

The personality of a robot. An adaptation of the HEXACO – 60 as a tool for HRI

Giulia Siri^{1,2}[0000-0001-5869-4728], Serena Marchesi² [0000-0001-9931-156X] Agnieszka Wykowska²[0000-0003-3323-7357], Carlo Chiorri¹[0000-0002-1640-3897]

¹ Università degli Studi di Genova, Dipartimento di Scienze della Formazione (DI-SFOR)

² Social Cognition in Human-Robot Interaction Unit, Istituto Italiano di Tecnologia, Genoa, Italy

Carlo Chiorri

carlo.chiorri@gmail.com

carlo.chiorri@unige.it

Abstract. In this paper, we report on a study in which we used an observer-report version of the HEXACO–60, a questionnaire designed to assess human personality, to evaluate how people perceive the personality traits of robots. The results showed that a four-factor measurement model fitted the data better than the expected six-factor one and suggested that the domains of the perceived personality structure of robots might differ from those of humans.

Keywords: Human-Robot Interaction, Personality Assessment, Psychometric Validation

1 Introduction

Nowadays, the use of robotics range from the industrial settings, such as production lines, to social applications, such as healthcare, assistance to elderly, children, and educational activities [1]. In this context, social robotics is an emerging field of research, interested in understanding how humans interact with social robots in everyday environments. Recent studies showed that humans can deploy similar social cognitive mechanisms during the interaction with a robot [for reviews, see 2 and 3] as during interactions with other humans. Moreover, many authors investigated the human tendency to attribute humanlike characteristics to robots [4, 5, 6], from physical traits to sociality [7] and intentions (i.e. adopting the intentional stance [8]) [9, 10, 11]. In this context, several questionnaires have been developed to assess the perception of social robots and their personality [12, 13, 14], but, to the best of our knowledge, no study has employed measures commonly used for assessing human personality to evaluate robot

personality. To this end, we developed an observer-report version of Ashton and Lee's HEXACO-60 [15], which has already been used in HRI to measure personality traits about humans in interaction with robots [16, 17, 18, 19], but never as a tool to assess the perceived personality traits of a humanoid robot.

The HEXACO model of personality is a dimensional taxonomy of human personality based on findings from a series of lexical studies [20, 21, 22] that proposes an organization of individual differences in personality characteristics in terms of six broad trait domains: Extraversion (i.e., tendency to feel positively about oneself, to feel confident and comfortable in social situations, to experience high levels of arousal and energy), Agreeableness (i.e., tendency to forgive the wrongs suffered, to be lenient in judging others, to be open to compromise and cooperation), Conscientiousness (i.e., tendency to be organized, disciplined, accurate, and reliable in performing tasks), Emotionality (i.e., tendency to experience negative affects such as anxiety, worry, fear, and stress), Openness to Experience (i.e., tendency to appreciate beauty, art, and unusual ideas and people, and to be curious about various domains of knowledge), and Honesty-Humility (i.e., tendency to avoid manipulation and deception for personal gain and to feel little interest for wealth, luxuries, and social status). The authors proposed an additional, 'interstitial' domain, Altruism, that taps into the tendency to be empathic and soft-hearted to others. Although developed in the last two decades, the model has received convincing empirical support for its stability across cultures and predictive validity (see, e.g., [23, 24]).

2 Aims

The main aim of the present study was to investigate whether the dimensional HEXACO model of human personality could generalize to robots, too. To test this hypothesis, we asked a group of participants to think of a robot and to complete an observer-report version of an HEXACO measure that assessed the six original domains and the additional Altruism factor. We then use factor analysis to investigate the dimensional structure of robot personality ratings.

3 Methods and results

3.1 Participants

We recruited 133 online participants (mean age 34.46 ± 14.170 range:19-65) through opportunistic sampling (via social media and email). All participants were Italian speakers.

