

Effectiveness of Attribute-Matching Agents on User Impressions and Recommendation Satisfaction in Human-Agent Interactions

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Abstract—In the realm of human-agent interaction, personalized attribute-matching has emerged as a pivotal factor in enhancing user experiences and satisfaction. This study investigates the effectiveness of attribute-matching agents on user impressions and recommendation satisfaction through a controlled experimental approach using a museum appreciation simulation game. We assessed participants who interacted with agents designed to align attributes with user characteristics, specifically focusing on curiosity and individuality traits. Agents employing attribute-matching received significantly more favorable evaluations across key dimensions: agreement, desire for future interaction, perceived understanding, and appreciation. Notably, the impact was particularly pronounced among participants exhibiting high inquisitiveness and high uniqueness scores. These results highlight the significance of implementing personalized attribute-matching strategies. Conversely, attribute-matching showed limited influence on actual behavioral changes, underscoring the necessity for more dynamic task design.

Keywords—Human-agent interaction; attribute-matching; personalization; recommendation system; personalization.

I. INTRODUCTION

In recent years, artificial intelligence technologies have accelerated research into intelligent agents capable of engaging meaningfully with humans [1]. These agents are conceptualized not merely as task execution tools, but as entities capable of forming significant social bonds with humans [2]. Despite these advancements, users frequently perceive agents as mechanistic constructs rather than entities with distinct personalities [3][4], presenting a considerable obstacle to cultivating enduring human-agent interactions.

This study seeks to integrate principles of human-human interaction into intelligent agents' design. This methodology is grounded in research demonstrating the applicability of social norms governing Human-Human Interaction (HHI) to Human-Computer Interaction (HCI) [5].

Attribute-matching draws from psychological principles of similarity-attraction and homophily, suggesting individuals form stronger connections with others sharing similar characteristics [6][7]. This principle encompasses value similarity and status similarity [8], manifesting in digital contexts and social media platforms [9][10]. Individuals sharing similar experiences or knowledge are more inclined to cultivate interpersonal relationships [11]. When applied to human-agent interaction, this principle suggests users may develop more

positive impressions when interacting with agents exhibiting similar attributes.

Two theoretical frameworks guide this research. First, common ground theory [12] suggests successful communication requires shared knowledge and mutual understanding [13]. In computational agents, common ground mechanisms include embodiment, social features, joint action, knowledge base, and mental models, thereby enhancing communication quality and user satisfaction. Second, the Media Equation [14] explains why people treat agents as social actors, responding socially and physiologically to agent cues with emotional-response patterns similar to human interactions [15]. This suggests users unconsciously apply social rules to technological agents, treating them as social entities.

In interpersonal interactions, constructing mental representations of others is imperative for predicting actions and enabling seamless exchanges [16]. Greater similarity between partners facilitates this model formation, leading to smooth and sustainable interactions. Integration of similarity principles into human-agent interaction demonstrates efficacy [3].

We hypothesize that designing agents whose characteristics correspond with users' attributes will significantly improve user impressions and trust. Characteristics include both demographic (e.g., gender, age) and psychological factors (e.g., values, interests). Attribute congruence is intrinsically associated with common ground formation, facilitating enhanced mutual understanding between agents and users. We developed an agent with varied levels of attribute matching and executed interaction experiments entailing action recommendations directed at users. The experiment evaluated users' perceptions of agents and their recommendations, while also analyzing the influence of attribute matching. Furthermore, we explored the correlation between users' personal characteristics and the attribute matching process.

This paper is organized as follows: In Section 2, we briefly introduce related works. Section 3 provides an outline of the proposed method. Section 4 contains a description of our experiment that compared experimental and control groups, and presents our results. In Section 5, we discuss the achievements of this research and some future work. We present our conclusion and future work in Section 6.

