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 tendency to associate similarity and attraction in interpersonal relations — in Human-Robot Interaction. The experiment presented here involved 30 human observers who watched and rated 45 robotic gestures in terms of Big-Five personality traits and Godspeed scores. The results show that, for 24 of the 30 observers, there was a statistically significant correlation between the Godspeed scores and the perceived similarity between the robot's personality and their own. However, the association was positive for 15 subjects — meaning that for these there is a similarity-attraction effect — and negative for the other 9 — meaning that for these there is a complementarity-attraction effect. Furthermore, the strength of the effect depends on the particular trait under examination.**

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 analysing this phenomenon and its effects on human-human interactions [3]. After an initial focus on *actual* similarity, 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 perceive themselves to be similar, irrespectively of their actual similarity, to increase the chances of the effect taking place. This observation has allowed the attraction paradigm to be extended to Human-Robot Interaction (HRI), since robots can convey the impression of being similar to their users by, e.g., imitating their inner state or their behaviour [5].

Previous HRI experiments examining 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*" [6], where the word 'personality' actually refers only to the Extraversion personality trait. Similarly, the results presented in [5] show that higher similarity in the preferences for certain toys leads to higher friendliness ratings, but that this does not change the enjoyment that the users experienced during the interaction. Other approaches have varied the proxemic and paralinguistic behaviour of a robot to convey higher or lower Extraversion impressions, and have found that users tend to spend more time with robots that they perceive as more similar to themselves [7]–[9]. Finally, there have been studies that found no similarity attraction [10], [11], or that show there is *complementarity-attraction* instead [12].

Overall, the previous studies listed 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, observing a negative association is not uncommon — i.e., in some cases, the observations show the complementarity-attraction effect, where people tend to prefer robots that they perceive to be less similar to themselves.

This work adopts the attraction paradigm to investigate whether there is a relationship between perceived similarity in terms of personality, and the perceived quality of the interaction with the robot. To do so, the experiments of this work involved 30 human observers rating 45 robotic gestures in terms of Big-Five personality traits and Godspeed scores. Here, the Big-Five personality traits derive from a five dimensional trait-based personality model [13] that is commonly adopted in both psychology and computing [14], while the Godspeed scores derive from a questionnaire is commonly used in HRI to quantitatively measure the perception that a person develops about a robot they observe or interact with, along five dimensions [15]. In addition, the observers also self-assessed their own personality, so that it is possible to test whether they tend to more favourably rate a robot — in terms of Godspeed scores — when it displays a gesture that conveys the impression of a more similar personality.

The main novelty of the experiments presented is that they take into account not only Extraversion (as in previous works), but also the other Big-Five personality traits, thus providing a more exhaustive explanation of the observed associations between similarity and (Godspeed) subjective ratings than available thus far. We focus on robot gestures as these are effective at conveying messages when there is a high level of acoustic noise [16], [17], a condition typical of settings where robots appear increasingly more frequently, such as stations, airports and shopping malls [18].

The results of the experiments show that the majority of the subjects display the similarity-attraction effect (15 out of 30), but the *complementarity-attraction* effect is observed as well, i.e., the tendency to rate more favourably robots that convey a

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more different personality (9 subjects out of 30). Furthermore, they show that the observed effects depend on the particular personality trait under examination. The adoption of the attraction paradigm to design gestures can therefore enhance the experience of the users and, ultimately, can make the robots more effective at completing their assigned tasks.

The rest of this article is organized as follows: Section II and Section III present the data used in this work; Section IV presents the methodology adopted in the experiments; Section V their arrangement, while Section VI reports on the results; Section VII provides some discussion and draws conclusions.

II. The Stimuli

The experiments of this work revolve around 45 gestures — the *stimuli* hereafter — synthesized with Pepper, a 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 were 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).

III. Personality and Godspeed Scores

Personality is a psychological construct that accounts for "*habitual behaviours, cognitions, emotional patterns and so on*" [19], 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

[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" (Head-Touching); "animations/Stand/Gestures/Far_3" (Pointing) ; and "animations/Stand/Emotions/Positive/Happy_1" (Cheering).

