Do We Really Like Robots that Match our Personality? The Case of Big-Five Traits, Godspeed Scores and Robotic Gestures

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Abstract— **This work investigates the role of the attraction paradigm - the investigation of the tendency to associate similarity and attraction in interpersonal relations - in Human-Robot Interaction. The experiments have involved 30 human observers that have watched and rated 45 robotic gestures in terms of Big-Five personality traits and Godspeed scores. The results show that, for 26 out of the 30 observers above, there is a statistically significant correlation between perceived personality similarity and Godspeed scores. However, the association is positive for 16 subjects - meaning that for these there is a similarity-attraction effect - and negative for the other 10 - meaning that for these there is a complementarity-attraction effect. Furthermore, the results depend on the particular trait under exam.**

I. Introduction

The association between interpersonal similarity and interpersonal attraction has been widely investigated in the last decades - the first studies date back to the early sixties [1] - especially when it comes to the *similarity-attraction* effect [2], i.e., the tendency to observe higher interpersonal attraction between people that are more similar to one another. Correspondingly, the expression *attraction paradigm* accounts for methodologies and theories aimed at analyzing the phenomenon and its effects on human-human interactions [3]. After the initial focus on *actual* similarity, the attention has shifted towards *perceived similarity* because this, "*rather than actual similarity, [is] predictive of attraction*" [4]. In other words, it is sufficient that people believe to be similar, irrespectively of their actual similarity, to increase the chances that the effect takes place. Such an observation has allowed the extension of the attraction paradigm to Human-Robot Interaction (HRI). The reason is that robots can convey the impression of being similar to their users by, e.g., imitating their inner state or their behavior [5].

This work adopts the attraction paradigm to investigate whether there is a relationship between perceived similarity in terms of personality and perceived quality of the interaction with the robot. In particular, the experiments of this work have involved 30 human observers that have rated 45 robotic gestures in terms of Big-Five personality traits [6] and Godspeed scores [7]. Furthermore, the observers have self-assessed their own personality so that it is possible to test whether they tend to rate more favorably a robot - in terms of the Godspeed scores - when it displays a gesture that conveys the impression of a more similar personality. The results show that the majority of the subjects display the similarity-attraction effect (16 out of 30), but it is frequent to observe the *complementarity-attraction* effect as well, i.e., the tendency to like more the robots that look more different (10 subjects out of 30). Furthermore, the observed effects depend on the particular trait under analysis.

Unlike this work, previous HRI experiments based on the attraction paradigm have focused mainly on Extraversion, the trait that accounts for the tendency to establish social interactions. A study based on the use of synthetic facial expressions shows that "*participants who interacted with a similar personality robot were more comfortable, [but] the evaluation of social presence presented an opposing result*" [8], where the word personality actually accounts for the sole Extraversion trait. Similarly, the results presented in [5] show that higher similarity in the preferences for certain toys leads to higher friendliness ratings, but does not change the enjoyment that the users experienced during the interaction. Other approaches, have changed proxemic and paralinguistic behavior of a robot to convey higher or lower Extraversion impressions and the results show that the users tend to spend more time with robots they feel more similar [9], [10], [11]. Finally, there are works that show that there is no similarity attraction [12], [13] or there is *complementarity-attraction* [14]. The main novelty of the experiments of this work is that they take into account not only Extraversion, but also the other Big-Five traits, thus providing a more exhaustive explanation of the observed associations between similarity and ratings.

Overall, the results above confirm that the main tenet of the attraction paradigm - the association between similarity and attraction - applies to HRI. However, unlike in human-human interactions, it is frequent to observe that the association is negative, i.e., it takes the form of the complementarity-attraction effect, where people tend to like more the robots that they perceive to be less similar. The main reason for focusing on gestures is that these are effective at conveying messages when there is a high level of acoustic noise [15], [16], a condition typical of settings where robots appear increasingly more frequently like, e.g., public spaces, stations, airports and shopping malls [17]. The adoption of the attraction paradigm to design gestures can therefore contribute to enhance the experience of the users and, ultimately, can make the robots more effective at completing the tasks they are expected to accomplish.

The rest of this article is organized as follows: Section II presents the data used in this work, Section III presents the methodology adopted in the experiments, Section IV reports on the results and the final Section V draws some conclusions.

