

## IMPACT OF ARTIFICIAL MANAGEMENT ON THE WORK OF A TEAM OF HUMANS. RESULT OF RESEARCH

Olaf FLAK

Jan Kochanowski University of Kielce; olaf.flak@ujk.edu.pl, ORCID: 0000-0001-8815-1185

**Purpose:** The purpose of this paper is to present an answer to the research question of what could be the real impact of an artificial manager on the work of a team consisting of humans.

**Design/methodology/approach:** In presenting the arguments for one way of proceeding AI-based management, a review of the recent literature in the field of artificial management and artificial leadership was used. The artificial manager used in the research was the result of a non-participating, long-term observation of a group of students working on a specific task, whose activity was recorded by online management tools called TransistorsHead.com.

**Findings:** The real impact of the artificial manager on the human team members was very weak. Although team members were taking similar managerial actions as they were told by the system of TransistorsHead.com, they mixed the order and decreased or increased a period of the managerial actions.

**Research limitations/implications:** Human members did not feel any emotional pressure on their behaviour from the artificial manager and they do not treat the system too seriously. What is interesting, the most obedient person was the appointed assistant of the artificial manager. The rest two members did not obey the rules.

**Practical implications:** If we manage to create an artificial manager, it will be much harder to make it effective in working with human team members. The research on team management automation will impact upon the business by giving a chance of implementing artificial management.

**Social implications:** even if we manage to create an artificial manager, it will be much harder to make it effective in working with human team members.

**Originality/value:** There is a new research problem of replacing a human manager with an artificial manager which has to be solved in management sciences and managerial practice in the future. This paper contains findings which are the next step in solving a new research problem of replacing a human manager with an artificial manager.

**Keywords:** artificial management, artificial leadership, virtual team, system of organizational terms.

**Category of the paper:** Research paper, case study.

## 1. Introduction

After the first age of robotics in mechanical processes and manufacturing it appeared rapid development of computer science and Internet which created opportunities to replace team managers with artificial managers (McAfee, and Brynjolfsson, 2016). Research on Artificial Intelligence (AI) in management has slowly appeared as a challenge for the future (Teddy-Ang, Toh, 2020). AI in management seems to exceed any other technological breakthrough that humanity has ever seen (Antonescu, 2018) and human-machine teamwork seems to be a promising paradigm to approach future situations in which humans and autonomous systems closely collaborate (van der Vecht et al., 2018).

Despite the fact that there are still discussions if AI management will evolve in artificial management (Franken, and Wattenberg, 2019) or in artificial leadership (Derrick, Elson, 2018), it seems that AI will overwhelm team management in the future (Webber et al., 2019). Even popular science and business journals raise this aspect of team management as the most important challenge in the next few years (Khan, 2020; Dzieza, 2020). If it happens, this would be the real accomplishment of Peter Drucker's words that in the future "computers" will not only make decisions but they will do much more (Drucker, 1967).

Therefore, there is a new research problem of replacing a human manager with an artificial manager. This problem is not yet sufficiently defined in the literature. However, we can predict that before implementing an artificial manager, it is necessary to make a choice of management with AI and answer if it should be more like team management or team leadership. Even if we discover which option is better, the research problem mentioned above entails a number of challenges that arise during the implementation of AI-based management. Some of these have already been discussed in the author's previous papers, such as how to represent manager's actions and how to imitate them. The purpose of this paper is the next step and it is to present an answer to the research question of what could be the real impact of an artificial manager on the work of a team consisting of humans.

The paper uses two research methods. In presenting the arguments for one way of proceeding AI-based management, a review of the recent literature in the field of artificial management and artificial leadership was used. While the answer to the research question was formulated based on the results of the author's research on the management of a virtual team by an artificial manager which he created. The artificial manager used in the research was the result of a non-participating, long-term observation of a group of students working on an specific task, whose activity was recorded by online management tools called TransistorsHead.com.

Section 2 of the paper presents definitions of a virtual team and a review of the literature on artificial management and artificial leadership. Section 3 describes the methodological basis of the non-participant, long-term observation carried out, which is the system of organizational

terms, the author's original methodological concept used by him to study organizational reality using online managerial tools. Section 4 presents the results of the study, which guides the answer to the research question on the impact of the artificial manager on the human members of the virtual team.

