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SOCIAL ASPECTS OF THE IMPACT OF SOFTWARE AGENTS ON PARTICIPANTS OF BUSINESS PROCESSES IN KNOWLEDGE BASED ORGANISATIONS

Summary: The use of agent systems in knowledge dissemination is a key element of business processes of an organisation. When building agent systems to support such activities, it is important to determine the impact of agents on participants of business processes. Agent units designed to support the operation of an organisation, especially a knowledge-based organisation, should be considered as a system whose main task is to support business processes of such an organisation, participate in knowledge management processes and support the different participants of business processes. The aim of this paper is to analyse the results of conducted research experiments against social features of the examined group. The first part of the paper presents research in this area carried out by the authors. The second part shows the results of research into usability of software agents in the context of social features of the analysed group.

Keywords: software agent, social aspect, business process, knowledge.

Introduction

The market sets high requirements to entrepreneurs. The key is to implement a development model in which both employees and recipients of a business process will have constant access to necessary knowledge and possibility of acquiring new skills, which are important both from their individual perspective and the perspective of the company whose strategy they are implementing. Knowledge in an organisation can be explicit or tacit. Another division is into individual (expert) and group knowledge. Its use is intentional and directed to

tasks and actions performed as part of undertaken activities. We can thus accept the proposal by Norman [2005], according to which the operation of a system in the context of available technological support is connected with objectives, which in turn will depend on users and interested parties and their real needs.

Agent solutions are a proposed solution to support the integration of knowledge in the area of its use in business processes. They can be used in various areas, as indicated in academic literature, from marketing, direct contact with the customer, through product recommendation, search for goods and suppliers, negotiation of prices, delivery terms and guarantee, to representation of a human being at auctions and electronic markets [Gris et al., 2014; Rus et al., 2013; Graesser et al., 2014]. The task of conversational software agents deployed in organisations is, among other things, to increase the customer's trust in the company, provide assistance during online shopping, answer frequently asked questions, gather information about the user, personalise the content of services, build durable and meaningful relationships with the customer, and consequently – increase satisfaction with the contacts with the company and build loyalty of the customer. Interface agents are electronic representatives of companies. They provide advice, advertise products, show the user around a website, are designed to prejudice us in favour of the company and engage in conversation, and gather valuable marketing data, e.g. concerning the age, sex and preferences of the customer. "[…] The common feature on which their reliability and similarity to human beings as conversation partners are based are models of information technologies that ensure them such functions as synthesis of emotions and personality, implementation of behaviour during human interaction or presentation skills. Anthropomorphic characters support a user interface and improve communication skills […]" [Stanek, 2005]

An important element of agents are artificial intelligence mechanisms, which allow agents to take the right decisions and actions in the process of implementation of an objective. These mechanisms depend on the specificity of an agent connected with its use and requirements set for it. However, from the perspective of an organisation, where software agents constitute an element of a business process, they are not crucial. What is the most important is the impact of such a solution on how a process runs and on its participants.

Interviews conducted by the research team with companies that create and implement agent technologies in Poland indicated a range of problems such as, among other things, lack of formalised methodologies that support the development of such technologies, problems with integrating them with IT systems of an organisation and consequently − lack of topicality of agents' knowledge and focus on building single software agents. [Żytniewski, Kowal, Sołtysik, 2013a; Żytniewski, Kowal, Sołtysik, 2013b].

As a result, in order to conduct research into the impact of agent systems on an organisation and users it was necessary to develop a research method capable of determining whether the systems currently available on the Polish market contribute to the improvement of business processes that take place in such organisations. The findings presented in this paper constitute continuation of those presented in the paper addressing [Żytniewski, Kopka, 2014] the use of the concept of ergonomics and usability of agent systems and evaluation of [Żytniewski, Kopka, 2014] their impact on participants of business processes. For the purpose of the research a hypothesized base was adopted, which states that the use of software agents in the conditions of ubiquitous communication contributes to the improvement of business processes taking place in knowledge based organizations. The paper contains only part of the findings.

First chapter is focused on knowledge dissemination. Definitions are given, and then current research analysis is taken. Therefore, authors go to analysis of social features between agents and users. Further subjects of management inventory's company and creative thinking are combined in chapter dedicated to creative solving problems, with computer support topic underlined. Last part of this article is a review of the results of analyses of the (impact) of social characteristics on the process of knowledge acquisition.

1. Knowledge dissemination

Knowledge in an organisation can be explicit or tacit. Another division of knowledge is into individual (expert) and group one [Jordan, Henderson, 1995]. We should also note the fact that users and those interested in acquiring knowledge from an agent operating in an organisation may implement opposing tasks and goals, so it is necessary to model roles to be fulfilled by an agent, and consequently – its knowledge. We can thus accept Norman's proposal [Norman, 2005], in which the operation of a system in the context of available technological support is connected with goals, which in turn will depend on the users and interested parties and their actual needs.