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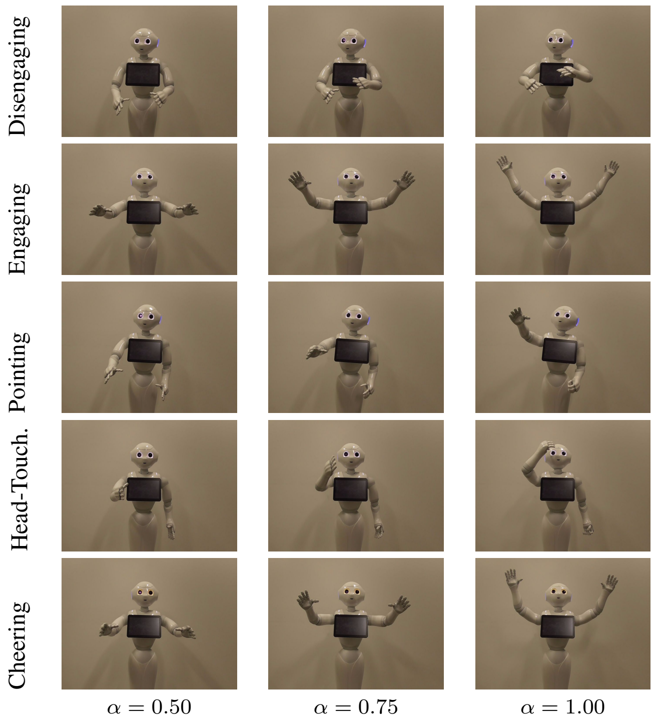

TABLE I

THE FIGURES SHOW, FOR EACH OF THE FIVE CORE STIMULI, THE EFFECT OF THE PARAMETER α. THE RIGHTMOST COLUMN ($\alpha = 1.00$) CONTAINS THE CORE STIMULI.

II. THE DATA

The experiments of this work revolve around 45 gestures - the *stimuli* hereafter - synthesized with Pepper, the robotic platform manufactured by Softbank Robotics. The gestures have been obtained by manipulating amplitude and speed (see below for more details) of the following animations available in the Pepper's standard library[1]:

- Disengaging / Send-away;
- Engaging / Gain attention;
- Pointing / Giving Directions;
- Head-Touching / Disappointment;
- Cheering / Success.

The gestures above - the *core gestures* hereafter - have been performed with three different values of the speed λ, namely 15, 25 and 35 *frames per second* (fps), where 25 fps is the original speed of the core gestures in the library provided by the robot's manufacturer. In this way, the original set of 5 core gestures has led to a new set of stimuli including in total $5 \times 3 = 15$ stimuli.

If $\Delta\theta_i(t) = \theta_i(t) - \theta_i(t-1)$ is the variation of θ_i (the angle between the two mechanical elements connected by joint i) between frame $t-1$ and frame t, then it is possible to modify the stimuli by multiplying $\Delta_i(t)$ by a constant α for all values of i and t. When $\alpha < 1.00$, the result is a dampened version of the original gesture, i.e., a version in which the amplitude is lower. During the experiments, each of the 15 stimuli obtained so far has been played using three values of α, namely 0.50, 0.75 and 1.00. This has led the final $15 \times 3 = 45$ stimuli adopted in the experiments (see Table I).

[1]The animations associated to the core stimuli are available on the version 1.6B of Pepper in the following directories: "`animations/Stand/Gestures/No_3`" (Disengaging), "`animations/Stand/Gestures/Hey_2`" (Engaging), "`animations/Stand/Emotions/Negative/Hurt_1`" (Pointing), "`animations/Stand/Gestures/Far_3`" (Head-Touching) and "`animations/Stand/Emotions/Positive/Happy_1`" (Cheering).

I ...	The robot ...
am reserved	is reserved
am generally trusting	is generally trusting
tend to be lazy	tends to be lazy
am relaxed, handles stress well	is relaxed, handles stress well
have few artistic interests	has few artistic interests
am outgoing, sociable	is outgoing, sociable
tend to find fault with others	tends to find fault with others
do a thorough job	does a thorough job
get nervous easily	gets nervous easily
have an active imagination	has an active imagination

TABLE II

THE BFI-10 QUESTIONNAIRE IN FIRST-PERSON (LEFT COLUMN) AND THIRD-PERSON (RIGHT COLUMN) VERSIONS. THE FORMER AIMS AT PERSONALITY SELF-ASSESSMENT, WHILE THE LATTER AIMS AT ASSESSING OTHERS.