## **2. Artificial management or artificial leadership in a virtual team**

### **2.1. Virtual teams a new organizational environment of management**

Scholars traditionally define a team as a bounded and stable set of individuals as a group of people who are interdependent for a common purpose or who work interdependently towards shared goals (O'Neill, and Salas, 2018). Thus, teams have two required elements: membership and collaborative tasks. Team memberships in the past were often mutually exclusive, with members working in only one team at a time. Traditional teams are located in the same place and have easy access to both face-to-face and electronic communication. These teams have been formally studied for more than half a century, resulting a huge body of literature (Kozłowski, Chao, 2018; Mathieu et al., 2017). Contemporary the term membership tends to overlap, because members working virtually and simultaneously in more than one team.

Virtual teams in organizations appeared in the last decade of the 20th century and they are associated with accelerating business activities and increasing innovations (Ebrahim, Taha, 2009). A virtual team as a group of people who do not stay geographically, organizationally or temporally in the same place, but co-operate with each other through the use of ICT for one or more organizational tasks (Kožusznik, Pollak, Chrupała-Pniak, 2020).

The virtual team is also described by the category of temporality when short, undefined time of the team's activity is conditioned by the needs of the organization and individual motivations of its members (Gassmann, Von Zedtwitz, 2003). Virtual teams are also found in organizations which bring together specialists (Engerer, 2019). During the COVID-19 pandemic virtual teams appeared in organizations as a necessity to meet the challenges of isolating employees and virtual teams became a hallmark of the pandemic. The pandemic has boosted the implementation of virtual teamwork, with many employees working at homes using virtual tools to collaborate with their teammates (Feitosa, Salas, 2020). These changes are linked with uncertainty because of the growing variability and complexity of many work processes. Result of this is that teamwork has become more cognitively demanding due to increased technology, task variety and knowledge-based work together with ICT tools. For this reason, AI-enabled management has become an important research topic in many areas of management science, bringing with it many opportunities and challenges (Xiong, Xia, Wang, 2022).

## 2.2. Differences between artificial management and artificial leadership

The first vision of artificial management were spoken in words that in the future “computers” will not only make decisions but they will do much more (Drucker, 1967). Looking for an answer if it is possible to replace human team managers with artificial ones, it is necessary to consider two terms “artificial management” and “artificial manager” created nearly 40 years ago (Geisler, 1986).

On the one hand, it is true that the concept of artificial management and its operational consequence of implementing an artificial manager were seen as a dehumanizing attempt to eliminate participation of human in the management processes in the organization. Therefore, traditionally most of researchers considered artificial management applications only in organizational decision systems or routine operational processes which were well structured (Mitroff, Linstone, 1993; Courtney, 2001; Gigerenzer, nd Gaissmaier, 2011). After decades it led to focus mostly on automated decision making (Zimmermann et al., 2019). However, in literature we can find research on influence of AI management on such aspects as planning (Liu et al., 2020), decision making (Smith, Green, 2018), problem solving (Waizenegger et al., 2020).

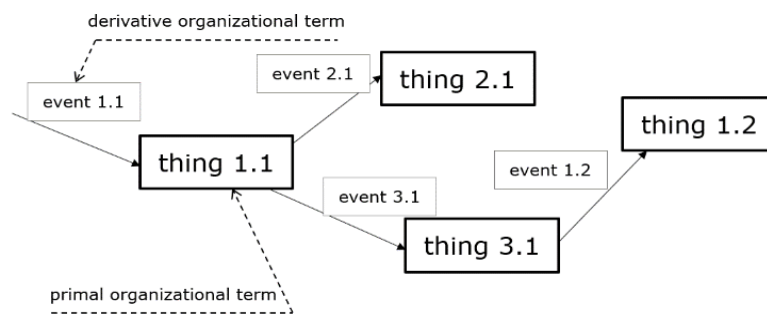
On the other hand, after decades AI overwhelms more and more areas of business management. Artificial intelligence is emerging as a potential growth area for facilitating the improvement and development of teams in the workplace. AI in team management is currently underdeveloped and limited, despite the wide-scale adoptions and implementations of AI to improve team leadership (Webber et al., 2019). New applications such as artificial agents, automation or intelligent assistance are becoming drivers of a wide-ranging change process in companies which requires reorganisation of team management according to a leadership approach (Franken, Wattenberg, 2019). AI-based leadership could theoretically be deployed at a local level in their scope of operation (Chen, 2019). There is also further philosophical dilemmas about ethical aspects of artificial leadership (Brendel et al., 2021). This will decreased focus on getting machine followers to feel part of a virtual team (Smith, Green, 2018).