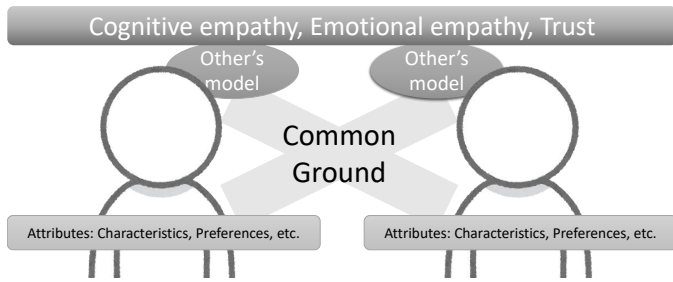


Figure 1. Formation of other's model and positive impression by attribute matching.

II. RELATED WORK

In Human-Agent Interaction (HAI), agent functions have transformed from information providers to interactive communicative partners [17][18]. This transformation is manifest in non-task-oriented dialogue agents facilitating organic social engagement [19]. Recent advancements underscore the significance of individual cognitive models in shaping interactions with artificial agents [20]. Methodologies, such as minimal design [21] and Common Ground theory-informed strategies [22], facilitate enhanced social connections during human-agent exchanges.

Substantial research has examined incorporating human attributes into artificial agents, demonstrating that integrating human characteristics augments interaction consistency and favorably affects user perceptions [23][24]. Agent personality traits exert beneficial influence on user assessments [25]. Equipping agents with distinctive traits enables users to construct 'other person models,' promoting extended and meaningful interactions.

Attribute matching involves static alignment of visible agent traits to create surface-level similarity and establish initial rapport [26][27]. Adaptive personalization involves dynamic modification of agent behavior over time using data-driven user models to continuously refine interaction strategies. While both approaches aim to improve user experience, they operate through different mechanisms. Attribute matching is particularly effective for establishing initial rapport and positive first impressions, while adaptive personalization suits long-term relationship building.

III. ATTRIBUTE MATCHING

In this study, we examine attribute matching's impact on user impressions and satisfaction with agent recommendations. We view trust building through forming 'other's models' via attribute matching, which subsequently influences empathy formation (Figure 1). Attitude similarity positively affects interpersonal attraction among humans [28]. When humans perceive personal attributes as common ground through agent similarities, this enhances 'other's model' estimation. Successfully estimating these models fosters affinity and liking toward agents, eventually evolving into empathy and trust.

Importantly, when agents deviate from user expectations, even thoroughly established rapport may be compromised.

Thus, agents must perpetually assimilate user characteristics through engagement and respond appropriately. By demonstrating understanding of diverse user characteristics, agents can preserve relationships even amidst conflicts. Virtual agents engineered to cultivate and sustain enduring social-emotional bonds are esteemed and trusted more significantly [29].

In the present study, the agent estimates user characteristics and facilitates model building through self-disclosure and attribute-aligned recommendations. We assist users in recognizing common attributes by offering actions and perspectives congruent with their values.

a) Estimation of User Attributes:: Before interaction, the agent estimates user characteristics using pre-obtained survey data, creating an informed profile that enables personalized communication.

b) Dynamic Attribute Refinement:: During interaction, the agent collects and analyzes user preferences and behaviors. When predictions prove inaccurate, attribute information is immediately adjusted, enabling the agent to refine its understanding iteratively.

c) Self-Disclosure Based on Attribute Alignment:: The agent presents insights grounded in attribute data, adapting to curiosity levels. For highly curious users, it emphasizes unique perspectives; for others, it highlights consensus-based views. This nuanced approach ensures personalized engagement.

d) Action Recommendation Based on Attributes:: When users make choices, the agent recommends actions aligned with both prior survey data and interaction-acquired information, providing relevant and personalized recommendations.

Survey data provides an efficient foundation for prior knowledge. Through interaction, participants disclose values and intentions, which the agent uses to propose aligned actions. By mirroring participant viewpoints, agents facilitate recognition of common attributes. This self-disclosure process cultivates consensus and empathy [30]. As the agent's perspectives increasingly resonate with users' inclinations, user disposition improves, enhancing acceptance of recommendations. This iterative process sustains and intensifies social rapport.