3.2 The HEXACO - 60

The HEXACO-60 is a short personality questionnaire developed to assess the HEXACO trait domains [15]. It asks participants to rate their agreement with 60 statements (see Appendix) on a 5-point, Likert-type scale (from 1 = "strongly disagree" to 5 = "strongly agree"). As reported by Ashton and Lee [15], the internal consistency reliability (Cronbach's α) ranged from .77 to .80 and from .73 to .80 for two different representative samples, revealing a good internal consistency of this short version. We included in the study seven further items that assessed Altruism. All the items were adapted to address the study aims by adding the expression "A robot" as the subject of each sentence (i.e. "[A robot] would never accept a bribe, even if it were very large").

3.3 Procedure

Participants were asked to complete a schedule for collecting background information and the HEXACO questionnaire. They were not compensated for their participation. In order to access the survey, participants had to explicitly declare their intention to participate after reading an informed consent form. Data collection was conducted in accordance with the privacy laws and accordance with the Regulation 2016/697 of the European Parliament of the Council of 27 April 2018, concerning the protection of the individuals about the processing of the personal data and on the free movement of such data and abrogating Directive 95/46/EC" (General Data Protection Regulation -GDPR) and in accordance to the Declaration of Helsinki.

3.4 Results

In order to determine the optimal number of factors to be extracted, we carried out a scree-test and a parallel analysis (PA) and inspected the Minimum Average Partial Correlation Statistic (MAP), the Bayesian Information Criterion (BIC), and the Sample Size adjusted BIC (SABIC) (see, e.g., [25]). The scree test suggests that the optimal

number of factors corresponds to the factors before which the downward curve of the eigenvalues seem to flatten out. PA indicates to extract all those factors whose observed eigenvalues are larger than the 95th percentile of the distribution of the eigenvalues generated from 1,000 simulated matrices of random data of the same size. For the other indices, the optimal number of factors is the one at which their values reach their minimum. As shown in Figure 1, these methods did not suggest the same number of factors, hence we carried out a series of Exploratory Factor Analyses (EFAs) setting to 1 to 7 the number of factors to be extracted. We then considered as most adequate the factor-solution that provided the allowed to obtain what Sass and Schmitt [26] call an "approximate simple structure", i.e., that each item had a substantial (i.e., $> |.30|$) loading on one factor and negligible loadings (i.e., $< |.20|$) on the others (cross-loadings).

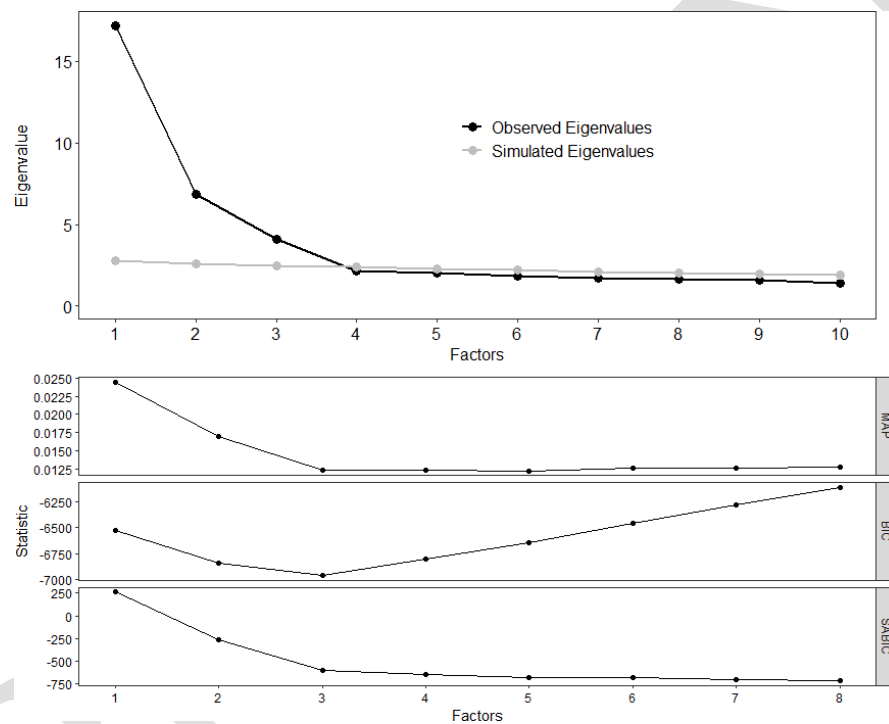


Fig.1 Dimensionality analyses of the HEXACO questionnaire.