As can be seen from the above literature review, the dilemma of whether to direct efforts toward artificial management or toward artificial leadership has not been resolved. However, in the author’s opinion, the artificial management approach is more feasible, and this is the approach the author has been using in his research for several years. The most important arguments in favor of artificial management are the problems of adequate and sufficiently accurate representation of a manager’s work, recording and recognizing patterns of his behavior, and then implementing artificial actions taken by an artificial manager. Since these problems have not yet been fully solved, the artificial leadership approach still seems beyond the reach of management science, not to mention the practical implementation of such solutions.

Section 3 presents a methodological approach, the system of organizational terms, which is compatible to the artificial management trend, as well as an example of research tools in this approach, online managerial tools called TransistorsHead.com.

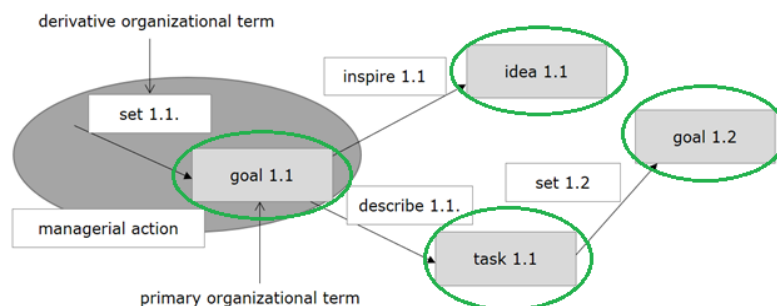
### 3. Methodology of research based on the system of organizational terms

The system of organizational terms has been developed and tested in the last years (Flak, 2017, 2021; Yang, Flak, Grzegorzek, 2018; Flak, Hoffmann-Burdzińska, Yang, 2018). This methodology lets us record managerial actions one by one and it is possible to answer what a team manager and his team members really do (Sinar, Paese, 2016). The philosophical foundation of the system of organizational terms is based on Wittgenstein's philosophy. According to this approach team management can be organised by events and things. As it is shown in Figure 1, each event and thing have the label n.m, in which n and m represent a number and a version of a thing, respectively. Event 1.1 causes thing 1.1, which in turn releases event 2.1 that creates thing 2.1. Thing 1.1 simultaneously starts event 3.1 which creates thing 3.1. Then, thing 3.1 generates a new version of the first event, i.e. event 1.2. In such a way, a new version of the first thing is created, which is called thing 1.2. So, the managerial action structure consists of, e.g. event 1.1 and thing 1.1. As it is shown in Figure 2, differences between features of things let us do reasoning on the team management process (Yang, Flak, Grzegorzek, 2018).



**Figure 1.** Types of organizational terms.

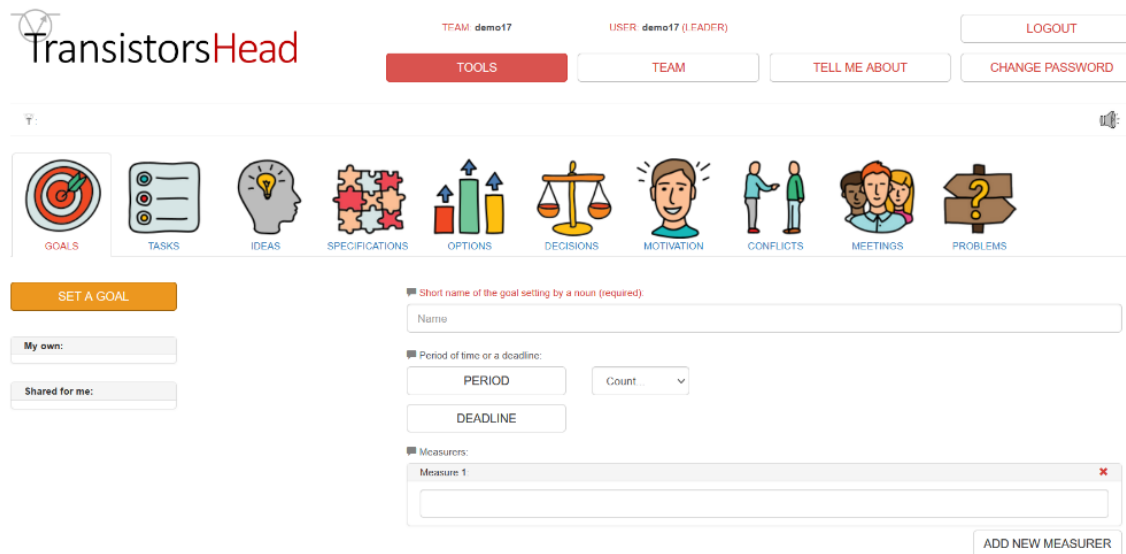
Source: Own elaboration.