Building agents capable of analysing the context of statements, reacting to questions of the user and articulating their emotional states, as well as disseminating their knowledge, is a complex task that requires the use of various information technologies [Stanek, 2008]. A solution of this type, in which the above mentioned technologies can be implemented, is an interface agent, represented by an avatar which communicates with the user through mechanisms of artificial intelligence.

Agent systems are comprised of interacting, autonomous entities, issues of organisational design and political theory become important in their design and evaluation. Because prediction of other agents' actions may be important to an agent, sociological and legal theories of norms and group behaviour are relevant, along with psychological theories of trust and persuasion. Analysis of social aspects between agents (like anthropomorphic characters) and users can provide the capability for behaviour modelling. It allows to study the interactions between the agent and user at both macro and micro levels, as well as in both directions (i.e. knowledge dissemination) [Luck, 2003; Moss, 2000].

Interface (anthropomorphic) agents allow to extend interaction with the user through such features of an agent as personification or personality in the process of non-verbal communication that may affect satisfaction with the contact with such an entity. In the case of using software agents as an element supporting business processes, in particular treating them as an element of a knowledge management system, such solutions can be treated as an element supporting knowledge dissemination. In this case, a software agent improves the implementation of a business process, providing the user with new knowledge and impacting their satisfaction with the performance of the process.

Research shows [Żytniewski, Kopka, 2015a] that one of the measures of the evaluation of agents' impact on users is their usability, which can be considered in terms of system performance, effectiveness and user satisfaction [Kim, Moon, 1998]. Research concerning analysis of experiments conducted so far in this area shows that it is necessary to treat these usability factors in a more comprehensive way, also in the area of supporting the processes of disseminating knowledge to the user. For a conversational agent to be a partner of the user, it has to arouse trust, i.e. it has to meet some conditions, such as being friendly, including, easy and fast access, convenient navigation and nice appearance [Angeli de, Johnson, Conventry 2001]. In addition, the way the consultant communicates has to be adjusted to the communication style of the person that cooperates with the agent. One of the aspects that was examined by the authors [Żytniewski, Kopka, 2015a] in the area of usability of agents was the aspect of knowledge dissemination. It was assumed in the research that in order to determine the impact of an agent on the user, it is necessary to establish a set of expected knowledge of the user (1). As pointed out by the authors, the set of such elements of knowledge is the sum of knowledge possessed by a specific person and knowledge they want to obtain from the agent.

$$D_{ij}^{(EX)} = \{d_{x_{ij}+1}^{(EX)}, ..., d_{x_{ij}+a_{ij}}^{(EX)}\}$$

where, $| D_{ij}^{(EX)} |=: a_{ij}, D_{ij}^{(EX)} \cap D_{ij}^{(X)} = \emptyset$ (1)

This is knowledge that the user wants to obtain as a result of interaction with an agent. It was assumed during the research that the expected knowledge of users participating in the examination of agent usability cannot be possessed by it, and the expected knowledge has to be part of the knowledge of the agent. At the same time, the user has to have some expectations about interaction with an agent (2).

$$\forall j \in \{1, 2, ...l\}\ D_{ij}^{(EX)} \cap D_{ij}^{(X)} = \emptyset \wedge \exists\, k \in \{1, 2, ..., m\}$$
$$D_{ij}^{(EX)} \subseteq D_{kj}^{(Y)} \text{ and } D_{ij}^{(EX)} \neq \emptyset \quad (2)$$

This was a key assumption because it was agreed that if the user had knowledge that we wanted them to obtain during the experiment, their evaluation of the agent would be unreliable. This resulted from the assumption that actions of the user in contact with the agent might not lead to acquisition of expected knowledge, which would distort the evaluation of operation of the agent. In such a case, the user may try to deliberately mislead the agent, which would lead to unreliable evaluation of its actions. Due to such restrictions, the experiment excluded people whose knowledge was good enough to affect the evaluation of the operation of an agent. At the same time, users that were really interested in working with an agent and did not possess required knowledge were defined.

The experiment used multiple criteria, taking into account analysis of all pre-defined measures of usability, i.e. knowledge, usability, performance and satisfaction. It should be stressed that interface agents implementing various objectives and tasks were used in the experiment. As a result, every agent distributed a different kind of knowledge and showed different reactions to interactions with the user by means of words/speech synthesis (systematic forms of knowledge representation) and gestures as part of individually defined context – understood here as ability to adapt to different situations. Agent A performed the function of a salesperson, and its task was to acquaint the user with the offer of products and functioning of the organisation. Agent B performed informational tasks; by substituting traditional hotline, it disseminated knowledge about social insurance, whereas Agent C supported the user in the area of the functioning of urban services for example through providing appropriate models of documents, directing to the right department, etc.

2. Analysis of social features

The aim of the research [Żytniewski, Kopka, 2015b] presented in the paper was to show a research method developed by the authors to analyse usability of software agents. 102 research experiments were conducted to evaluate this method. The experiment used random sampling – users varied in terms of knowledge concerning the work with both conversational software and agent systems. The research experiment was conducted in November/December 2014. This chapter will present research findings from the perspective of social features of the examined population. The experiment conducted allowed us to observe phenomena between participants of the experiment not only in the context of ergonomics and usability, but also social conditions, understood as age, sex, place of residence, education, computer skills and experience in working with agent systems.

