sciendo

VOLUME 16, N° 2 2022
Journal of Automation, Mobile Robotics and Intelligent Systems

Factor Analysis of the Polish Version of Godspeed Questionnaire (GQS)

Submitted: 8th September 2021; accepted: 24th March 2022

Remigiusz Szczepanowski, Tomasz Niemiec, Ewelina Cichoń, Krzysztof Arent, Marcin Florkowski, Janusz Sobecki

DOI: 10.14313/JAMRIS/2-2022/13

Abstract:
The rapid development of robotics involves human-robot interaction (HRI). It is a necessary to assess user satisfaction to develop HRI effectively. Thus, HRI calls for interdisciplinary research, including psychological instruments such as survey questionnaire design. Here, we present a factor analysis of a Polish version of the Godspeed Questionnaire (GSQ) used to measure user satisfaction. The questionnaire was administered to 195 participants. Then, factor analysis of the GSQ was performed. Finally, reliability analysis of the Polish version of the GSQ was done. The adapted version of the survey was characterized by a four-factor structure, i.e., anthropomorphism, perceived intelligence, likeability, and perceived safety, with good psychometric properties.

Keywords: *human-robot interaction (HRI), Godspeed questionnaire, User Experience, perception of the robot*

1. Introduction

Over the last 20 years, one observe the evolution in robotics development towards interaction with humans. A variety of robots perform their tasks by sharing space with humans or working for them, often engaging themselves in interactions with humans to accomplish their tasks. Assistive, medical, social, and entertainment robots are the most prominent examples of this technological trend, defined by the domain of social robotics. This tendency can be observed when analyzing the aims and scopes of several recent EU funded projects, e.g., FELICE, RAMCIP, ReMeDi, DREAM, and LIREC [28–32].

Human-robot interaction (HRI) still is an open research problem in all fundamental robotic dimensions, including perception, reasoning, or acting [26]. The current state of the art in science and technology shows intensive development in building robots capable of cooperation and social interactions with humans at a satisfactory level in selected areas of life. It also still exemplifies the maturing stages of technological advances of social robots. Each new robotic design in the case of human-robot interaction needs evaluations based on unified and standardized instruments so that it can be improved.

At the level of technical specification and evaluation of HRI, psychological studies have begun to play a fundamental role in understanding the impact of social robots on humans. There have also been several reports from the field of HRI published in Poland (for instance, see JAMRIS articles, e.g.: [18], [21]). The psychology and engineering communities have realized that HRI presents specific challenges regarding measuring robots functioning as cooperating partners for humans. Evaluations of industrial robots mainly deal with their performance and effectiveness in human environments [6, 7] and can be applied precisely given the technological constraints of robotic technology. However, effective interactions between humans and social robots also involve psychological variables, including user satisfaction [7].

In the HRI field, the quality of a product is defined in ISO 9241 norms by two factors: usability and user experience (UX). The former is defined as, "the extent to which a product or service can be used by specified users to achieve specified goals on effectiveness, efficiency, and satisfaction in a specified context of use". The latter can be defined as users' judgment of a product arising from their experience of the interaction and the qualities of the product, in terms of the effective use of the product and user's pleasure [24]. In robotic systems, UX evaluation methods, especially for those with shared attention capability, are not apparent. In the case of computer systems, to evaluate UX, we can use a questionnaire [16], in which participants answer questions regarding their experience and satisfaction from working with the system. The most popular questionnaires in the area of HCI are SUS (System Usability Scale) and UMUX (Usability Metric for User Experience) [17]. They enable subjective assessment of usability and user experience using items ranked on the Likert scale.

The commercial potential for measuring user satisfaction of a given product, such as the social robot, should also not be overlooked. Many psychological and marketing studies aim at assessing the affective states that appear in the user's manifested behaviors oriented towards the product. Such affective factors include attitudes toward the product [14] and user satisfaction [15]. These variables largely determine whether the user decides to buy the goods, so they shape the commercial potential of a given product [14].