A. *Personality and Godspeed Scores*

Personality is a psychological construct that accounts for "*habitual behaviors, cognitions, emotional patterns and so on*" [18], i.e., for the most stable aspects that can be observed in an individual. The literature proposes a large number of personality models, but the one that is most commonly adopted, both in psychology and computing [19], is the Big-Five, a trait-based model that represents the personality in terms of the following five dimensions:

- *Openness*: tendency to be artistic, curious, imaginative, insightful, original, to have wide interests, etc.
- *Conscientiousness*: tendency to be efficient, organized, reliable, responsible, thorough, etc.
- *Extraversion*: tendency to be active, assertive, energetic, outgoing, talkative, etc.
- *Agreeableness*: tendency to be appreciative, kind, generous, forgiving, sympathetic, trusting, etc.
- *Neuroticism*: tendency to be anxious, self-pitying, tense, touchy, unstable, worrying, etc.

Assessing the personality of an individual means to measure, possibly in quantitative terms, how pronounced the tendencies above are for a given individual. In general, such a task is performed with the help of questionnaires that allow one to map the answers given to a predefined set of questions into quantitative measures. In the experiments of this work, the 30 observers involved in the experiments have been asked to self-assess their personality by filling the first-person version of the *Big-Five Inventory 10* (see left column of Table II) [20]. Similarly, after watching each of the 45 stimuli used for the experiments, the observers have been asked to rate the robot by filling the third-person version of the the same questionnaire (see right column of Table II).

The main reason behind the success of the Big-Five traits in psychology is that they are predictive of important life aspects, including "*happiness, physical and psychological health, [...] quality of relationships with peers, family, and romantic others [...] occupational choice, satisfaction, and performance, [...] community involvement, criminal activity, and political ideology*" [21]. In other words, measuring the personality of an individual through the Big-Five allows one to make reliable guesses about the aspects mentioned in the quote above and the many others the model is predictive of. When it comes to computing, the Big-Five model has been widely adopted because it represents personality as a five-dimensional vector, a format particularly suitable for computer processing [19].

Given that the goal of this work is to test whether people associate perceived personality similarity and perceived quality of interaction, the 30 observers have been asked to fill, for each of the 45 stimuli, the Big-Five Inventory 10 in third person (see above) and the Godspeed questionnaire [7], an instrument commonly adopted to measure how the users perceive the interaction with a robot along the following dimensions:

- *Anthropomorphism*: tendency of human users to attribute human characteristics to a robot;
- *Animacy*: tendency of human users to consider the robot alive and to attribute intentions to it;
- *Likeability*: tendency of human users to attribute desirable characteristics to a robot;
- *Perceived Intelligence*: tendency of human users to consider intelligent the behavior of a robot;
- *Perceived Safety*: tendency of human users to consider safe the interaction with a robot.

At the end of the annotation process, the available data is the self-assessment of the 30 observers in terms of the Big-Five and, for each of the 45 stimuli, 30 personality assessments (one per observer) and 30 Godspeed measurements (one per observer).

III. Methodology

The main question addressed in this work is whether the attraction paradigm applies to the stimuli described in Section II, i.e., whether there is a relationship between similarity (in terms of personality in the experiments of this work) and attraction (in terms of Godspeed scores in the experiments of this work). Given a particular observer, it is possible to measure the Euclidean distance between her or his self-assessed personality traits (see Section II-A) and the personality traits attributed to stimulus k:

$$d_k = \left[\sum_{j=1}^{T} (t_j^{(s)} - t_{jk}^{(a)})^2 \right]^{\frac{1}{2}} \quad (1)$$

where T is the number of traits, $t_j^{(s)}$ is the score corresponding to self-assessed trait j and $t_{jk}^{(a)}$ is the score corresponding to the trait j attributed to stimulus k. Once the value of d_k is available, for a given observer, for all stimuli k, then it is possible to measure its correlation with each of the Godspeed scores. When the correlation is statistically significant and negative, it means that the observer tends to assign higher Godspeed scores to those stimuli that she or he perceives to be closer in terms of personality. The correlation is measured with the Spearman Rank Correlation Coefficient [22].