Most participants of the experiment were urban dwellers. The average age of the experiment participants was 27 years. All the participants had secondary or higher education.

The research [Żytniewski, Kowal, Sołtysik, 2013a] showed that from the perspective of a comprehensive view of ergonomics of agent systems in the context of their usability the existing research methods took into account only selected aspects of the process of evaluation of software agents' ergonomics. Thanks to relating ergonomics of an agent system with its usability and indicating areas of possible criteria for evaluating agents, as proposed by the authors, the attempt made in this paper to make a synthesis of these approaches enables a more complete view of ergonomics of agent systems in terms of development of agent research methods in this area.

The aim of the above-mentioned research by the authors was to analyse agent solutions currently used on the Polish market using a proposed qualitative research method to evaluate usability and degree of knowledge distribution between the human being and the computer in terms of using agent systems. Earlier research addressed in literature dealing with software agents mainly refers to standard quantitative metrics describing such characteristics as reactivity, proactivity, autonomy, communication and cooperation [Franklin, Abrao, 2000; Alonso et al., 2008; Alonso et al., 2009; Sivakumar, Vivekanandan, 2012], not taking into account the social aspect of the application of such solutions.

Analysis of data collected as part of the experiment enables diagnosing a range of dependencies going beyond the fundamental research assumptions – modelled on other questionnaires, including those recommended by SEI for

evaluating maturity of processes [Zubrow, Hayes, Siegel, 1994], the introductory part of the research included aggregation of data showing the user profile. The questionnaires developed for the purpose of the experiment asked about:

- the sex;
- the age;
- education level;
- place of residence;
- experience in work with conventional computer systems (no experience, basic level, intermediate level, advanced level).

Data obtained in this way allowed us to analyse social factors in the system: the human being – anthropomorphic conversational agent.

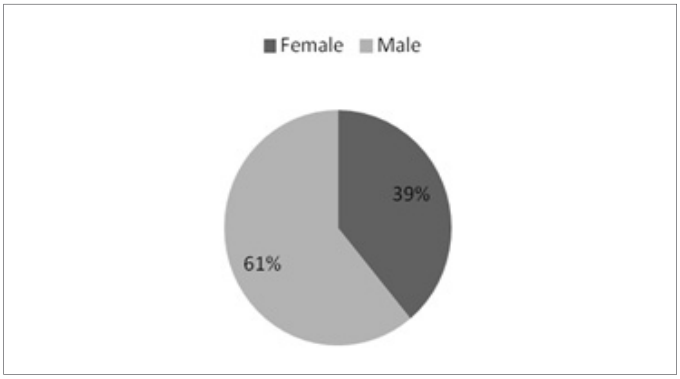

Fig. 1. Distribution of the research participants by sex

Source: Own research.

The distribution of the research participants by sex was as follows: females accounted for 39% of those surveyed, whereas males – 61%.

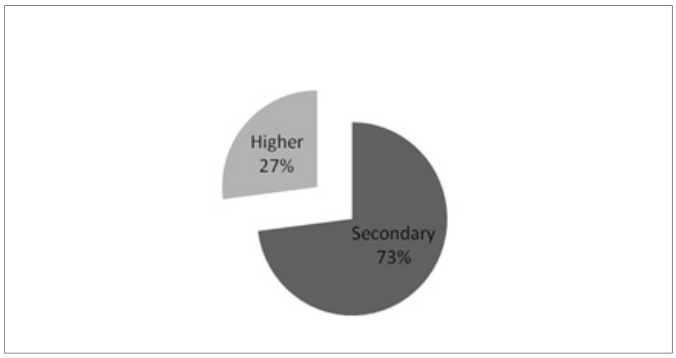

Fig. 2. Distribution of the research participants by education

Source: Own research.

Research participants had secondary education (73%) or higher education (27%). None of the participants indicated primary education, second stage of basic education or vocational education.

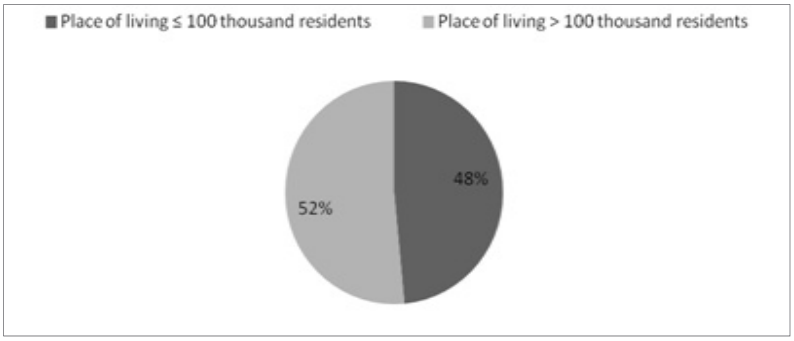

Fig. 3. Distribution of the research participants by place of residence

Source: Own research.