Steinfeld and colleagues [23] have proposed the idea of introducing a standardized set of HRI measurements that consider user satisfaction. Psychological measures of user satisfaction can be done in several ways. For instance, one can observe a user's behavior for a longer time to see how the user engages in the interaction with the social robot. Behavior-based measurements based on long-term observation of the user often use video recordings [8]. Long-term observation

of HRI may be problematic, as there may be mental states underlying behaviors irrelevant to user satisfaction. For example, the user may be involved in the interaction with the robot because of feelings of satisfaction due to other competing cognitive activities linked to the interaction.

Other measures of user satisfaction are based on psychophysiological signals linked with heart activity or electrical skin conductivity. However, such measurements face interpretational issues when making clear distinctions between internal states [20], e.g., euphoria and anger may result in the same signals from the body. The third standard measure of user satisfaction is a psychological questionnaire, which is a series of questions asked to users to gain relevant information about a given topic. This type of measurement has pros and cons. On one hand, the questionnaire enables quick measurement, is relatively easy to apply, and also is characterized by sufficient precision [10]. On the other hand, it may be inaccurate because of the user's tendency to give biased answers, i.e. answers that they feel are socially acceptable.

A validated questionnaire measure of HRI is the Godspeed Questionnaire (GSQ), which is available in a variety of languages including English, German, Spanish, Chinese, Japanese, French, Greek, Arabic, and Dutch [27]. The GQS has been effectively used for evaluating many types of robots [7,27]. The GQS has been used, for example, to assess a medical robot [3] that autonomously moves through corridors typically used by humans. The original GSQ version proposes measuring user satisfaction by evaluating user' feelings and perceptions towards distinct features of the robot: anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety [7]. In particular, the factor of anthropomorphism describes the attributional processes of assigning human characteristics to nonhuman objects, e.g., robots, computers, or animals. The subscale of animacy measures perception of the degree to which moving objects that can be distinguished as being alive. The gradient of "being alive" distinguishes humans from machines. The subscale of likeability describes positive feelings and emotions for others or producing positive evaluations of the perceived object. The factor of intelligence refers to the robots' ability to express intelligent and humanlike behavior. Finally perceived safety measures feelings of danger and comfort when interacting with the social robot, indicating user willingness to accept a social robot as a partner. According to Bartneck et al. [7], this five-factor structure of GSQ has proven remarkably effective in HRI research. The original factor structure of GQS may be subject to change when adapting this psychological measure into other cultural and social conditions. This study examine the factor structure of the Polish version of the GQS questionnaire and its psychometric parameters.

The development of any robot intended to interact with the environment not only mechanically but also socially, requires meaningful and objective evaluation. Evaluation results are crucial for improving and tuning the ultimate version of the robot. Here, we consider the GQS questionnaire as a tool used at a certain stage of the intelligent robotic system development process rather than a measurement tool for gaining a piece of new knowledge in HRI. The meta-analysis by Weiss and Bartneck reported that The Godspeed Questionnaire Series are the most-published HRI measurement in interdisciplinary or computer and robotic science journals [27].

2. Materials and Methods

One hundred and ninety-five persons (110 woman and 85 men), aged between 18 and 58 (mean $= 26.44$, SD $= 8.19$), participated in the study. The participants were undergraduate students from the Wrocław branch of University of Social Sciences and Humanities, Wroclaw University of Science and Technology and University of Zielona Góra. All participants took part in this study after filling out the informed consent forms. The study was conducted following the Declaration of Helsinki. The Ethics Committee at the Institute of Psychology, SWPS University of Social Sciences and Humanities approved the protocol.

We used the Polish version of the Godspeed Questionnaire, which was adapted from five questionnaires by Bartneck et al. [7] that measured human perceptions of different robot features. The tool is made of 24 items forming five subscales of user satisfaction in HRI: anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety. Each item includes statements that are assessed by participants on a 7-point Likert-type scale from 1 (*totally disagree*) to 7 (*totally agree*). The authors have made the Polish version of the Godspeed Questionnaire available for public use free of charge (see Appendix).