**Figure 2.** Structure of a managerial action.

Source: Own elaboration.

The important aspect of this methodology is the set of online management tools (Figure 3) which record parameters if the managerial actions (effects marked with a green round, e.g. a goal 1.1 as a result of set 1.1 in Figure 2). TransistorsHead.com records changes in team management processes. It reminds making a movie of teamwork with frames of features team management processes in 10 areas of team management. However, not only it can learn the human managerial actions (taken by a human manager and its team members), but also allows to implement an artificial manager. This is an extraordinary combination self-learning research tools imitating main common managerial actions of a human manager.



**Figure 3.** Online management tools in TransistorsHead.com as research tools.

#### 4. Results of research

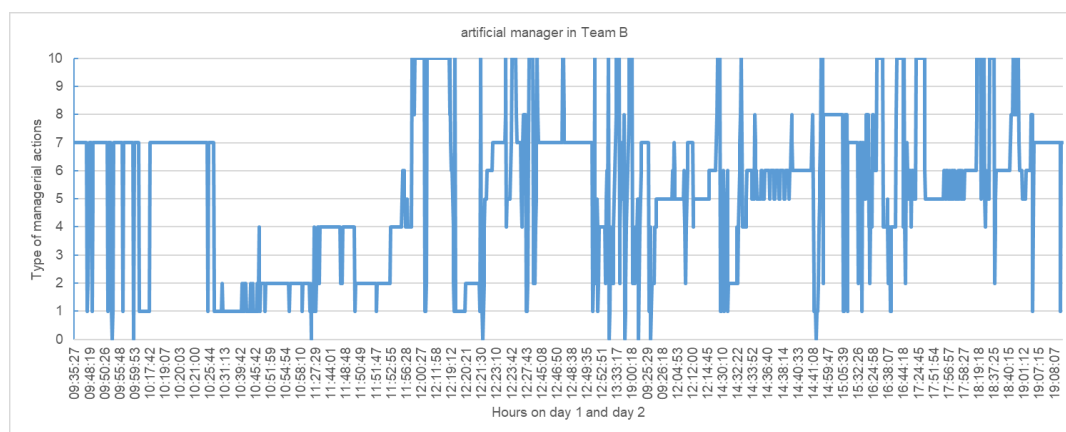
The non-participant, long-term observation was conducted in two parts in June (Team A) and December (Team B) 2021 and both lasted 36 hours. The groups of participants in the observations consisted of 3 students of the University of Silesia in Katowice (different students in both parts), working in virtual teams, each of whom was assigned the role of team manager. Participants could work at any time between 9 a.m. on the first day and 9 p.m. on the second day of observation using online management tools at TransistorsHead.com and the MS Teams communication tool. Participants had basic competencies in managerial techniques, acquired during the “Managerial Techniques” and “Business Plan” courses. Both groups were given the same task, which was to design an entertainment program in Talent Show format on a YT channel.

However, Team A was completely free to do the task using the online management tools in TransistorsHead.com. The tools were recording 8 of their managerial actions (Table 1). 6 months later Team B was asked to work with the artificial manager embedded in TransistorsHead.com. The sequence of managerial actions which the artificial manager took was a result of analyzing managerial actions taken by the team manager in Team A. Another words, the system of TransistorsHead.com was taught by Team A how to do the task and during the second part of the research the system played a role an artificial manager in Team B. During the second part of the study, members of Team B saw on the screen what managerial action should be taken at the moment and 5 managerial actions which the artificial manager wanted to take in the future, along with the time to start them.

The results of both parts of the research contain hundreds of thousand of records in SQL database which, on the one hand, describe behaviour of human members and a human manager during the first part of the research (Team A) and human members of the virtual team in the second part of the research (Team B).