According to this criterion, the best solution was the four-factor one (Table 1).

Table 1 Pattern Matrix shows the factor loadings for each factor. Bolded values are larger than .30.

Factors					Factors					Factors				
Item	1	2	3	4	Item	1	2	3	4	Item	1	2	3	4
hex58	.93	.03	-.02	-.14	hex01	.17	.68	.15	-.12	hex42	-.36	-.03	.44	.08
hex33	.88	.03	.09	-.03	hex05	.32	-.63	.37	.07	hex07	.00	.08	.43	-.07
hex14	.85	.08	.18	.10	hex18	.10	.63	.06	-.17	hex38	-.04	.18	.43	-.38
hex24	.84	-.03	-.03	-.12	hex06	.38	.63	-.05	-.12	hex52	-.02	.23	.41	-.38
hex02	.83	.02	-.02	-.06	hex03	-.02	.56	.02	.11	hex59	.16	-.13	.39	-.13
hex61	.81	.03	.14	.13	hex57	-.13	-.50	-.16	.01	hex30	-.05	-.32	.35	.27
hex29	.76	.08	.04	.07	hex16	.30	-.49	-.17	-.07	hex44	.30	.02	-.34	.19
hex41	.73	.03	-.25	-.07	hex28	.38	.47	.10	.07	hex20	-.11	.21	.30	-.30
hex63	.70	.02	-.32	-.26	hex62	.16	.47	.21	.27	hex66	.21	-.04	-.28	.24
hex40	.64	.08	.21	.29	hex11	.29	.47	.19	.24	hex21	.09	.04	.05	.55
hex55	.63	.11	-.16	-.02	hex19	.22	.47	.11	.27	hex53	.23	-.06	.02	.46
hex32	.61	.08	.09	.21	hex37	.34	-.46	.18	-.11	hex39	.09	-.07	-.21	.45
hex25	.60	-.01	.01	.16	hex43	.09	.43	-.12	-.13	hex26	.07	.08	-.12	.45
hex48	.60	-.04	-.07	.27	hex10	-.08	.41	.15	.36	hex67	-.08	-.12	.03	-.44
hex09	.58	-.09	-.13	-.06	hex49	-.24	.34	.05	.20	hex27	.09	.28	.00	.42
hex17	.58	-.06	-.01	.21	hex51	-.04	.05	.70	.09	hex36	.30	.07	-.15	.39
hex50	.54	-.38	-.14	-.21	hex15	.01	.03	.53	.05	hex23	-.06	.25	-.12	.37
hex22	-.52	.01	.20	-.16	hex64	-.19	.06	.51	-.05	hex47	.08	-.29	.23	-.34
hex34	.51	.21	-.16	-.07	hex04	.20	.19	-.51	.00	hex45	.22	.15	-.20	.34
hex12	.48	-.05	-.04	.16	hex54	-.22	.15	.50	-.13	hex46	-.27	.16	.27	-.33
hex13	.45	.16	-.01	.18	hex65	.02	.08	.46	-.13	hex31	.30	-.02	-.27	.31
hex08	.39	.21	-.02	.29	hex60	.36	-.42	.46	.00	hex56	.28	-.11	-.11	.30
hex35	.38	-.27	.30	-.33										

Table 2 Factor Correlation Matrix shows the correlation between the factors.