The value of d_k takes into account all personality traits, but it is possible to apply the same approach for each of the Big-Five traits individually:

$$d_k^{(j)} = t_j^{(s)} - t_{jk}^{(a)}, \quad (2)$$

where the meaning of the symbols is the same as in the previous equation. The value of $d_k^{(j)}$ corresponds to the difference between a specific self-assessed trait and the same trait attributed to a particular stimulus k. In this way, it is possible to estimate the correlation between $d_k^{(j)}$ and the Godspeed scores, thus testing if and how the attraction paradigm applies not only at the level of the personality as a whole, but also at the level of the individual traits. To the best of our knowledge, such an analysis was not proposed before in the HRI literature.

IV. Experiments and Results

Age Range	18-22	23-25	26-30	31-35	36-40	¿40
No. of Subjects	11	6	6	3	1	3

TABLE III
AGE DISTRIBUTIONS OF THE SUBJECTS INVOLVED IN THE EXPERIMENTS.

The experiments of this work have involved 30 observers (20 male and 10 female) that have watched and rated the stimuli in terms of Big-Five personality traits and Godspeed scores (see Section II for more details). Given that the number of stimuli is large, the observers have completed their assessments in three separate sessions that have been held in different days (15 stimuli per session). The stimuli have been administered in random order to avoid possible tiredness effects due to the repetitiveness of the task. During each session, three different observers have watched and assessed the same stimuli at the same time. However, the three observers involved in the same session have worked independently and there has been no communication between them. The assessments have been entered via an online interface that has been accessed using a tablet (each of the three observers involved in the same session has used a different tablet). The robot performing the 45 gestures was positioned at a distance of 1.5 meters from the observers. The observers have been selected from a pool of subjects available at the University of Glasgow, where the experiments have been performed, and they have been paid 6 British Pounds by the hour (the minimum legal wage in the United Kingdom). The age distribution of the observers is available in Table III.