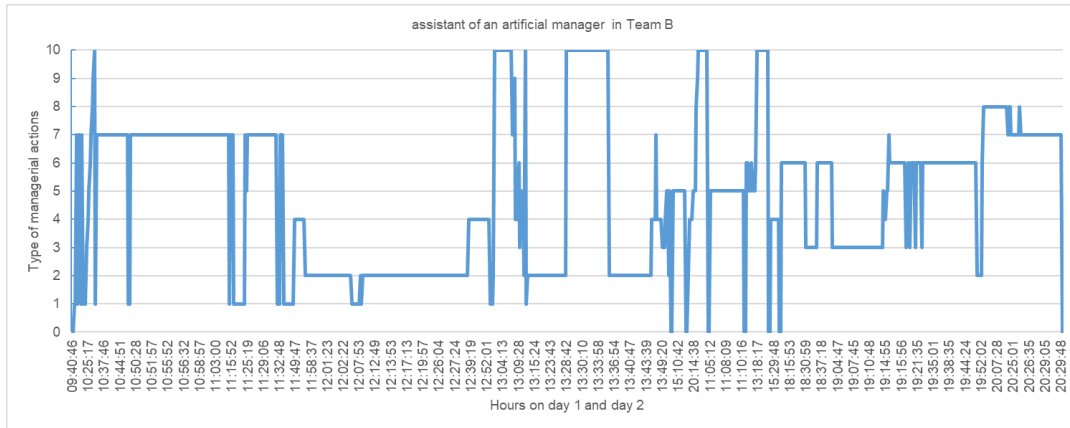
Figure 4 shows the function of time in giving orders by an artificial manager in the second part of the research. The artificial manager was leading human members in a virtual team (Team B). Figures 5, 6, 7 present which managerial actions were taken by every one of human members cooperating with the artificial manager in Team B. A special member is presented in Figure 6, because he was an assistant of the artificial manager. This person was instructed by the investigator about his special role as an intermediary between the artificial manager and the other team members.

In Figures 4, 5, 6, 7 we can see 10 types of managerial actions. Their meaning is described in Table 1.



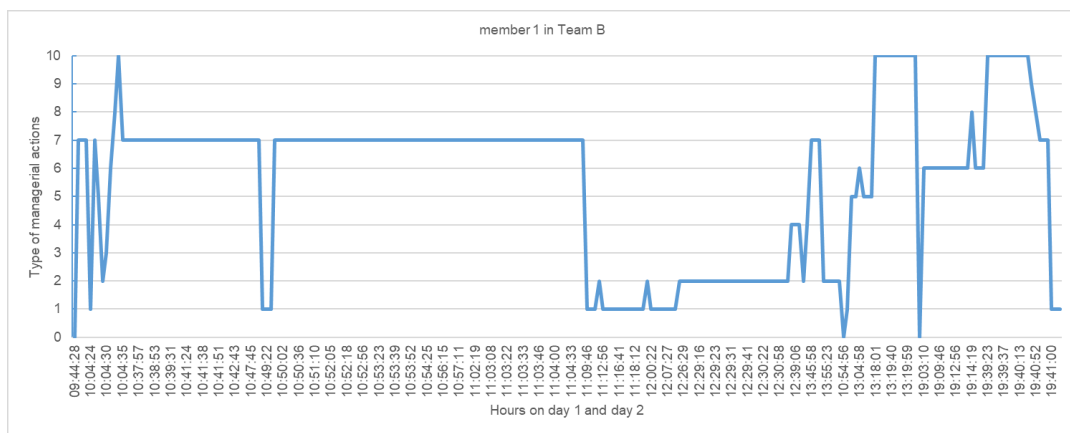
**Figure 4.** Managerial actions taken by an artificial manager.

Source: Own elaboration.



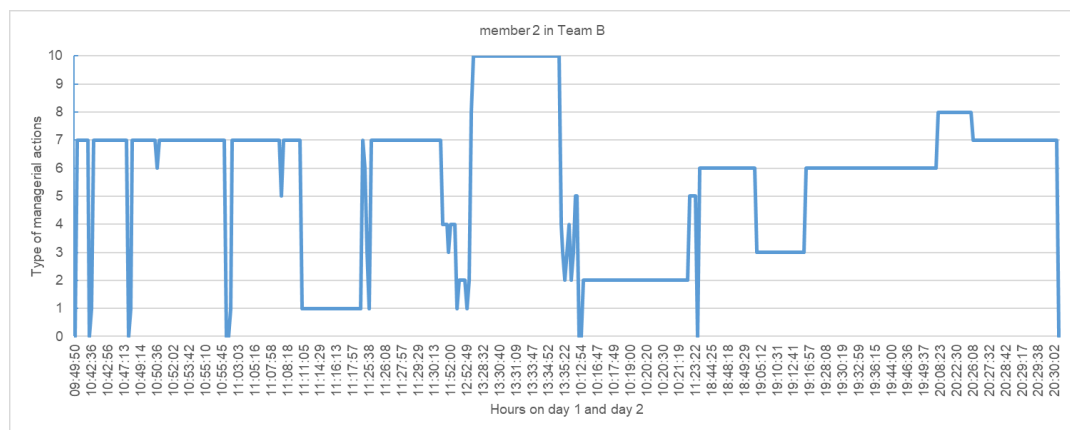
**Figure 5.** Managerial actions of a human assistant of an artificial manager (Team B).