The study used a short video presenting a moving, humanoid robot NAO. The video was the result of collaboration between the Department of Cybernetics and Robotics and the Department of Computer Science at the Wrocław University of Science and Technology. It presented the robot playing an interactive game with an adult. After the video presentation, participants were asked to fill out the Polish version of the Godspeed Questionnaire to assess their perceptions of anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of the robot.

To identify specific concepts of the Godspeed inventory, a Principal Component Analysis (PCA) was conducted. According to the assumption that the factors constitute differential scales, a Varimax rotation method was performed, which is an orthogonal rotation method assuming that the factors in the analysis are uncorrelated.

The analysis established four Godspeed scales with eigenvalues > 1.0 (13.26, 2.16, 1.30, and 1.10, respectively). Additionally, an inspection of the scree plot indicated a four-factor structure. In the next step, we used PCA combined with a Varimax rotation method along with Kaiser normalization to identify a four-factor solution of the scale.

3. Results

The factor loadings for the four-factor solution are presented in Table 1. This solution indicated that the first scale included 10 items, the second and third scales were composed of 5 items, and the fourth scale had only 3 items (one item is the reverse score statement). We included statements with factorial loadings above the value 0.4 [11]. Some of these items met the criteria for the inclusion of several factors at the same time. Finally, these items were included in the scale with higher factorial loadings. All items met the criteria for inclusion into one of the selected factors. The total variance of the four-factor solution was 74.24%, yielding a value of 27.29% for the first factor, 19.88% for the second factor, 18.91% for the third factor and 8.16% for the fourth factor.

The scale labels were termed as follows: Scale 1 – *Anthropomorphism*, 2 – *Perceived Intelligence*, 3 – *Likeability*, and 4 – *Perceived Safety*. Scale 1 consisted of eleven items concerning the attribution of a human form, human characteristics, or human behavior (e.g., Conscious *vs* Unconscious). In this factor, all items from the original version were included. However, the statements in the original version of GSQ composing the scale of animacy (e.g., dead *vs.* alive; stagnant *vs.* lively) formed the first scale in the Polish version. Factor 2 included five items regarding the perception of the robot as intelligent, which depends on its competence (e.g., incompetent *vs.* competent). The third distinguished concept is labeled as likeability (e.g., unpleasant *vs.* pleasant), and considers positive first impressions of the object, often leading to more positive evaluations of that object. The last factor was formed by the three items of the perceived safety scale, which refers to the user's perception of the level of danger when interacting with a robot and the user's level of comfort during the interaction (e.g. agitated *vs.* calm).

In the next step, we assessed the reliability of the Godspeed scale by calculating the Cronbach's alpha reliability coefficients for each factor. We obtained the following values of the Cronbach's alphas:

1) *Anthropomorphism* $\alpha = 0.947$;
2) *Perceived Intelligence* $\alpha = 0.932$;
3) *Likeability* $\alpha = 0.927$;
4) *Perceived Safety* $\alpha = 0.536$.

The reliability of the first three scales was very high, indicating the homogeneous structure of the particular sub-scales. The alpha value of perceived safety is below 0.7, and hence we concluded that the likeability subscale had insufficient internal consistency reliability. For that reason, we analyzed the reliability after removing selected items. This procedure significantly improved the perceived safety reliability after deleting item 3: Quiescent *vs.* Surprised (Cronbach's $\alpha = 0.840$). This item has been removed from the scale.

4. Discussion and Conclusions

Several HRI studies [23] indicate the importance of standardizing methods for measuring HRI. An interdisciplinary approach to adequately measure HRI takes into account user satisfaction and relevant psychological aspects of interaction with the social robot [7]. Nowadays, standardized assessments of user' psychology in HRI uses surveying results from a standardized GSQ [7].

