues via digital tools, their need for affiliation could also be satisfied and thus their well-being at work.

The affiliative dimension of robots could also be enhanced through gamification (Deterding et al., 2011; Hunter & Werbach, 2012), for example allowing teammates to gain feedback to their work (e.g., unlock badges allowing them to observe their progress; Seaborn & Fels, 2015) and share the results on a dedicated social platform (e.g., similar to Runtastic, a running application). The product or service may then be *"more fun, engaging and motivating"* (Lallemand & Gronier, 2018, p. 372, our translation) while satisfying operators' need for affiliation (Lallemand & Gronier, 2018).

5 Conclusion

By considering robotics as a work tool, as a means of carrying out a task, we envisage robotics as a factor in the development of operators. One serious avenue would be ikigai robotics. In this approach, robotics would become a lever for well-being by bringing meaning to work. The aim is to understand current practices, possible practices, the interests and pleasures of operators in their work, the points of difficulty and disinterest, and the important professional gestures of which they are proud while being performant. This approach will make it possible to counter the possible loss of know-how and skills that can be observed in certain contexts of total automation. By certain aspects, the notion of ikigai recalls self-determination theory, with a collective dimension (Fukuzawa et al., 2018; Kumano, 2006) that seems stronger than in the Western view. The aim of satisfying the need for affiliation is likely to inspire the creation of a myriad of new functionalities for industrial tools interacting with people, which currently do not promote the social dimension of work enough. What makes our project original and stimulating is the idea that such functionalities may contribute to driving ikigai, therefore well-being, engagement, performance, and physical health.

To make this new approach a reality, we are currently conducting a design project for railway maintenance workers. After an initial phase focused on their functional needs, carried out in co-design, we are now starting a motivational phase focused on their fundamental needs, particularly the need for affiliation. At the moment, we feel that these are deeply rooted dimensions and therefore difficult for future users to verbalise. This design will be the subject of an article in order to shed light on this new ikigai-centred design approach.

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