Factor Correlation Matrix				
Factor	1	2	3	4
1	1,00	-0,15	-0,37	0,43
2	-0,15	1,00	0,18	0,24
3	-0,37	0,18	1,00	-0,31
4	0,43	0,24	-0,31	1,00

The first factor grouped items tapping into altruism, sociability, and openness to others (Empathy/Altruism/Sociability). The second factor grouped items related to fairness and resilience (Integrity). The third factor grouped items that operationalize dependability and sobriety (Dependability). The fourth factor grouped items expressing self-confidence attitudes (Self-confidence).

4 Discussion

The present study was carried out to test the usefulness of an HEXACO questionnaire in an HRI context to assess how people perceive the personality traits of the robot. Results showed that the dimensional structure usually obtained with human participants was not replicated, but, rather, a four-factor structure was found as the best measurement model. Beyond the labels that can be used for the factors in Table 1, it is apparent that the items did not group themselves according to the original scales, nor the items of the same scale were grouped in the same factor. Interestingly, the Empathy/Altruism/Sociability and Dependability factors found here resembled two dimensions of Spatola et al.'s Human-Robot Interaction Evaluation Scale (HRIES) [7] (Sociability and Intentionality). This result suggests that these domains might be particularly relevant in the evaluation of robot personality, as they are perceived salient and defining characteristics of the robot behaviour.

The opportunistic sampling strategy used here and the relatively low sample size suggest caution in interpreting the results of this study in terms of generalizability, also because a generic "robot" was mentioned in the items. As a result, there could have been considerable variance in the type of robot that participants referred to when providing their ratings. Future studies are thus invited to use the HEXACO questionnaire presented here to evaluate how people perceive the personality traits of a specific robot (i.e. [iCub] would never accept a bribe, even if it were very large), for which independent information about the perceived characteristics is available. In this way, it would be possible to compare how humans perceive the personality traits of robots with different attributes and test the sensitivity of the HEXACO questionnaire.

5 References

- [1] A. Wykowska, "Social Robots to Test Flexibility of Human Social Cognition", *Int J of Soc Robotics* 12, pp. 1203–1211, 2020. <https://doi.org/10.1007/s12369-020-00674-5>
- [2] A. Wykowska "Robots as Mirrors of the Human Mind", *Current Directions in Psychological Science*, 30,1 pp. 34-40, 2021. <https://doi.org/10.1177/0963721420978609>
- [3] J. Perez-Osorio & A. Wykowska, "Adopting the Intentional Stance Towards Humanoid Robots", In J.P. Laumond, E. Danblon, C. Pieters (eds) *Wording Robotics. Springer Tracts in - Advanced Robotics*, 130, Springer, Cham, 2019 https://doi.org/10.1007/978-3-030-17974-8_10
- [4] G. Airenti "The development of anthropomorphism in interaction: Intersubjectivity, imagination, and theory of mind", *Frontiers in psychology*, 9, 2136, 2018 <https://doi.org/10.3389/fpsyg.2018.02136>