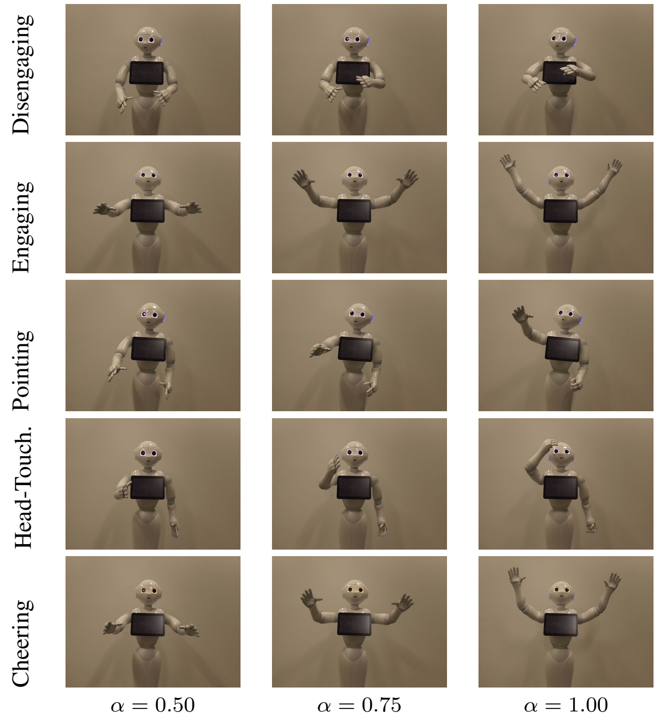

TABLE I

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.

adopted, both in psychology and computing [14], 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 measuring, 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*

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 USED IN THE EXPERIMENTS OF THIS WORK (LEFT COLUMN: FIRST-PERSON, RIGHT COLUMN: THIRD-PERSON). THE VERSION REPORTED HERE IS THE ONE THAT HAS BEEN PROPOSED IN [20].

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 [14].

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 [15], 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 the behaviour of a robot intelligent;
- *Perceived Safety*: tendency of human users to consider the interaction with a robot safe.

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).

IV. 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

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 OBSERVERS INVOLVED IN THE EXPERIMENTS.

his self-assessed personality traits (see Section III) 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's 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 has not been proposed before in the HRI literature.

V. EXPERIMENTAL ARRANGEMENT

The experiments of this work involved 30 observers (20 male and 10 female) who 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 completed their assessments in three separate sessions on different days (15 stimuli per session). The stimuli were administered in random order to avoid possible tiredness effects due to the repetitiveness of the task. During each session, three different observers watched and assessed the same stimuli at the same time. However, the three observers involved in the same session worked independently and there was no communication between them. The assessments were entered via an on-line interface that has been accessed using a tablet (each of the three observers involved in the same session used a different tablet). The robot performing the 45 gestures was positioned at a distance of 1.5 meters from the observers. The observers were selected from a pool of subjects available at the research institute where the experiments were performed, and they received a payment corresponding to the minimum legal hourly wage in the country where the experiments were conducted. The age distribution of the observers is available in Table III.

VI. Attraction Paradigm Effects

The traits that the observers 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 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 IV) — 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 a personality (or personality trait) more similar to their own.

In the case of the personality as a whole (leftmost 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 in 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, in the form of the complementarity-attraction effect. The effects are mixed for two subjects (numbers 3 and 14) — meaning that there is similarity or complementarity attraction depending on the particular Godspeed dimension — and no effects were 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 represents 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 HRI literature has provided mixed evidence so far, with some works claiming that there is a relationship between similarity and attraction [7]–[9] and others that claim the contrary [10]–[12]. In fact, such works tend to revolve around the similarity-attraction effect and, hence, to consider the presence of the complementarity effect a failure, 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.

When it comes to the results for 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 that 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 prefer 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 those robots less 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 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).

VII. 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, since this is 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.).