Analysis of the place of residence shows that 48% come from the places under or even 100 thousand of residents, 52% from a city with number above 100 thousand residents.

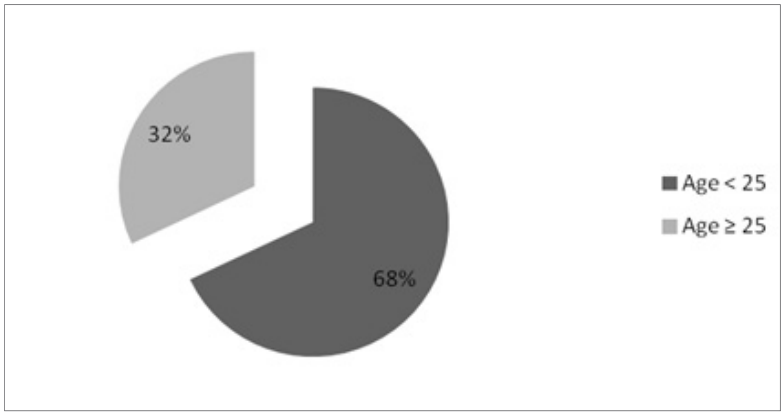

Fig. 4. Age structure of the respondents

Source: Own research.

For the purpose of simplifying statistical calculations, the age structure of the research participants was defined as two age groups: < 25 (68% of population) and ≥ 25 (32% of population). The youngest research participant was 20 years old, the eldest – 82 years old. The average age of the experiment participants was 27 years.

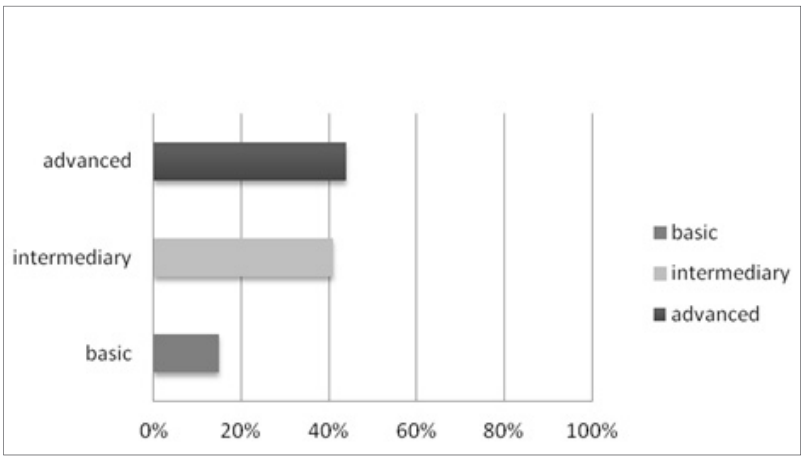

Fig. 5. Experience in work with computer systems

Source: Own research.

15% of research participants indicated that they had basic knowledge of conventional computer systems; 41% indicated intermediary level, whereas 44% described their knowledge level as advanced.

3. Review of the results of analyses of the (impact) of social characteristics on the process of knowledge acquisition

The abovepresented data concerning the research participants contributed to a deeper analysis in the context of usability of an agent system and the effectiveness of supporting the process of propagating system knowledge to users.

Statistical analysis was based on non-parametric methods. For independent samples, Mann-Whitney U test was used, whereas dependent samples were examined using Wilcoxon signed-rank test. Correlation relationships of the characteristics were examined by means of gamma coefficient (γ). This reason for using this coefficient was the fact that there was a big number of the same values among the data (the so-called related observations). All the tests were carried out using the software Statistica v10.

Parameters used for research could assume values from 0 to 1, where 1 is the highest indicator of satisfaction and the highest level of knowledge propagation. Also in the case of knowledge propagation parameter, 1 means that the agent transferred all the required knowledge to the user.

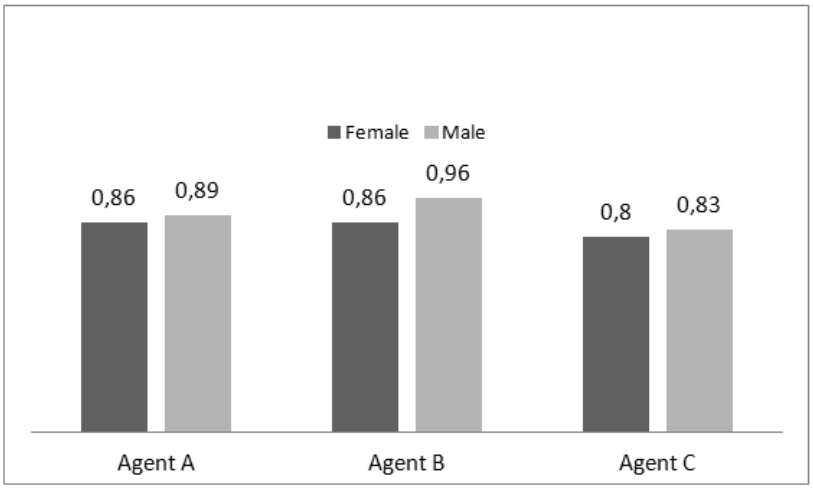

Fig. 6. Growth of knowledge based on sex

Source: Own research.