- [5] N. Epley, A. Waytz & J.T. Cacioppo “On seeing human: a three-factor theory of anthropomorphism” *Psychological review*, 114, 4, 864, 2007 <https://doi.org/10.1037/0033-295x.114.4.864>
- [6] N. Spatola & A. Wykowska “The personality of anthropomorphism: How the need for cognition and the need for closure define attitudes and anthropomorphic attributions toward robots”, *Computers in Human Behavior*, 122, 106841, ISSN 0747-5632, 2021 <https://doi.org/10.1016/j.chb.2021.106841>
- [7] N. Spatola., B. Kühnlenz, & G. Cheng “Perception and Evaluation in Human–Robot Interaction: The Human–Robot Interaction Evaluation Scale (HRIES)—A Multicomponent Approach of Anthropomorphism” *International Journal of Social Robotics*, 1-23, 2021 <https://doi.org/10.1007/s12369-020-00667-4>
- [8] D.C. Dennett, “Intentional System”, *The Journal of Philosophy*, 68, 4, pp. 87-106, 1971 <https://doi.org/10.2307/2025382>
- [9] S. Thellman, A. Silvervarg & T. Ziemke, “Folk-Psychological Interpretation of Human vs. Humanoid Robot Behavior: Exploring the Intentional Stance toward Robots” *Frontiers in Psychology*, 14, 2017. <https://doi.org/10.3389/fpsyg.2017.01962>
- [10] S. Marchesi, D. Ghiglino, F. Ciardo, J. Perez-Osorio, E. Baykara, A. & Wykowska, (2019) “Do we adopt the Intentional Stance toward humanoid robots?” *Frontiers in Psychology*, 15, 2019. <https://doi.org/10.3389/fpsyg.2019.00450>
- [11] S. Marchesi, N. Spatola, J. Perez-Osorio, A. & Wykowska, “Human vs Humanoid: A behavioral investigation of the individual tendency to adopt the intentional stance”, In *HRI '21: Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction*, 2021, pp. 332–340. <https://doi.org/10.1145/3434073.3444663>
- [12] K. A. Barchard. L. Lapping-Carr, R. S. Westfall, S. B. Banisetty & D. Feil-Seifer. "Perceived Social Intelligence (PSI) Scales test manual. Unpublished psychological test and test manual. Observer report of 20 aspects of social intelligence of robots with four items per scale" Technical Report, 2018.
- [13] L. P. Robert, “Personality in the Human Robot Interaction Literature: A Review and Brief Critique” In *Proceedings of the 24th Americas Conference on Information Systems*, New Orleans, LA, 2018.
- [14] K. M. Lee, W. Peng, S.A Jin & C. Yan, “Can Robots Manifest Personality?: An Empirical Test of Personality Recognition. Social Responses and Social Presence in Human–Robot Interaction”, *Journal of Communication*, 56, 4, pp. 754-772, 2006. <https://doi.org/10.1111/j.1460-2466.2006.00318>
- [15] M. C. Ashton & K. Lee, “The HEXACO–60: A Short Measure of the Major Dimensions of Personality”, *Journal of Personality Assessment*. 91,4, pp. 340-345, 2009. <https://doi.org/10.1080/00223890902935878>
- [16] S. Petisca, A. Paiva & F. Esteves. 2020. “The effect of a robotic agent on dishonest behavior”, In *Proceedings of the 20th ACM International Conference on Intelligent Virtual Agents (IVA '20)*, Association for Computing Machinery, New York, NY, USA, 2020, 46, pp. 1–6. <https://doi.org/10.1145/3383652.3423953>