Source: Own elaboration.



**Figure 6.** Managerial actions of a human member 1 (Team B).

Source: Own elaboration.



**Figure 7.** Managerial actions of a human member 2 (Team B).

Source: Own elaboration.

In Table 1 there are numbers of managerial actions given as orders to a human virtual team and numbers of real managerial actions taken by human team members.



**Table 1.***Numbers of managerial actions taken by all members of team A*

Number of a managerial action	Type of a managerial action (name of a managerial tool in TransistorsHeac.com)	Artificial manager	Assistant of an artificial manager	Human member 1	Human member 2
1	set goals (GOALS)	157	46	29	36
2	describe tasks (TASKS)	247	234	37	59
3	generate ideas (IDEAS)	0	69	1	29
4	specify ideas (SPECIFICATIONS)	167	59	4	8
5	create options (OPTIONS)	212	63	6	7
6	choose options (DECISIONS)	220	121	17	95
7	check motivation (MOTIVATION)	447	214	123	179
8	solve conflicts (CONFLICTS)	82	29	3	18
9	prepare meetings (MEETINGS)	0	3	1	0
10	explain problems (PROBLEMS)	164	79	23	43
Total:		1696	917	244	474

Source: Own elaboration.

We can compare charts of managerial actions in function of time of the artificial manager (Figure 5) to any other member of Team B (Figures 6, 7, 8). None of them did not follow the orders given by the artificial manager. For example, if the artificial manager showed all members to do a motivation check (Tool 7 - CHECK MOTIVATIONS), they turned it on, however, they stayed longer than the artificial manager wanted and they did not skip to setting goals (Tool 1 - SET GOALS), despite the fact they were told to do it.

Very few of the managerial actions taken by team members were concurrent with those imposed by the artificial manager. Only 17% of them were started within 5 seconds or less of the artificial manager's command, 8% of which was by the assistant of the artificial manager designated by the investigator. As can be seen in Figures 7 and 8, the other two participants were rather passive and remained "in the activity" for a long time, meaning that they did nothing at the time, and only the online management tool was open on their computer screen.

The insignificant impact of the artificial manager's commands on the work of the team, which meant that the members simply ignored the commands of the artificial manager, is confirmed by the data on the numbers of managerial actions taken of a given type. For example, the artificial manager gave the command to set (or re-set) goals 157 times (Tool 1 - SET GOALS), while team members took this action a total of 111 times. The artificial manager instructed to create, improve or just see what decision options could be considered 212 times, while team members responded only 76 times (Tool 5 - OPTIONS). Interestingly, team

members tried to prepare a meeting 4 times (Tool 9 - MEETINGS), while the artificial manager did not mention this managerial action even once. Admittedly, the sum of instructions given by the artificial manager to all managerial actions taken by Team A is similar, but their structure and arrangement in time is completely different.

## 5. Conclusions

The purpose of the paper is to present an answer to the research question which derived from the research problem about replacing a human manager with an artificial manager. Basing on the non-participant, long-term observation there is an attempt of answering what could be the real impact of an artificial manager on the work of a team of humans.

The general answer is that the real impact of the artificial manager on the human team members was very weak. Although team members were taking similar managerial actions as they were told by the system of TransistorsHead.com, they mixed the order and decreased or increased a period of the managerial actions. It seems that human members of Team B did not feel any emotional pressure on their behaviour from the artificial manager and they do not treat the system too seriously. What is interesting, the most obedient person in Team B was the appointed assistant of the artificial manager. The rest two members did not obey the rules. In informal talks with the author of the paper they said that the orders given by the artificial manager were even an obstacle in their performance and they did not want to listen to “him” (the artificial manager).