IV. EXPERIMENT

This experiment investigated the influence of attribute congruence on users' perceptions of an artificial agent and their overall satisfaction with the recommendations provided by the agent in its capacity as an intermediary. The research incorporated two distinct categories of agents: one configured to utilize attribute matching techniques and the other devoid of such characteristics. The agent employing attribute matching formulated recommendations grounded in initial questionnaires that evaluated the individual traits of the participant, which included the application of the Uniqueness Scale posited by Yamaoka [31] and the inquisitiveness dimension derived from the Critical Thinking Orientation Scale developed by Hirooka et al. [32], along with attributes ascertained during the interactive task. The efficacy of attribute matching was assessed through subsequent questionnaires.

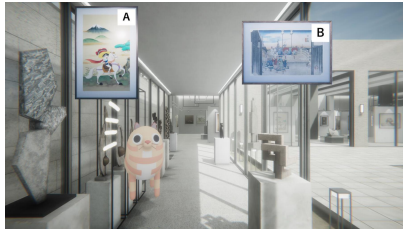


Figure 2. Screen shot of the museum appreciation simulation game.

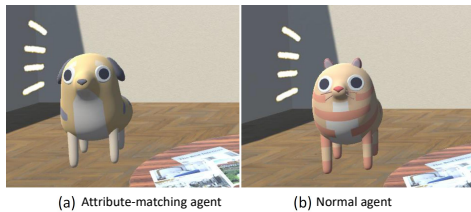


Figure 3. The appearance of the agents.

A. Task

We employed a “museum appreciation simulation game” developed using Unity platform. Participants explored a virtual museum alongside an agent, examining three artwork categories. Prior to each category, the agent proposed two viewing options based on constrained examination duration. Participants selected one agent-recommended artwork, and the agent elucidated each choice. Figure 2 shows the screen shot of the museum appreciation simulation game.

The attribute-matching agent customized recommendations based on the Uniqueness Scale and inquisitiveness level. For high inquisitiveness participants, it emphasized subjective assessments; for low inquisitiveness, objective evaluations. For high uniqueness participants, it accentuated individuality; for low uniqueness, unity. The control agent provided systematically contrasting recommendations. Following the evaluation of each artwork, participants assessed their satisfaction with the recommended piece utilizing a scale ranging from 1 to 5. Figure 3 shows the appearance of the agents.

B. Experimental Settings

Experiments were conducted in a controlled environment utilizing a 70-inch display (SHARP PN-H701) in conjunction with a Nintendo Joy-Con game controller. Participants were positioned in front of the display, employing the controller to interact with the game. The precise configuration of the experimental setup is illustrated in Figure 4. Engagements with the agent were conducted through the Wizard Of Oz (WOZ) methodology, wherein the experimenter manipulated the agent in accordance with established protocols.

C. Participants

The study involved 19 undergraduate students (15 males, 4 females; $M = 22.3$, $SD = 2.16$). Due to technical malfunction, 18 participants’ data were analyzed. Participants were classified as high/low based on Uniqueness Scale and inquisitiveness median values.

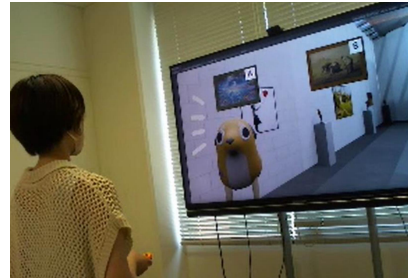


Figure 4. The experimental setting.

D. Procedure

Participants received experimental orientation and trial sessions. Each participant engaged with both attribute-matching and non-attribute-matching conditions, with sequence counter-balanced. Upon completion, participants completed follow-up questionnaires assessing both agents using a 7-point Likert scale for six items: agreement, desire for future interaction, understanding, appreciation, and artwork satisfaction.

Individual assessments utilized the GodSpeed questionnaire, evaluating Anthropomorphism, Animacy, Likability, Perceived intelligence, and Perceived safety [33]. This investigation concentrated on Anthropomorphism, Animacy, and Likability.