- [17] S. Petisca, F. Esteves & A. Paiva. "Cheating with robots: how at ease do they make us feel?", In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2019, pp. 2102-2107. <https://doi.org/10.1109/IROS40897.2019.8967790>
- [18] M. Laakasuo, A. Kunnari, J. Palomäki, S. Rauhala, M. Koverola, N. Lehtonen, J. Halonen, M. Repo, A. Visala & M. Drosinou, "Moral Psychology of Nursing Robots – Humans Dislike Violations of Patient Autonomy but Like Robots Disobeying Orders", PsyArxiv, 2019. <https://doi.org/10.31234/osf.io/bkhyq>
- [19] S. Liu & D. R. Insua, "Group Decision Making with Affective Features", Group Decis Negot, 2, pp. 843–869, 2020 <https://doi.org/10.1007/s10726-020-09682-2>
- [20] Ashton, M. C., & Lee, K. (2001). A theoretical basis for the major dimensions of personality. European Journal of Personality, 15(5), 327–353. <https://doi.org/10.1002/per.417>
- [21] Ashton, M. C., Perugini, M., De Vries, R. E., Boies, K., Lee, K., Szarota, P., Di Blas, L., & De Raad, B. (2004). A Six-Factor Structure of Personality-Descriptive Adjectives: Solutions from Psycholexical Studies in Seven Languages. Journal of Personality and Social Psychology, 86(2), 356–366. <https://doi.org/10.1037/0022-3514.86.2.356>
- [22] Ashton, M. C., Lee, K., & Goldberg, L. R. (2004). A hierarchical analysis of 1,710 English personality-descriptive adjectives. Journal of Personality and Social Psychology, 87(5), 707–721. <https://doi.org/10.1037/0022-3514.87.5.707>
- [23] Ashton, M. C., Lee, K., & de Vries, R. E. (2014). The HEXACO Honesty-Humility, Agreeableness, and Emotionality Factors: A review of research and theory. Personality and Social Psychology Review, 18(2), 139–152. <https://doi.org/10.1177/1088868314523838>
- [24] Lee, K., & Ashton, M. C. (2008). The HEXACO personality factors in the indigenous personality lexicons of English and 11 other languages. Journal of Personality, 76(5), 1001–1054. <https://doi.org/10.1111/j.1467-6494.2008.00512.x>
- [25] Ruscio, J., & Roche, B. (2012). Determining the number of factors to retain in an exploratory factor analysis using comparison data of known factorial structure. Psychological Assessment, 24(2), 282–292. <https://doi.org/10.1037/a0025697>
- [26] Sass, D. A., & Schmitt, T. A. (2010). A comparative investigation of rotation criteria within exploratory factor analysis. Multivariate Behavioral Research, 45(1), 73–103. <https://doi.org/10.1080/00273170903504810>

Appendix
The HEXACO questionnaire used in this study
(please note that the Italian version was used)

On the following pages, you will find a series of statements about a robot. Please read each statement and decide how much you agree or disagree with that statement. Please answer every statement, even if you are not completely sure of your response.

Item	Factor	Text
hex01	Honesty-Humility	[A robot] It would never accept a bribe, even if it were very large.
hex02	Altruism	[A robot] It has sympathy for people who are less fortunate than it is.
hex03	Agreeableness	[A robot] It rarely hold a grudge, even against people who have badly wronged it.
hex04	Agreeableness	[A robot] People think of it as someone who has a quick temper.
hex05	Extraversion	[A robot] Most people are more upbeat and dynamic than it generally is.
hex06	Honesty-Humility	[A robot] It wouldn't use flattery to get a raise or promotion at work, even if it thought it would succeed.
hex07	Conscientiousness	[A robot] When working on something, it doesn't pay much attention to small details.
hex08	Extraversion	[A robot] It feels reasonably satisfied with itself overall.
hex09	Extraversion	[A robot] It prefers jobs that involve active social interaction to those that involve working alone.
hex10	Conscientiousness	[A robot] People often call it a perfectionist.
hex11	Conscientiousness	[A robot] It often pushes itself very hard when trying to achieve a goal.
hex12	Extraversion	[A robot] In social situations, it is usually the one who makes the first move.
hex13	Agreeableness	[A robot] It tends to be lenient in judging other people.
hex14	Altruism	[A robot] It tries to give generously to those in need.
hex15	Conscientiousness	[A robot] When working, it sometimes has difficulties due to being disorganized.
hex16	Emotionality	[A robot] It can handle difficult situations without needing emotional support from anyone else.
hex17	Openness to Experience	[A robot] If it had the opportunity, it would like to attend a classical music concert.
hex18	Honesty-Humility	[A robot] Having a lot of money is not especially important to it.
hex19	Conscientiousness	[A robot] It plans ahead and organize things, to avoid scrambling at the last minute.
hex20	Honesty-Humility	[A robot] If it wants something from someone, it will laugh at that person's worst jokes.
hex21	Agreeableness	[A robot] When people tell it that it is wrong, its first reaction is to argue with them.
hex22	Honesty-Humility	[A robot] It thinks that it is entitled to more respect than anyone else.
hex23	Agreeableness	[A robot] People sometimes thinks that it can be too stubborn
hex24	Altruism	[A robot] It is soft-hearted.
hex25	Openness to Experience	[A robot] It would enjoy creating a work of art, such as a novel, a song, or a painting.
hex26	Agreeableness	[A robot] People sometimes thinks that it is too critical of others.
hex27	Agreeableness	[A robot] Its attitude toward people who have treated it badly is "forgive and forget".
hex28	Honesty-Humility	[A robot] It wouldn't pretend to like someone just to get that person to do favors for it.
hex29	Extraversion	[A robot] The first thing that it always does in a new place is to make friends.
hex30	Openness to Experience	[A robot] It never really enjoys looking through an encyclopedia.
hex31	Extraversion	[A robot] It sometimes feels that it is worthless.
hex32	Openness to Experience	[A robot] It is interested in learning about the history and politics of other countries.