General conclusion which can be drawn from this research is that even if we manage to create an artificial manager, it will be much harder to make it effective in working with human team members. Even if the area of team management automation and its consequences seem to be dominant area of research in the nearest future (Derrick, Elson, 2018; Franken, Wattenberg, 2019; Webber et al., 2019; Teddy-Ang, Toh, 2020), we need to answer two other research questions in social domain of team cooperation: (1) how an artificial manager and team members influence on team management processes, (2) in what extent team members take actions of an artificial manager and other way round. Both aspects are planned to be involved in the author’s research projects in the future. Both research questions could let introduce further discoveries in the nature of cooperation between artificial team members and human members. In the future it is planned to organize a group of about 100 participants working within a year on certain projects which could let distinguish main sequences of managerial actions and discover their semantic meaning.

## Acknowledgements

This paper was undertaken as part of the Team Flow and Team Effectiveness in Virtual Teams project and was fully funded by a grant (NCN 2020/39/G/HS6/02124).

## References

1. Ale Ebrahim, N., Ahmed, S., ad Taha, Z. (2009). Virtual teams: A literature review. *Australian journal of basic and applied sciences*, 3(3), 2653-2669.
2. Antonescu, M. (2018). Are Business Leaders Prepared to Handle the Upcoming Revolution in Business Artificial Intelligence? *Quality-Access To Success*, Vol. 19, Iss. 5, pp. 15-19.
3. Brendel, A.B., Mirbabaie, M., Lembcke, T.-B., Hofeditz, L. (2021). Ethical Management of Artificial Intelligence. *Sustainability*, Vol. 13, Iss. 4, pp. 1-18.
4. Chen, J.Q. (2019). Who Should Be the Boss? Machines or a Human? In: P. Griffiths, M.N. Kabir (Eds.), *Proceedings of the European Conference on the Impact of Artificial Intelligence and Robotics (ECIAIR)* (pp. 71-79).
5. Courtney, J.F. (2001). Decision making and knowledge management in inquiring organizations: Toward a new decision-making paradigm for DSS. *Decision Support Systems*, Vol. 31, pp. 17-38.
6. Derrick, D.C., Elson, J.S. (2018). Automated Leadership: Influence from Embodied Agents. In: F. Nah, B.S. Xiao (Eds.), *HCI in Business, Government, And Organizations* (pp. 51-66). Book Series: Lecture Notes in Computer Science, 10923.
7. Drucker, P.F. (1967). The Manager and the Moron. *McKinsey Quarterly*, December, Retrieved from: <http://www.mckinsey.com/business-functions/organization/our-insights/the-manager-and-the-moron>.
8. Dzieza, J. (2020). *How hard will the robots make us work?* Retrieved from: <https://www.theverge.com/2020/2/27/21155254/automation-robots-unemployment-jobs-vs-human-google-amazon>.
9. Engerer, V.P. (2019). Information Systems in Interdisciplinary Research: Analytic and Holistic Ways to Access Information Science Knowledge. *Journal of Information Science Theory and Practice*, Vol. 7, Iss. 2, pp. 6-22.
10. Feitosa, J., Salas, E. (2020). Today's virtual teams: Adapting lessons learned to the pandemic context. *Organizational Dynamics*, Vol. 7, pp. 1-4.
11. Flak, O. (2017). *Methodological Foundations of Online Management Tools as Research Tools*. Proceedings of the 16th European Conference on Research Methodology for