E. Results

For direct comparisons among agents, a one-sample Wilcoxon signed-rank test was implemented, whereas ANalysis Of VAriance (ANOVA) was utilized for the assessment of responses garnered from the GodSpeed questionnaire and the satisfaction pertaining to the artworks presented by the agents. Both the attribute-matching and non-attribute-matching conditions functioned as within-participant, with inquisitiveness and uniqueness scales acting as between-participant.

1) *Agent Comparative Analysis*: Figure 5 illustrates the results obtained from the agent comparison questionnaire, demonstrating that evaluations of the attribute-matching agent were predominantly more favorable across all assessed dimensions. Enhanced assessments for the attribute-matching agent are indicated by a positive value (+1 to +3), while increased ratings for the conventional agent are signified by a negative value (-1 to -3). To evaluate the statistical significance of this discerned trend, a one-sample Wilcoxon signed-rank test revealed significantly higher ratings for the attribute-matching agent across four particular items: “We maintain agreement with one another,” “I wish to interact again,” “I perceive understanding,” and “I feel appreciated” ($p < .05$). These results underscore the notion that a strong alignment between an agents actions and the inherent attributes of the user fosters a deeper sense of familiarity and empathy. Consequently, this alignment not only enhances the overall user experience but also cultivates a more positive perception of the communication process. This suggests that when users feel understood and valued, their willingness to engage with the agent again is significantly increased, reinforcing the importance of attribute matching in the design of interactive agents.

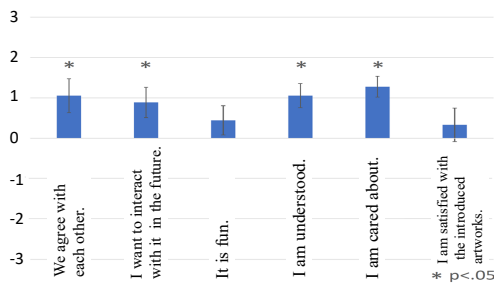


Figure 5. The results from the agent comparison questionnaire.

2) ANOVA: A two-way ANOVA was performed on the outcomes derived from the GodSpeed questionnaire and the degree of recommendation satisfaction. This statistical analysis incorporated high and low categorizations of inquisitiveness and uniqueness scales as between-participant variables, along with attribute matching as a within-participant variable. The findings are illustrated in Figure 6 and Figure 7.

a) Inquisitiveness:

Anthropomorphism: The analysis revealed a marginally significant difference in interaction between inquisitiveness and attribute-matching ($F(1,16) = 3.79, p < .1$). To further explore this interaction, a simple main effect test was conducted, which indicated a significant difference in the anthropomorphism score between the groups. Specifically, participants classified in the high inquisitiveness group demonstrated a markedly higher value within the attribute-matching condition ($F(1,16) = 7.15, p < .05$). This finding underscores the potential impact of inquisitiveness on the effectiveness of attribute-matching strategies, highlighting the importance of individual differences in cognitive processing.

Animacy: The analysis revealed that there was no statistically significant interaction between inquisitiveness and attribute-matching ($F(1,16) = 2.08, p = 0.17$). However, the main effect analysis indicated a trend worth noting: animacy ratings were observed to be marginally significantly higher in the attribute-matching condition ($F(1,16) = 4.41, p < 0.1$). This finding suggests that while the interaction between inquisitiveness and attribute-matching was not significant, the attribute-matching condition may still have a noteworthy impact on perceptions of animacy, hinting at the potential importance of this condition in understanding how attributes are matched in relation to perceived animacy.

Likability: There was a significant difference in the interaction between the factors of inquisitiveness and attribute-matching ($F(1,16) = 7.48, p < .05$). Further examination through a simple main effect test highlighted that within the attribute-matching condition, participants categorized as having high inquisitiveness demonstrated the higher likability score ($F(1,16) = 4.77, p < .05$). This finding underscores the influence of inquisitiveness on outcomes when individuals engage in tasks that require matching attributes. Moreover, within the subset of participants identified as high in inquisitiveness, the results indicated that those in the attribute-

matching condition exhibited an even more pronounced effect, yielding a significantly higher score ($F(1,16) = 8.72, p < .01$). This further emphasizes the critical role that inquisitiveness plays in enhancing likability in scenarios where attribute-matching is involved.