hex33	Altruism	[A robot] It would feel very badly if it were to hurt someone.
hex34	Openness to Experience	[A robot] People thinks that it has a good imagination.
hex35	Altruism	[A robot] It wouldn't bother it to harm someone it doesn't like.
hex36	Emotionality	[A robot] It sometimes can't help worrying about little things.
hex37	Emotionality	[A robot] It worries a lot less than most people do.
hex38	Honesty-Humility	[A robot] If it knew that it could never get caught, it would be willing to steal a million dollars.
hex39	Altruism	[A robot] It likes the idea that only the strong should survive.
hex40	Extraversion	[A robot] On most days, it feels cheerful and optimistic.
hex41	Emotionality	[A robot] When it suffers from a painful experience, it needs someone to make it feel comfortable.
hex42	Conscientiousness	[A robot] It makes decisions based on the feeling of the moment rather than on careful thought.
hex43	Agreeableness	[A robot] Even when people make a lot of mistakes, it rarely says anything negative.
hex44	Extraversion	[A robot] When it is in a group of people, its is often the one who speaks on behalf of the group.
hex45	Extraversion	[A robot] It feels that it is unpopular.
hex46	Honesty-Humility	[A robot] It wants people to know that it is important and of high status.
hex47	Openness to Experience	[A robot] It doesn't think of itself as the artistic or creative type.
hex48	Openness to Experience	[A robot] It likes people who have unconventional views.
hex49	Agreeableness	[A robot] Most people tend to get angry more quickly than it does.
hex50	Emotionality	[A robot] It remains unemotional even in situations where most people get very sentimental.
hex51	Conscientiousness	[A robot] It makes a lot of mistakes because it doesn't think before it acts.
hex52	Honesty-Humility	[A robot] It would be tempted to use counterfeit money, if it were sure it could get away with it.
hex53	Openness to Experience	[A robot] It thinks of itself as someone who is somewhat eccentric.
hex54	Honesty-Humility	[A robot] It would get a lot of pleasure from owning expensive luxury goods.
hex55	Agreeableness	[A robot] It is usually quite flexible in its opinions when people disagree with it
hex56	Emotionality	[A robot] When it comes to physical danger, it is very fearful.
hex57	Emotionality	[A robot] Even in an emergency it wouldn't feel like panicking.
hex58	Emotionality	[A robot] When someone it knows well is unhappy, it can almost feel that person's pain itself.
hex59	Openness to Experience	[A robot] It would be quite bored by a visit to an art gallery.
hex60	Extraversion	[A robot] It rarely expresses its opinions in group meetings.
hex61	Altruism	[A robot] It tries to respect other people's feelings.
hex62	Conscientiousness	[A robot] It always tries to be accurate in its work, even at the expense of time.
hex63	Emotionality	[A robot] It feels like crying when it sees other people crying.
hex64	Conscientiousness	[A robot] It prefers to do whatever comes to mind, rather than stick to a plan.
hex65	Conscientiousness	[A robot] It does only the minimum amount of work needed to get by.
hex66	Emotionality	[A robot] It would feel afraid if it had to travel in bad weather conditions.
hex67	Openness to Experience	[A robot] It thinks that paying attention to radical ideas is a waste of time.