Figure 6 shows the aspect of knowledge growth in relation to the sex of those surveyed. The data shows that in the group of women knowledge growth was for Agent A = 0,86; Agent B = 0,86 and Agent C = 0,8 whereas in the group of men, it was for Agent A = 0,89; Agent B = 0,96 and Agent C = 0,83.

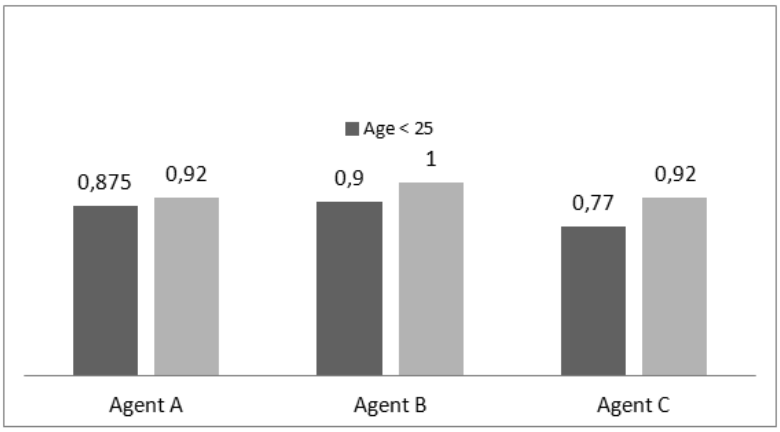

Fig. 7. The growth of knowledge based on age

Source: Own research.

Figure above (Fig. 7) shows knowledge growth in relation to the age of those surveyed. In the group of young people below the age of 25, knowledge growth was at the level for Agent A = 0,87; Agent B = 0,9 and C = 0,77 whereas in the group of people above the age of 25, it was for Agent A = 0,92; Agent B = 1 and Agent C = 0,92.

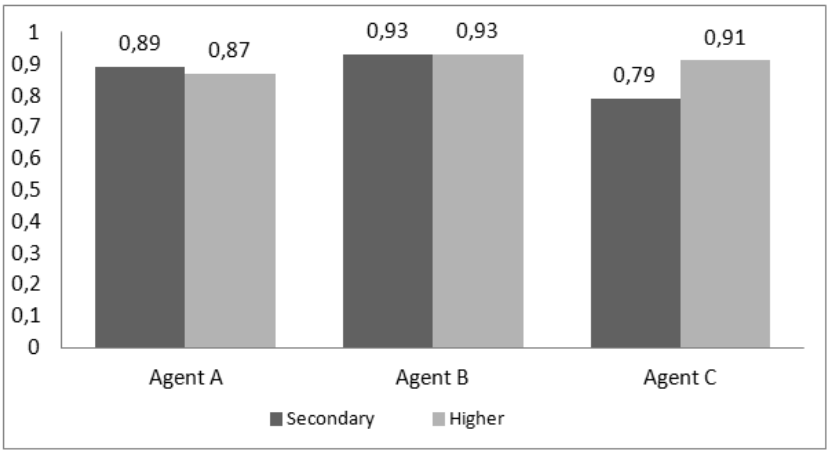

Fig. 8. Knowledge growth in relation to education

Source: Own research.

Figure 8 presents knowledge growth in relation to the level of education. In the group of people with secondary education, knowledge growth rate was for Agent A = 0,89; Agent B = 0,93 and Agent C = 0,79. In the group of people who got higher education it was, for Agent A = 0,87; Agent B = 0,93 and Agent C = 0,91.

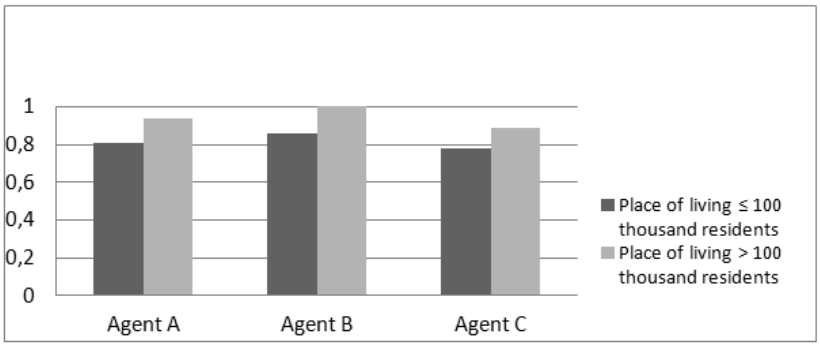

Fig. 9. The growth of knowledge based on place of living

Source: Own research.

Figure 9 shows knowledge growth of the respondents in relation to the place of residence. In this test, the biggest knowledge growth was noticed among people living in cities bigger than 100 thousand residents.