This work examine the adaptation of the Polish version of the GSQ. We adapted the GSQ to Polish cultural settings by performing factor analysis. The analysis revealed the four-factor structure of user satisfaction in handling HRI. The factors included anthropomorphism, perceived intelligence, likeability, and perceived safety. The resulting discrepancies between the original version and the Polish version are nothing unusual since the concept of user satisfaction is a complex phenomenon and may be modified [7]. Nevertheless, one should bear in mind that adaptation of the psychological questionnaire for a given culture may substantially change its factor structure [10]. It turned out that the animacy subscale vanished from the Polish version. This subscale most likely confused the respondents regarding animacy and anthropomorphism as previously indicated by Bartneck et al. [7], which had suggested that anthropomorphic objects may be also perceived as animated and vice versa. In the Polish version, most items pertaining to animacy were moved to the anthropomorphism subscale.

Good psychometric properties of the subscales characterized the Polish adaptation of the GSQ. The Cronbach's alpha reliability coefficients were anthropomorphism $\alpha = 0.947$; perceived intelligence $\alpha = 0.932$; likeability $\alpha = 0.927$; and perceived safety. After removing selected items, we ended up with the value 0.840. Moreover, lower reliability of the safety subscale was detected before removing the items from the full version. This effect is in line with previous studies [27] which reported difficulties with this subscale because of the small number of safety items. Another questionnaire measure of HRI proposed by Nomura and colleagues [19] included safety with more items and had better reliability.

As mentioned in the Introduction, current development in social robotics strongly focuses on cooperation and interaction with humans. This implies that psychological research should be applied in designing modern robotic projects, in particular, at the stage of system evaluation. The following selected works can serve as examples [1, 2, 4, 5, 9, 12, 13, 25]. These works are about social robotics, the exception being Arent et al. [1]. The study presents the design of the medical ReMeDi robot that was evaluated using the GQS. Undoubtedly, the present proposal of the Polish adaptation of the GQS will contribute to advancing fields of social robotics and Human-Robot Interactions in Poland and will expand a battery of Polish questionnaires addressing HRI measurements, initiated by Pochwatko and colleagues, who first had made available HRI measurement such as NARS-PL (Polish Version of the Negative Attitude Toward Robots Scale) for the JAMRIS community [22].

Table 1. Principal Component Analysis and factor loading of the Godspeed items ($N = 195$) for four-factor solution. *Note*: The items included in the particular subscales are presented in bold. The values above 0.3 were established as inclusion criteria.

Item	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
Fake — Natural	**0.796**	0.248	0.130	0.183
Artificial — Lifelike	**0.795**	0.290	0.217	0.129
Mechanical — Organic	**0.750**	0.288	0.366	−0.066
Machinelike — Humanlike	**0.737**	0.242	0.094	0.110
Moving rigidly — Moving elegantly	**0.725**	0.209	0.291	0.103
Unconscious — Conscious	**0.702**	0.491	0.154	0.048
Dead — Alive	**0.695**	0.378	0.367	−0.070
Stagnant — Lively	**0.598**	0.315	0.451	−0.144
Apathetic — Responsive	**0.582**	0.426	0.349	−0.202
Inert — Interactive	**0.564**	0.348	0.502	−0.069
Ignorant — Knowledgeable	0.379	**0.802**	0.242	0.001
Irresponsible — Responsible	0.218	**0.799**	0.244	0.129
Unintelligent — Intelligent	0.369	**0.794**	0.205	0.031
Foolish — Sensible	0.387	**0.765**	0.191	0.023
Incompetent — Competent	0.428	**0.681**	0.364	−0.057
Unkind — Kind	0.235	0.203	**0.872**	0.179
Unpleasant — Pleasant	0.212	0.264	**0.838**	0.165
Unfriendly — Friendly	0.361	0.280	**0.761**	0.302
Dislike — Like	0.518	0.255	**0.563**	0.217
Awful — Nice	0.408	0.364	**0.497**	0.197
Agitated — Calm	0.081	0.066	0.229	**0.839**
Anxious — Relaxed	0.176	0.126	0.439	**0.739**
Still — Surprised	0.161	0.296	0.377	**−0.466**

Appendix

The Polish version of the GSQ, which is available for public use free of charge, is included in Table 2.

AUTHORS

Remigiusz Szczepanowski – Department of Computer Science and Systems Engineering, Wroclaw University of Science and Technology, Poland, e-mail: remigiusz.szczepanowski@pwr.edu.pl, www: www.pwr.edu.pl.