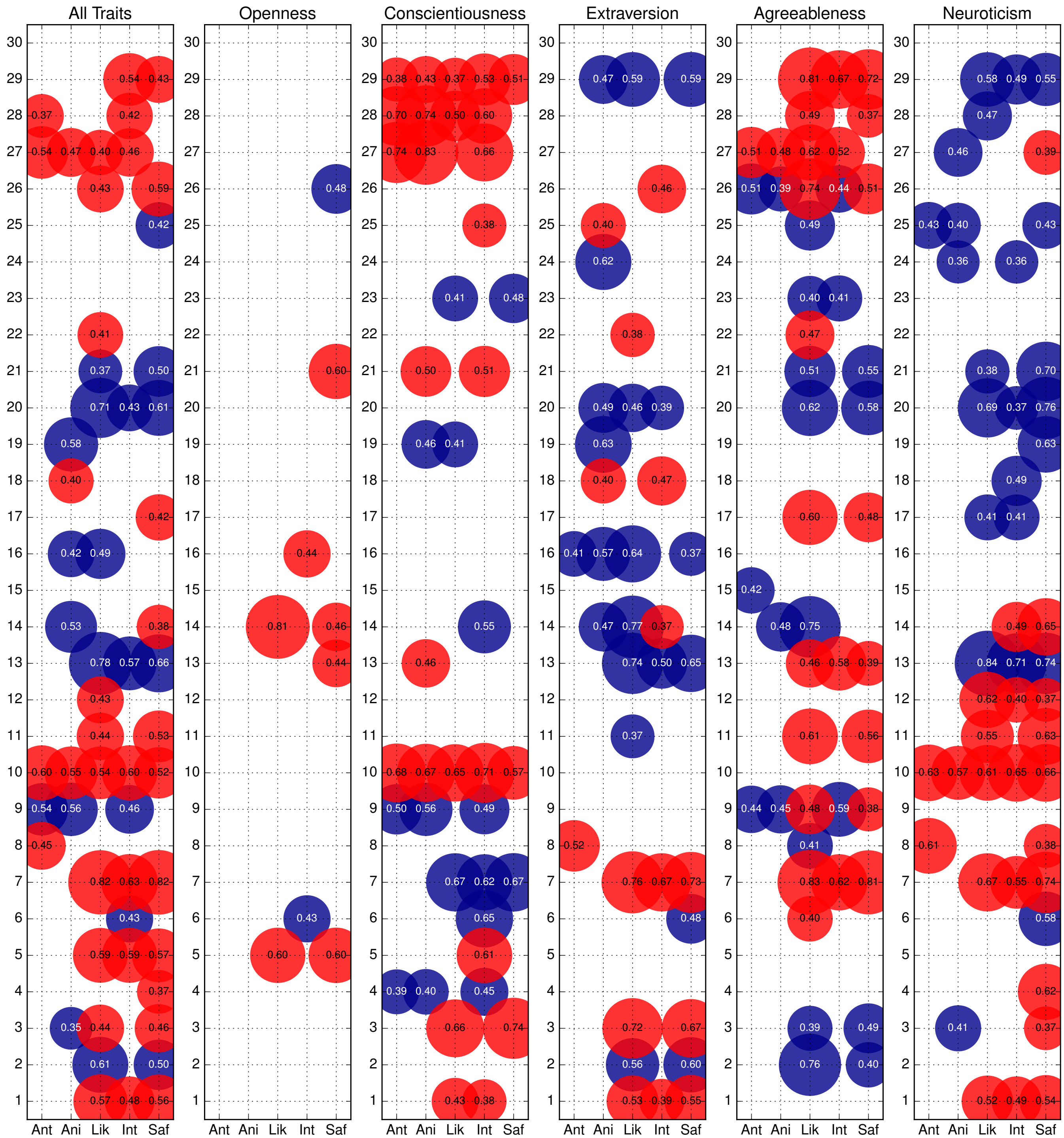

Fig. 1. Correlation between Godspeed scores and distance between self-assessed and attributed traits, per-subject (subject numbers on the vertical axis). Only statistically significant correlations are included in the plot ($p < 0.05$ after False Discovery Rate correction [23]). Blue and red bubbles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

Overall, the experiments have shown that most of the human observers (24 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, where the latter is 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, 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, as these results 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 tendency he or she 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 behaviour 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 behaviour 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 III) revolve around personality because that is expected to capture most individual differences and to be independent of a particular context and setting [13]. 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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