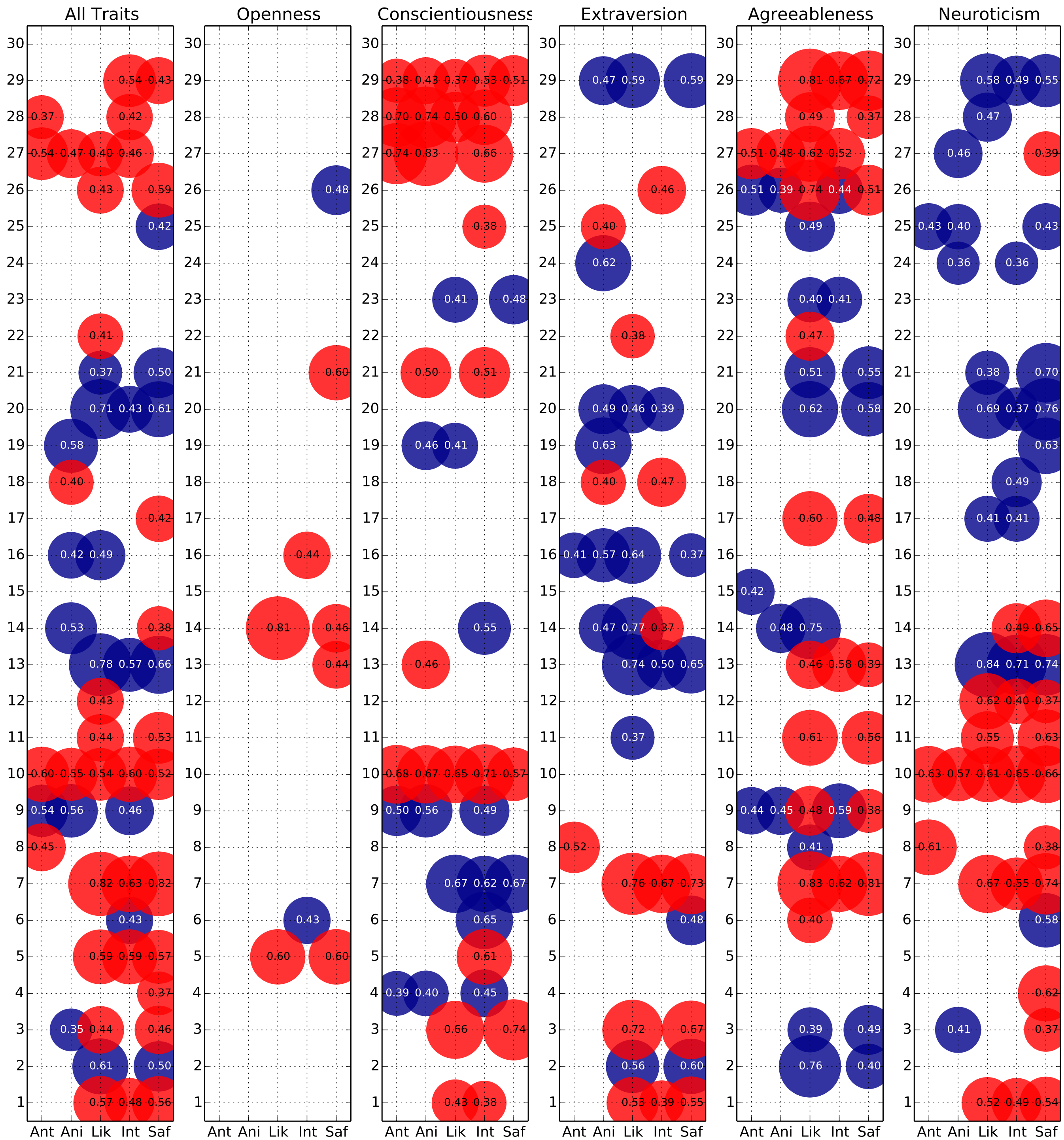

Fig. 1. Correlation between Godspeed scores and distance between self-assessed and attributed traits. Only statistically significant correlations are included in the plot ($p < 0.05$ after False Discovery Rate correction [23]). Blue and red bubbles account for positive and negative correlations, respectively.

A. Attraction Paradigm Effects

The traits that the observers have attributed to the robots during the experiments can be thought of as the traits that the observers perceive the robot to have. According to the literature, it is the perceived similarity that is predictive of the attraction [4]. Therefore, the personality assessments collected during the experiments can be used to test whether there is a relationship between the perceived similarity - measured through the distance between attributed traits and self-assessed traits (see Section III) - and the attraction - measured through the Godspeed scores. Figure 1 shows the correlations between distance and Godspeed scores for each of the 30 subjects involved in the experiments, both at the level of the personality as a whole (the leftmost plot) and at the level of the individual traits (the other five plots). Whenever there is a negative correlation between the distance and the Godspeed scores, it means that the subject tends to assign higher scores to the stimuli perceived to convey the impression of a personality (or personality trait) more similar to their own.

In the case of the personality as a whole (leftomost plot of Figure 1), the results show that all statistically significant correlations are negative for 15 subjects out of the 30. This means that the attraction paradigm applies to these subjects under the form of the similarity-attraction effect, at least for those traits and dimensions of the Godspeed that correspond to the bubbles in the plot. For another 9 subjects, the statistically significant correlations are always positive and, therefore, the attraction paradigm applies again, but, in this case, under the form of the complementarity-attraction effect. The effects are mixed for two subjects - meaning that there is similarity or complementarity attraction depending on the particular Godspeed dimension - and no effects have been observed for the remaining 4 subjects.

Overall, the pattern above suggests that the attraction paradigm actually applies to HRI, at least when it comes to the stimuli adopted for these experiments. However, it takes the form of both the similarity and complementarity-attraction effects, unlike what happens in human-human interactions where the former tends to take place in the largest majority of the cases. One possible explanation of the frequent occurrences of the complementarity-attraction effect is the *uncanny valley* [24], i.e., the tendency of people to turn attraction into repulsion when the similarity between people and robots goes beyond a certain threshold and the robot fails in meeting the resulting expectations of being life-like.

The presence of both similarity-attraction and complementarity-attraction effects in the same pool of subjects might explain why the literature has provided mixed evidence so far, with some works claiming that there is a relationship between similarity and attraction [9], [10], [11] and others that claim the contrary [12], [13], [14]. In fact, such works tend to revolve around the similarity-attraction effect and, hence, to consider a failure the presence of the complementarity effect, while it should be considered a confirmation that the attraction paradigm actually applies to HRI. Furthermore, unlike this work, the previous articles present the results in terms of an average over multiple observers and the presence of opposite effects - like in the case of Figure 1 - can lead to low or null average effects.