Artwork Satisfaction: The interaction effect between the variables of inquisitiveness and attribute-matching did not yield a statistically significant result ($F(1,16) = 2.53, p = 0.13$). However, when examining the main effects separately, participants categorized in the high inquisitiveness group reported a significantly elevated satisfaction score ($F(1,16) = 7.07, p < .05$). This finding underscores the importance of inquisitiveness as a contributing factor to artwork satisfaction, indicating that individuals with higher levels of curiosity tend to derive greater enjoyment or appreciation from the art. Additionally, the attribute-matching condition, while not reaching conventional levels of statistical significance, did show a marginally significant trend with a higher satisfaction score ($F(1,16) = 3.87, p < .1$). This suggests that there may be a potential relationship between how well the attributes of the artwork match the viewer’s preferences and their level of satisfaction, warranting further investigation to fully understand the nuances of this effect. Overall, these results highlight the complex interplay of inquisitiveness and attribute-matching in shaping individuals’ experiences and satisfaction with artwork.

b) Uniqueness Scale:

Anthropomorphism: The interaction between the uniqueness scale and attribute-matching showed a marginally significant difference ($F(1,16) = 3.79, p < .1$). To delve deeper, the simple main effects tests indicated that within the attribute-matching condition, participants who were categorized in the high uniqueness scale group exhibited a significantly elevated anthropomorphism score ($F(1,16) = 17.7, p < .01$). This finding underscores the importance of uniqueness in enhancing the perception of anthropomorphic qualities. Furthermore, when examining the high uniqueness scale group more closely, it was found that their anthropomorphism scores were also significantly higher when assessed under the attribute-matching condition ($F(1,16) = 7.15, p < .05$). Overall, these results highlight the complex interplay between uniqueness and attribute matching in shaping anthropomorphic perceptions.

Animacy: There was no significant difference in the interaction between the uniqueness scale and attribute-matching ($F(1,16) = 1.00, p = 0.33$). However, when examining the main effects, noteworthy findings emerged. Specifically, participants in the high uniqueness scale group exhibited a significantly elevated animacy score, as evidenced by the analysis ($F(1,16) = 6.98, p < .05$). This result indicates that higher perceived uniqueness is associated with a greater sense of animacy. Furthermore, the animacy score was also significantly higher in the attribute-matching condition ($F(1,16) = 4.15, p < .1$), suggesting that when attributes aligned effectively, participants perceived a stronger sense of animacy. These findings highlight the importance of both uniqueness and attribute matching in shaping perceptions of animacy.

Likability: There was no significant difference in the inter-

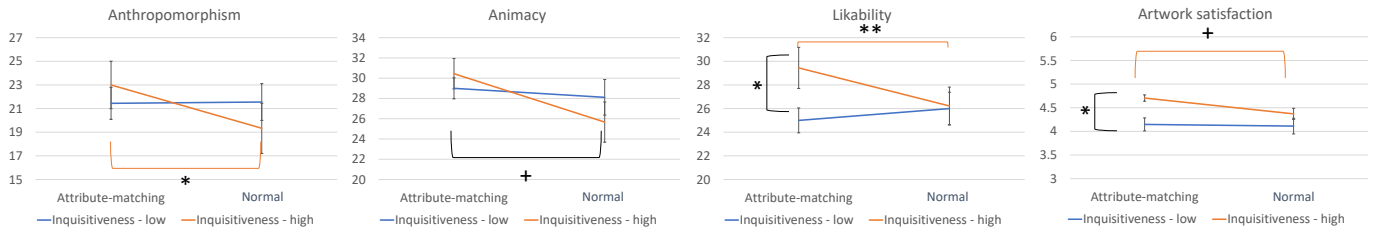


Figure 6. The results of the GodSpeed questionnaire and recommendation satisfaction related to inquisitiveness.