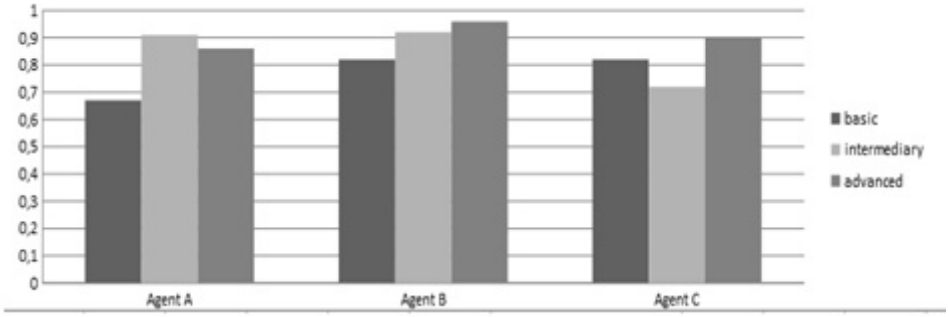

Fig. 10. The growth of knowledge based on experience in work with computer systems

Source: Own research.

Another test checked the level of experience in working with the computer. Figure 10 shows the aspect under examination. In the case of people without experience in working with the computer, knowledge growth was 0 (participants didn't point out this value) among people with experience at the basic level it was 0,77 (average for all agents), among people with experience at the intermediate level, it was 0,85 (average for all agents), whereas among those with experience at the advanced level, it was 0,90 (average for all agents).

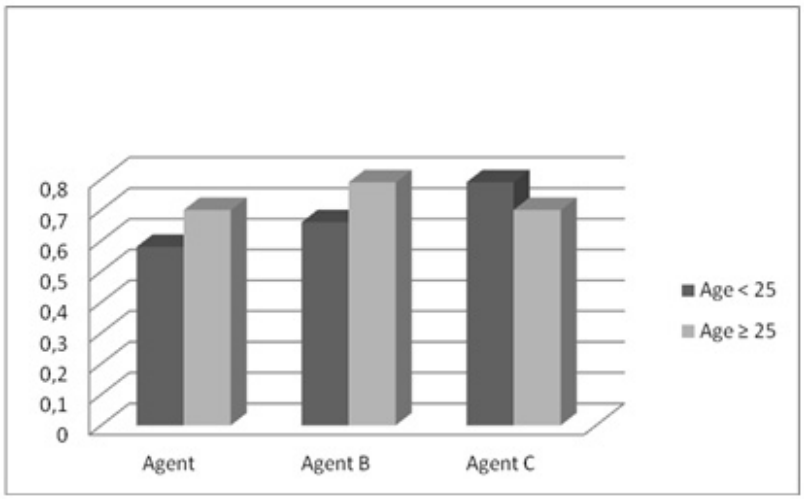

Fig. 11. Satisfaction level and age

Source: Own research.

The conducted anlysis shows that the biggest satisfaction (Fig. 11) of interaction with software agents was in group ≥ 25. People from the group < 25 were less satisfied about contact with agents.

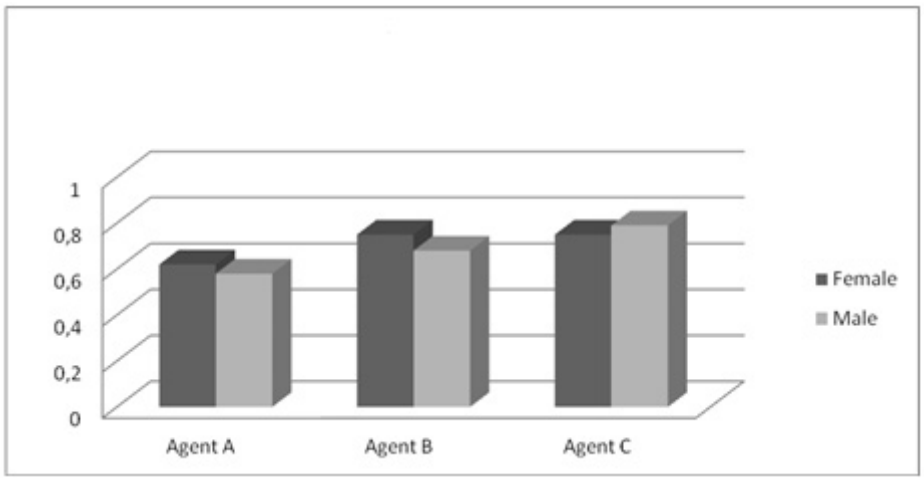

Fig. 12. Satisfaction level by sex

Source: Own research.

Figure 12 shows the aspect of satisfaction in relation to the sex of those surveyed. As the data for the female group shows they were slightly more satisfied (average value 0,7 for all agents), than males (average value 0,68).