- Business and Management Studies ECRM2017, K. Lawlor, A.P. Buckley (Eds.), pp. 113-121.
12. Flak, O. (2021). *Knowledge Acquisition on Team Management Aimed at Automation with Use of the System of Organizational Terms*. Proceedings of the 10th International Conference on Pattern Recognition Applications and Methods ICPRAM. M. De Marsico, G.S. di Baja, A. Fred (Eds.), pp. 302-311.
  13. Flak, O., Hoffmann-Burdzińska, K., Yang, C. (2018). Team Managers Representation and Classification Method based on the System of Organizational Terms. Results of the Research. *Journal of Advanced Management Science, Vol. 6, Iss. 1*, pp. 13-21.
  14. Franken, S., Wattenberg, M. (2019). *The Impact of AI on Employment and Organisation in the Industrial Working Environment of the Future*. Proceedings of the European Conference on the Impact of Artificial Intelligence and Robotics (ECIAIR). P. Griffiths, M.N. Kabir (Eds.), pp. 141-148.
  15. Gassmann, O., Von Zedtwitz, M. (2003). Trends and determinants of managing virtual RandD teams. *RandD Management, Vol. 33, Iss. 3*, pp. 243-262.
  16. Geisler, E. (1986). Artificial Management And The Artificial Manager. *Business Horizons, Vol. 29, Iss. 4*, pp. 7-21.
  17. Gigerenzer, G., Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology, Vol. 62*, pp. 451-482.
  18. Khan, T.N. (2020). *69% Of Managers' Work To Be Completely Automated By 2024: Gartner*. Retrieved from: <https://www.entrepreneur.com/article/345435>.
  19. Kozlowski, S.W.J., Chao, G.T. (2018). Unpacking team process dynamics and emergent phenomena: Challenges, conceptual advances, and innovative methods. *American Psychologist, Vol. 73, Iss. 4*, pp. 576-592.
  20. Kozusznik, B., Pollak, A., Chrupała-Pniak, M. (2020). Zespół pracowniczy. In: B. Roznowski, P. Fortuna (Eds.), *Psychologia biznesu* (pp. 349-366). Warszawa: PWN.
  21. Liu, J., Chang, H., Forrest, J., Yang, B. (2020). Influence of artificial intelligence on technological innovation: Evidence from the panel data of China's manufacturing sectors. *Technological Forecasting and Social Change, Vol. 158*, 120142.
  22. Mathieu, J.E., Hollenbeck, J.R., van Knippenberg, D., Ilgen, R. (2017). A century of work teams in the Journal of Applied Psychology. *Journal of Applied Psychology, Vol. 102*, pp. 452-467.
  23. McAfee, A., Brynjolfsson, E. (2016). Human work in the robotic future: Policy for the age of automation. *Foreign Affairs, Vol. 95, Iss. 4*, pp. 139-150.
  24. Meng, H., Weifeng, L., Bowen, D. (2020). The Influence Mechanism of Authentic Leadership in Artificial Intelligence Team. *Journal of Physics, Vol. 1438*, pp. 1-7.
  25. Mitroff, I.I., Linstone, H.A. (1993). *The unbounded mind: Breaking the chains of traditional business thinking*. New York, NY: Oxford University Press.

26. O'Neill, T.A., Salas, E. (2018). Creating high performance teamwork in organizations. *Human Resource Management Review*, Vol. 28, Iss. 4, pp. 325-331.
27. Peifer, Y., Jeske, T., Hille, S. (2022). Artificial Intelligence and its Impact on Leaders and Leadership. *Procedia Computer Science*, Vol. 200, pp. 1024-1030.
28. Sinar, E., Paese, M. (2016). The new leader profile. *Training Magazine*, Vol. 46, pp. 46-50.
29. Smith, A.M., Green, M. (2018). Artificial Intelligence and the Role of Leadership. *Journal of Leadership Studies*, Vol. 12, Iss. 3, pp. 85-87.
30. Teddy-Ang, S., Toh, A. (2020). AI Singapore Empowering a Smart Nation. *Communications Of The ACM*, Vol. 63, Iss. 4, pp. 60-63.
31. van der Vecht, B., van Diggelen, J., Peeters, M., Barnhoorn, J., van der Waa, J. (2018). Social Artificial Intelligence Layer for Human-Machine Teaming. In: Y. Demazeau, J. Bajo, A.F. Caballero (Eds.), *Advances in Practical Applications of Agents, Multi-Agent Systems, and Complexity* (pp. 262-274). Lecture Notes in Artificial Intelligence, Vol. 10978.
32. Waizenegger, L., McKenna, B., Cai, W.J., Bendz, T. (2020). An affordance perspective of team collaboration and enforced working from home during COVID-19. *European Journal of Information Systems*, 29(4), pp. 429-442.
33. Webber, S.S., Detjen, J., MacLean, T.L., and Thomas, D. (2019). Team challenges: Is artificial intelligence the solution? *Business Horizons*, Vol. 62, Iss. 6, pp. 741-750.
34. Xiong, Y., Xia, S., Wang, X. (2020). Artificial intelligence and business applications, an introduction. *International Journal of Technology Management*, Vol. 83, Iss. 1-2, pp. 1-7.
35. Yang, C., Flak, O., Grzegorzec, M. (2018). Representation and Matching of Team Managers: An Experimental Research. *IEEE Transactions on Computational Social Systems*, Vol. 5, Iss. 2, pp. 311-323.
36. Zimmermann, A., Schmidt, R., Sandkuhl, K., Jugela, D. (2019). Intelligent Decision Management for Architecting Service-Dominant Digital Products. *Procedia Computer Science*, Vol. 159, pp. 2120-2129.