For what concerns the results along the individual Big-Five traits, Figure 1 shows that the number of subjects that manifest one of the two effects changes with the traits. In particular, it is 7 for Openness, 17 for Conscientiousness, 18 for Extraversion, 20 for Agreeableness and 21 for Neuroticism. Such a pattern suggests that, at least in the experiments of this work, Openness does not play a major role in the attraction paradigm, while the other traits do. One possible explanation is that the type of interaction considered in this work - the exchange of a message through a symbolic gesture - does not involve the tendencies associated to Openness (see Section II) and, therefore, such a trait does not give rise to observable effects.

The similarity-attraction effect accounts for the majority of the statistically significant correlations only in the case of Openness (5 out of 7 observers) and Conscientiousness (10 out of 17 observers), while it is less frequent than the complementarity-attraction effect for Extraversion (8 out of 18 observers), Agreeableness (9 out of 20 observers) and Neuroticism (8 out of 21 observers). This seems to suggest that the observers tend to like more the robots that they tend to perceive more similar in terms of competences - the tendencies associated for Openness and Conscientiousness correspond mainly to intellectual skills and effectiveness at accomplishing tasks - while they tend to like less the robots that they perceive to be similar in terms of social skills - the tendencies associated to Extraversion, Agreeableness and Neuroticism account mainly for the attitude towards others. One possible explanation is that the experiments revolve around a communication task - to convey a precise message through a gesture - in which the ability to actually complete the task is considered more desirable than the social skills. However, the difference between the number of times the two opposite effects are observed is never large (the maximum value corresponds to Neuroticism where similarity and complementarity-attraction are observed 8 and 11 times, respectively).

V. Discussion and Conclusions

This work has presented experiments about the relationship between similarity and attraction - the phenomenon at the core of the attraction paradigm [3] - in Human-Robot Interaction. The experiments have focused on the use of symbolic gestures to convey predefined messages. The main reason is that such a form of communication can be effective in settings like public spaces where there is a high level of acoustic noise and there are multiple stimuli that compete to attract the attention of the robot's users (e.g., advertisement, public announcements, other people, etc.).

Overall, the experiments have shown that most of the human observers (26 out of 30) display statistically significant correlations between similarity along the Big-Five traits and Godspeed scores. However, unlike in human-human interactions, the association is frequently negative, meaning that the complementarity-attraction effect tends to be as frequent as the similarity-attraction effect, typically targeted in the previous HRI works dealing with the attraction paradigm (see Section I). Furthermore, the experiments show that the observed effects tend to change with the personality trait. In particular, the similarity-attraction effect tends to be more frequent in the case of traits that account for competence and intellectual skills, while the complementarity-attraction effect tends to be more frequent in the case of traits that account for social skills.

The main implication from a HRI point of view is that the use of the similarity-attraction effect as a means to achieve an interactional goal - e.g., to make the users spend more time with a given robot - requires more caution than in the case of human-human interactions, where it has been shown to be successful in a wide spectrum of contexts [25]. Not surprisingly, the previous works that have tried to improve the interaction between people and machines through the similarity-attraction effect have provided mixed evidence and contradictory results (see above).

If the complementarity-attraction is as frequent as the similarity-attraction effect, like the results of this work seem to suggest, then the use of the attraction paradigm can be successful only if it is possible to predict, for a given user, what is the tendency that she or he is displaying. In fact, once it is known whether the users display one effect rather than the other, then it is possible to change the behavior of the robot accordingly so that the Godspeed scores - or any other equivalent measures - can be improved. To the best of our knowledge, no studies have been done so far to identify the factors that can make a user more prone to like similar or dissimilar robots. Correspondingly, no attempts have been made to make the robots capable to infer what type of effect the users display from their observable behavior and characteristics. Both problems can be the subject of future research efforts.

Another possible direction for future work is the use of criteria different from personality to measure the perceived similarity between users and robots. Most of the works presented so far in the literature (see Section **??**) revolve around personality because such a construct is expected to capture most individual differences and to be independent of a particular context and setting [6]. However, it cannot be excluded that measuring the similarity along other dimensions - e.g., the gender, the way of speaking, the lexical choices, etc. - can lead to the prevalence of one of the two effects (similarity-attraction or complementarity-attraction), thus making it easier to adopt the attraction paradigm in view of an HRI goal.

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