Tomasz Niemiec – [1]Institute of Psychology, WSB University in Torun, Torun & Wrocław, Poland; University of Lower Silesia, Wrocław, Poland, e-mail: tomasz.niemiec@dsw.edu.pl, www: [1]www.wsb.pl, [2]www.dsw.edu.pl.

Ewelina Cichoń – [1]Institute of Psychology, WSB University in Torun, Torun & Wrocław, Poland; University of Lower Silesia, Wrocław, Poland, e-mail: ewelina.cichon@dsw.edu.pl, www: [1]www.wsb.pl, [2]www.dsw.edu.pl.

Krzysztof Arent – Department of Cybernetics and Robotics, Wroclaw University of Science and Technology, Poland, e-mail: krzysztof.arent@pwr.edu.pl, www: www.pwr.edu.pl.

Marcin Florkowski – Institute of Psychology, Faculty of Education, Psychology and Sociology, University of Zielona Góra, Poland, e-mail: m.florkowski@wpps.uz.zgora.pl, www: psychologia.wpps.uz.zgora.pl.

Janusz Sobecki* – Department of Computer Science and Systems Engineering, Wroclaw University of Science and Technology, Poland, e-mail: janusz.sobecki@pwr.edu.pl, www: www.pwr.edu.pl.

*Corresponding author

ACKNOWLEDGEMENTS

We thank Małgorzata Gakis, a former PhD student, for collecting the survey data from undergraduate students at the University of Social Sciences and Humanities.

The authors wish to thank Dr. Christoph Bartneck for agreeing to translate and publish the Polish version of the Godspeed Questionnaire.

References

[1] K. Arent, M. Cholewiński, Łukasz Chojnacki, W. Domski, M. Drwięga, J. Jakubiak, M. Janiak, B. Kreczmer, A. Kurnicki, B. Stańczyk, and D. Szczęśniak-Stańczyk, "Selected Topics in Design and Application of a Robot for Remote Medical Examination with the Use of Ultrasonography and Ascultation from the Perspective of the REMEDI Project", *Journal of Automation, Mobile Robotics and Intelligent Systems*, vol. 11, no. 2, 2017, 82–94, 10.14313/JAMRIS_2-2017/20.

[2] K. Arent, M. Gakis, J. Sobecki, and R. Szczepanowski, "Toward Emotion Recognition Embodied in Social Robots: Implementation of Laban Movement Analysis into NAO Robot", *Jour-*

Table 2. SKALA GODSPEED – ROBOT (nazwa robota)

	Człowieczeństwo robota							
	Instrukcja: Proszę oceń na skali Twoje wrażenia na temat robota							
Nieprawdziwe	1	2	3	4	5	6	7	**Naturalne**
Podobny do maszyny	1	2	3	4	5	6	7	**Podobny do człowieka**
Nieświadomy	1	2	3	4	5	6	7	**Świadomy**
Sztuczny	1	2	3	4	5	6	7	**Prawdziwy**
Ruchy ociężałe	1	2	3	4	5	6	7	**Ruchy zgrabne**
Nieżywy	1	2	3	4	5	6	7	**Żywy**
Bierny	1	2	3	4	5	6	7	**Energiczny**
Mechaniczny	1	2	3	4	5	6	7	**Naturalny**
Obojętny	1	2	3	4	5	6	7	**Pozytywnie nastawiony**
Apatyczny	1	2	3	4	5	6	7	**Żywo reagujący**
	Sympatia do robota							
	Proszę oceń na skali Twoje wrażenia na temat robota							
Nie podoba się	1	2	3	4	5	6	7	**Podoba się**
Nieprzyjazny	1	2	3	4	5	6	7	**Przyjazny**
Nieuprzejmy	1	2	3	4	5	6	7	**Uprzejmy**
Niemiły	1	2	3	4	5	6	7	**Miły**
Brzydki	1	2	3	4	5	6	7	**Ładny**
	Inteligencja robota							
	Proszę oceń na skali Twoje wrażenia na temat robota							
Niekompetentny	1	2	3	4	5	6	7	**Kompetentny**
Bezmyślny	1	2	3	4	5	6	7	**Myślący**
Nieodpowiedzialny	1	2	3	4	5	6	7	**Odpowiedzialny**
Nieinteligentny	1	2	3	4	5	6	7	**Inteligentny**
Naiwny	1	2	3	4	5	6	7	**Rozsądny**
	Odczuwane bezpieczeństwo							
	Proszę oceń na skali Twoje wrażenia na temat robota							
Zaniepokojony	1	2	3	4	5	6	7	**Zrelaksowany**
Pobudzony	1	2	3	4	5	6	7	**Spokojny**
Wyciszony	1	2	3	4	5	6	7	**Zaskoczony**