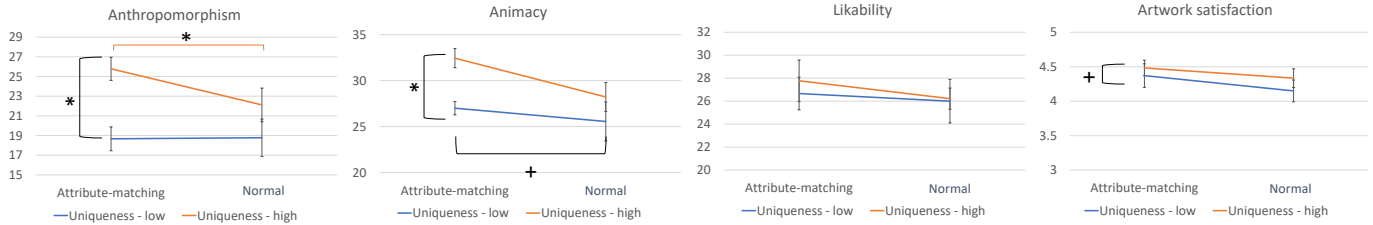


Figure 7. The results of the GodSpeed questionnaire and recommendation satisfaction related to uniqueness.

action between the uniqueness scale and attribute-matching ($F(1,16) = 0.23, p = 0.64$). This suggests that variations in the uniqueness scale did not meaningfully influence the relationship with attribute-matching in this particular study.

Artwork Satisfaction: In the artwork satisfaction score, there was no significant difference in the interaction between the uniqueness scale and attribute-matching ($F(1,16) = 0.14, p = 0.72$). In the main effects, the value was marginally significantly higher in the attribute-matching condition ($F(1,16) = 3.37, p < .1$). This marginal significance suggests that while the difference is not strong enough to be considered statistically conclusive, there is an observable tendency for individuals to report greater satisfaction when the attributes of the artwork align with their expectations or preferences.

These findings suggest that the alignment of attributes significantly affects the participants’ perceptions regarding both the agent and the recommendations provided. Specifically, individuals exhibiting elevated levels of inquisitiveness demonstrated a markedly more favorable impression of the agent whose conduct corresponded with their individual attributes. Furthermore, agents that matched attributes augmented participants’ perceptions of anthropomorphism and animacy, particularly among those scoring high on the uniqueness scale.

V. DISCUSSION

We investigated attribute-matching expression impacts on human-agent interactions. Findings indicate that agents employing attribute-matching strategies significantly enhance overall participant impressions and cultivate deeper social empathy. This outcome aligns with Media Equation Theory, which posits that individuals respond to computers as social actors [5]. Attribute matching establishes common ground, promoting similarity recognition crucial for relatable and engaging interaction [34].

Our investigation yielded significant insights into personality traits’ impacts on user-agent interactions. Participants

displaying high inquisitiveness evaluated attribute-matching agents more positively, enhancing their overall perception and increasing recommendation acceptance. Individuals scoring high on uniqueness reported heightened anthropomorphism and animacy when interacting with attribute-matching agents, forming more favorable impressions. These findings align with frameworks suggesting individuals develop stronger connections toward agents exhibiting similar characteristics [35].

Our study acknowledges limitations. Although relatively high satisfaction with recommendations was observed, analysis did not demonstrate statistically significant effects on actual behavioral changes. This lack of behavioral impact likely stems from the inherently passive task nature. In persuasive technology contexts [36], more engaging and active task designs could yield more insightful results. Future research should investigate how attribute-matching dynamics evolve with extended interactions, considering changing user preferences and expectations [29]. The uniform attribute-matching application underscores critical need for developing tailored strategies considering unique user characteristics and preferences.

VI. CONCLUSION AND FUTURE WORK

We conducted an empirical examination of agent attribute alignment impacts on human-agent interactions. Results indicate that attribute alignment functions as a fundamental foundation for favorable impression formation and agent rapport establishment. Individual traits, such as curiosity and distinctiveness, significantly influence users’ agent perceptions and recommendation satisfaction. These findings highlight promising opportunities for formulating tailored attribute alignment methodologies for improving agent-user rapport development. Ongoing progress in this domain is anticipated to promote more organic and substantive human-agent relationships, ultimately fostering a societal context where humans and agents coexist harmoniously.

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