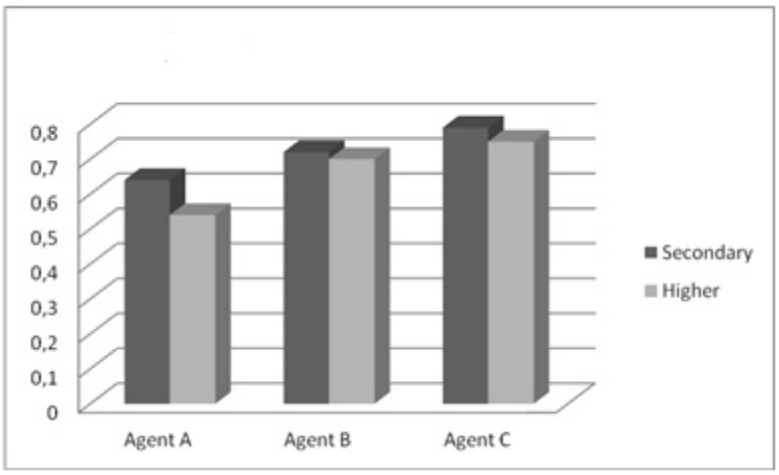

Fig. 13. Satisfaction level and education

Source: Own research.

Figure 13 shows that satisfaction level of interaction with agents was judged higher by users with secondary education level (Agent A = 0,64; Agent B = 0,72 and Agent C = 0,79) than those with higher education level (Agent A = 0,54; Agent B = 0,7 and Agent C = 0,75).

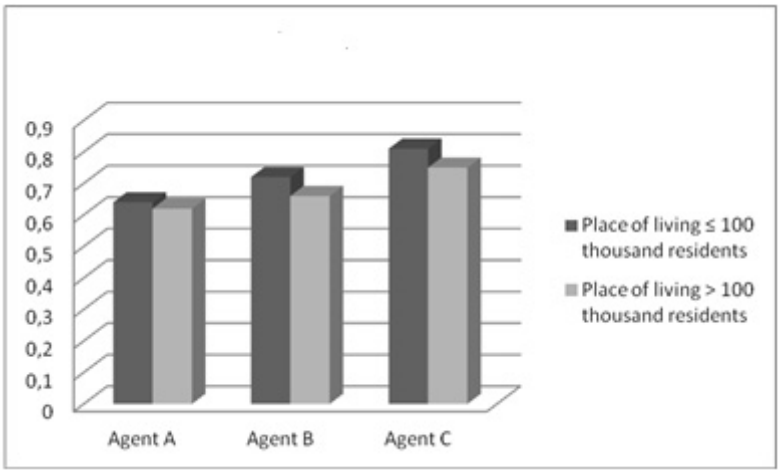

Fig. 14. Satisfaction level and place of living

Source: Own research.

This Figure 14 shows satisfaction of the respondents in relation to the place of residence. In this test, the bigger satisfaction was noticed among people living in cities ≤ 100 thousand residents than those who living in cities > 100 thousand residents.

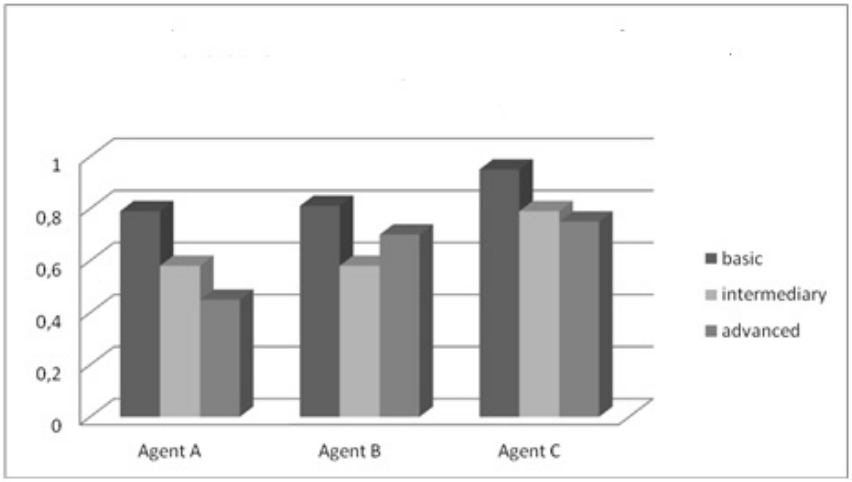

Fig. 15. Satisfaction based on experience in work with computer systems

Source: Own research.

In the case of people with basic level of experience in work with the computer, the satisfaction rate was highest (0,85 average for all agents) those with intermediary level of experience got medium level of satisfaction (0,65 average for all agents), and those with advanced level of experience pointed out the lowest rate of satisfaction (0,63 average for all agents).

Conducted statistical analyses showed correlation between effectiveness of an agent system and overall user satisfaction (for Agent A: $\gamma = 0.56$ $p = 0.000072$; for Agent B: $\gamma = 0.31$ $p = 0{,}059$ (observed statistical tendency) for Agent C: $\gamma = 0.52$ $p = 0.023$).