nal of Automation, Mobile Robotics and Intelligent Systems, vol. 11, no. 4, 2017, 3–7, 10.14313/JAMRIS_4-2017/31.

[3] K. Arent, J. Jakubiak, M. Drwięga, M. Cholewiński, G. Stollnberger, M. Giuliani, M. Tscheligi, D. Szczęśniak-Stańczyk, M. Janowski, W. Brzozowski, and A. Wysokiński, "Control of mobile robot for remote medical examination: Design concepts and users' feedback from experimental studies". In: *2016 9th International Conference on Human System Interactions (HSI)*, vol. ., 2016, 76–82, 10.1109/HSI.2016.7529612.

[4] K. Arent, J. Kruk-Lasocka, T. Niemiec, and R. Szczepanowski, "Social robot in diagnosis of autism among preschool children". In: *2019 24th International Conference on Methods and Models in Automation and Robotics (MMAR)*, vol. ., 2019, 652–656, 10.1109/MMAR.2019.8864666.

[5] K. Arent, M. Wnuk, and M. Kabała, "Towards the Therapeutic Spherical Robot: Design, Programming and Control". In: *Eighth International IFAC Symposium on Robot Control. Proceedings*, vol. 8, 2006.

[6] C. Bartneck, T. Belpaeme, F. Eyssel, T. Kanda, M. Keijsers, and S. Šabanović, *Human-Robot Interaction: An Introduction*, Cambridge University Press, 2020, 10.1017/9781108676649.

[7] C. Bartneck, D. Kulić, E. Croft, and S. Zoghbi, "Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots", *International Journal of Social Robotics*, vol. 1, no. 1, 2009, 71–81, 10.1007/s12369-008-0001-3.

[8] C. Bartneck and M. Rauterberg, "HCI Reality-an 'Unreal Tournament'?", *Int. J. Hum.-Comput. Stud.*, vol. 65, no. 8, 2007, 737–743, 10.1016/j.ijhcs.2007.03.003.

[9] R. Budziński, J. Kędzierski, and B. Weselak. *Problemy robotyki. Materiały XI Krajowej Konferencji Robotyki. Prace Naukowe, Elektronika: z. 175, tom 1*, chapter Social robot head Samuel - construction (in Polish). Oficyna Wydawnicza Politechniki Warszawskiej, 2010. ISSN: 0137-2343.

[10] D. A. Dillman. *The Logic and Psychology of Constructing Questionnaires*, chapter chapter9. Routledge, 2008.

[11] A. Field, *Discovering Statistics Using IBM SPSS Statistics*, Sage Publications Ltd., 2013.

[12] J. Kędzierski, P. Kaczmarek, M. Dziergwa, and K. Tchoń, "Design for a Robotic Companion", *International Journal of Humanoid Robotics*, vol. 12, no. 01, 2015.

[13] J. Kędzierski, R. Muszynski, C. Zoll, A. Oleksy, and M. Frontkiewicz, "EMYS—Emotive Head of a Social Robot", *International Journal of Social Robotics*, vol. 5, 2013, 237–249.

[14] D. T. Kenrick, S. L. Neuberg, and R. B. Cialdini, *Social psychology: Unraveling the mystery (3rd ed.)*, Pearson Education New Zealand, 2005.