Additionally, the research showed a range of detailed correlations, such as:

– dependence between the question "Has the artificial intelligence mechanism of the agent matched questions and answers correctly?" and measured effectiveness of the agent (Agent A: $\gamma = 0.66$ $p = 0.000022$; Agent B: $\gamma = 0.85$ $p = 0.000006$; Agent C: $\gamma = 0.76$ $p = 0.024$);
– correlation between the question "Has the knowledge possessed by the agent been sufficient to obtain the answer to the issues?" and measured effectiveness of the agent (Agent A: $\gamma = 0.65$ $p = 0.000019$; Agent B: $\gamma = 0.58$ $p = 0.00097$)
– correlation between the user's assessment concerning the question "Does the use of the agent allow the user to more quickly get to required knowledge connected with the process in which the user participates?" and measured effectiveness of the agent; (Agent A: $\gamma = 0.56$ $p = 0.00062$; Agent C $\gamma = 0.81$ $p = 0.00031$;)

Analysis of the impact of efficiency on satisfaction confirmed the existence of correlation for Agent B.

In the case of analysis of the impact of effectiveness on knowledge, correlation existed only in the case of Agent A. Analysis concerned the correlation between satisfaction and knowledge propagation for Agent A. We also noticed that the degree of experience in work with the computer determines the level of satisfaction. In particular, a negative correlation becomes evident here. In the case of the question "Does the use of the agent allow the user to more quickly get to required knowledge connected with the process in which the user participates?" – for Agent C, γ -0.5 $p=0.01$, Agent A γ -.049 $p = 0.015$; „Would you start cooperation (dialogue) with the agent beyond the research?" – for Agent C, γ -0.41 $p = 0.04$, Agent A γ -.05 $p = 0.01$. This shows that people without experience in work with the computer are more willing to use agent solutions.

Conclusion

Software agents are currently one of the most advanced IT technologies used to support processes of managing an organisation. They provide qualitatively and quantitatively new information. The use of an ergonomic agent system can change and simplify the processes of information management – both at strategic and operational levels. Multiple representative functions of agents as subjects of modelling can ensure a more faithful and effective approach to complicated organisational processes.

The research revealed a range of dependencies. All tested software agents contributed to the improvement of the user's knowledge. The knowledge growth rate was above 0.7 for all agents (Fig. 6 and 7). In the group of males and people over 25 years of age we observed a higher level of acquisition of the agent's knowledge. In the case of more simple tasks, people with lower education obtained better results. More complicated tasks were better performed by people with higher education (Fig. 8). The average knowledge growth rate was higher for people who indicated higher level of computer skills compared to those indicating lower level of such skills (Fig. 10). The level of satisfaction with the use of agents was also high – over 0.7 on average (Fig. 11). As far as satisfaction is concerned, we observed an increase in average satisfaction with work with the agent with the increase in sophistication of tasks supported by the agent (Fig. 12, 13, 14, 15). The research showed positive correlation between effectiveness and users' satisfaction. In particular, this refers to the questions: "Has the artificial intelligence mechanism of the agent matched questions and answers correctly?", "Has the knowledge possessed by the agent been sufficient to obtain the answer to the issues?" and "Does the use of the agent allow the user to more quickly get to required knowledge connected with the process in which the user participates?". Correlations between efficiency and satisfaction, effectiveness and knowledge, satisfaction and knowledge propagation were visible in the case of individual agents. What's interesting, the research showed negative correlations between the level of computer skills of users and their satisfaction with working with agents. Such correlations were identified in the case of agents A and C. This shows that agent solutions are better perceived by people with poor computer knowledge for whom contact with an agent is more of a form of cooperation with other users.

Acknowledgments

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SPOŁECZNE ASPEKTY ODDZIAŁYWANIA AGENTÓW PROGRAMOWYCH NA UCZESTNIKÓW PROCESÓW BIZNESOWYCH W ORGANIZACJACH OPARTYCH NA WIEDZY

Streszczenie: Zastosowanie systemów agentowych w dyseminacji wiedzy jest kluczowym elementem procesów biznesowych w dowolnej organizacji. Podczas budowy systemów agentowych dla wspomagania działań biznesowych ważne jest określenie oddziaływania agentów na uczestników procesów biznesowych. Zespoły agentów zaprojektowane dla wspomagania działania organizacji, szczególnie organizacji opartej na wiedzy, powinny być rozważane jako pewien system, którego głównym zadaniem ma być wspomaganie procesów biznesowych takiej organizacji, uczestnictwo w procesach zarządzania wiedzą i wspomaganie różnych uczestników procesów biznesowych. Celem tego artykułu ma być analiza wyników prowadzonych eksperymentów badawczych w konfrontacji z cechami społecznymi analizowanej grupy. Pierwsza część artykułu przedstawia badania w tym obszarze przeprowadzone przez autorów. Druga część obejmuje wyniki badań dotyczące użyteczności agentów programowych w kontekście cech społecznych analizowanej grupy.

Słowa kluczowe: agent programowy, aspekt społeczny, proces biznesowy, wiedza.