[15] Y.-F. Kuo, C.-M. Wu, and W.-J. Deng, "The relationships among service quality, perceived value, customer satisfaction, and post-purchase intention in mobile value-added services", *Computers in Human Behavior*, vol. 25, no. 4, 2009, 887–896, https://doi.org/10.1016/j.chb.2009.03.003, Including the Special Issue: The Use of Support Devices in Electronic Learning Environments.

[16] J. R. Lewis, "IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use", *International Journal of Human-Computer Interaction*, vol. ., 1995, 57–78.

[17] J. R. Lewis, B. S. Utesch, and D. E. Maher. *UMUX-LITE: When There's No Time for the SUS*, 2099–2102. Association for Computing Machinery, New York, NY, USA, 2013.

[18] A. Moussaoui, A. Pruski, and B. Cherki, "Interaction management between social angents and human", *Journal of Automation, Mobile Robotics and Intelligent Systems*, vol. 5, no. 1, 2013, 8–17.

[19] T. Nomura, T. Kanda, and T. Suzuki, "Experimental investigation into influence of negative attitudes toward robots on human–robot interaction", *AI & Society*, vol. 20, 2006, 138––150.

[20] K. Oatley, D. Keltner, and J. M. Jenkins, *Understanding Emotions, 2nd Edition*, Wiley-Blackwel, 2006.

[21] N. Piçarra, J.-C. Giger, G. Pochwatko, and J. Możaryn, "Designing social robots for interaction at work: Socio-cognitive factors underlying intention to work with social robots", *Journal of Automation, Mobile Robotics and Intelligent Systems*, vol. 10, no. 4, 2016, 17–26, 10.14313/JAMRI_4-2016/28.

[22] G. Pochwatko, J.-C. Giger, M. Różańska-Walczuk, J. Świdrak, K. Kukiełka, J. Możaryn, and N. Piçarra, "Polish Version of the Negative Attitude Toward Robots Scale (NARS-PL)", *Journal of Automation, Mobile Robotics and Intelligent Systems*, vol. 9, no. 3, 2015, 65–72, 10.14313/JAMRIS_2-2015/25.

[23] A. Steinfeld, T. Fong, D. Kaber, M. Lewis, J. Scholtz, A. Schultz, and M. Goodrich, "Common Metrics for Human-Robot Interaction". In: *Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-Robot Interaction*, vol. ., New York, NY, USA, 2006, 33–40, 10.1145/1121241.1121249.

[24] A. Sutcliffe. "Designing for User Engagement: Aesthetic and Attractive User Interfaces". In: *Synthesis Lectures on Human-Centered Informatics*, volume 2, 1–55. Springer Cham, 2009.

[25] K. Sydor and K. Arent. *Problemy robotyki. Materiały XI Krajowej Konferencji Robotyki. Prace Naukowe, Elektronika: z. 175, tom 1*, chapter FROGIT: a socially interactive robot (in Polish). Oficyna Wydawnicza Politechniki Warszawskiej, 2010. ISSN: 0137-2343.

[26] R. Szczepanowski, E. Cichoń, K. Arent, J. Sobecki, P. Styrkowiec, M. Florkowski, and M. Gakis, "Education biases perception of social robots", *European Review of Applied Psychology*, vol. 70, no. 2, 2020, 100521, https://doi.org/10.1016/j.erap.2020.100521.

[27] A. Weiss and C. Bartneck, "Meta Analysis of the Usage of the Godspeed Questionnaire Series". In: *2015 24th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*, vol. ., 2015, 381–388, 10.1109/ROMAN.2015.7333568.

[28] "DREAM - Development of Robot-Enhanced therapy for children with AutisM spectrum disorders". Project website.

[29] "FELICE - Flexible Assembly Manufacturing with Human-Robot Collaboration and Digital Twin Models". Project website.

[30] "LIREC - LIving with Robots and intEractive Companions". Project website.

[31] "RAMCIP - Robotic Assistant for MCI Patients at home". Project website.

[32] "ReMeDi - Remote Medical Diagnostician". Project website.