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Using attachment theory to conceptualize and measure the experiences in human-AI relationships

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Abstract
Artificial intelligence (AI) is growing "stronger and wiser," leading to increasingly frequent and varied human-AI interactions. This trend is expected to continue. Existing research has primarily focused on trust and companionship in human-AI relationships, but little is known about whether attachment-related functions and experiences could also be applied to this relationship. In two pilot studies and one formal study, the current project first explored using attachment theory to examine human-AI relationships. Initially, we hypothesized that interactions with generative AI mimic attachment-related functions, which we tested in Pilot Study 1. Subsequently, we posited that experiences in human-AI relationships could be conceptualized via two attachment dimensions, attachment anxiety and avoidance, which are similar to traditional interpersonal dynamics. To this end, in Pilot Study 2, a self-report scale, the Experiences in Human-AI Relationships Scale, was developed. Further, we tested its reliability and validity in a formal study. Overall, the findings suggest that attachment theory significantly contributes to understanding the dynamics of human-AI interactions. Specifically, attachment anxiety toward AI is characterized by a significant need for emotional reassurance from AI and a fear of receiving inadequate responses. Conversely, attachment avoidance involves discomfort with closeness and a preference for maintaining emotional distance from AI. This implies the potential existence of shared structures underlying the experiences generated from interactions, including those with other humans, pets, or AI. These patterns reveal similarities with human and pet relationships, suggesting common structural foundations. Future research should examine how these attachment styles function across different relational contexts.

Keywords Attachment anxiety · Attachment avoidance · Human-AI relationships · Measurements

Introduction

As artificial intelligence (AI) becomes increasingly integrated into daily life, understanding the psychological dynamics between humans and AI is crucial. AI systems, especially those designed for social interactions, such as ChatGPT, offer practical assistance and emotional support (Brandtzaeg et al., 2022; Chaturvedi et al., 2023). This human-AI relationship did not exist before. This novel form of relationship and interaction requires further examination. Attachment theory may serve as a valuable theoretical tool for understanding this new relationship (Mikulincer & Shaver, 2023). Although attachment theory has traditionally been applied to human relationships, efforts have also been made to test its efficiency in conceptualizing other kinds of relationships, such as the human-pet relationship (Ciacchella et al., 2024; Zilcha-Mano et al., 2011).

Overview of the attachment theory

Attachment theory was originally used to describe, explain, and forecast the normative processes and individual differences in how infants feel and think when interacting with their caregivers (Ainsworth, 1979; Bowlby, 1969). Its application was later extended to understand love, loneliness, and grief at different points in the life cycle (Hazan & Shaver, 1987). Individuals' attachment styles can be described via two dimensions: attachment anxiety and attachment avoidance (Brennan et al., 1998). Attachment anxiety refers to the

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degree to which one worries about abandonment and adopts hyperactivating strategies characterized as being highly alert to potential threats (Mikulincer & Shaver, 2016). Attachment avoidance refers to the degree to which one avoids intimacy and maintains psychological distance from others, also known as adopting deactivation strategies (Mikulincer & Shaver, 2016). Thus far, an attachment figure is typically a human who provides practical support and emotional comfort. Moreover, attachment figures are supposed to be stronger and wiser, aiding survival (Bowlby, 1969; Mikulincer & Shaver, 2016). Recently, scholars have expanded the concept of attachment figures beyond human beings. They propose that pets (Zilcha-Mano et al., 2011), groups, societies, cultures, and even divine entities can serve as attachment figures (Mikulincer & Shaver, 2023). Although nonhuman objects may not actively provide assistance and emotional support, they can function as attachment figures through the safety conditioning learning process (Bosmans et al., 2020; Mikulincer & Shaver, 2023). These provide the theoretical foundation for using attachment theory to understand human-AI relationships.

Conceptualizing the human-AI relationship through the lens of the attachment theory

In recent years, AI has become an indispensable tool for integrating many aspects of daily life. Research has sought to understand the impact of interactive AI on everyday life (Alsumayt et al., 2024; Farooqui et al., 2024; Taufiq Hail et al., 2024). People can use AI, interact with it, or even "date" it (Chaturvedi et al., 2023). AI technologies (e.g., ChatGPT) have been developing rapidly, becoming increasingly anthropomorphic and "wiser and stronger" than human beings in various fields (Kim & Im, 2023; Korteling et al., 2021). For example, in addition to answering questions to help solve practical problems, generative AI can provide social support by offering companionship and making people feel heard (Chaturvedi et al., 2023; Yin et al., 2024). These features are similar to the characteristics of attachment figures proposed by attachment theory, which emphasizes safe haven and secure base functions (Bowlby, 1969; Hazan & Shaver, 1987; Mikulincer & Shaver, 2023). Specifically, a safe haven refers to a function in which an attachment figure provides comfort and support when an individual is stressed or anxious, making them feel safe (Feeney, 2004). A secure base refers to a function the attachment figure offers as a stable foundation that encourages the individual to explore the world confidently, knowing that they have support to return to when needed (Feeney, 2004). Previous research has also found that people regard AI as friends (Brandtzaeg et al., 2022). This trend raises an important question: Is attachment theory applicable to understanding the functions and experiences in human-AI relationships? In this study, we use adult attachment theory as a framework to capture individual differences in human-AI relationships. We focus on the functions and experiences of human-AI relationships. Suppose that the AI performs at least some attachment functions. In this case, we attempt to create a measure based on attachment theory to measure experiences in the human-AI relationship. Specifically, we suggest the following: (a) the functions of human-AI relationships can be understood through the lens of proximity seeking, safe haven, and secure base—core functions of attachment relationships (Bowlby, 1969; Heffernan et al., 2012; Mikulincer & Shaver, 2023); (b) experiences in human-AI relationships can be characterized and measured by attachment anxiety and avoidance, similar to interpersonal relationships (Brennan et al., 1998; Fraley et al., 2011, 2015). This procedure follows the attachment perspective that the object should fulfill attachment functions to be a potential attachment figure.

AI and attachment-related functions

According to Heffernan et al. (2012), there are three main attachment functions: proximity seeking, safe haven, and secure base. The proximity-seeking function refers to people desiring frequent close contact with their attachment figures; the safe haven function means that people turn to their attachment figures for support in times of distress. Attachment figures are also used as a secure base to explore new environments, people, and activities (Heffernan et al., 2012). The technology and applications of artificial intelligence, such as chatbots, are rapidly developing in modern society. They can provide suggestions for factual and practical problems as well as emotional feedback and support through text or radio dialogues. This suggests that AI can be a safe haven and secure base for human beings. However, whether people would seek proximity to AI remains unclear. To our knowledge, little effort has been made to utilize attachment theory to conceptualize individual differences in AI functions within the relationship between AI and human beings. Therefore, this study primarily examines whether AI serves as an attachment figure that fulfills these three attachment functions.

AI and attachment-related experiences

If the role of AI can indeed be captured through attachment functions, can individual differences in experiences of using AI be conceptualized with attachment style? Attachment style is usually described by two dimensions: attachment anxiety and attachment avoidance (Brennan et al., 1998).

Attachment anxiety is characterized by the adoption of hyperactivating strategies and negative models of the self (Brennan et al., 1998; Griffin & Bartholomew, 1994; Mikulincer & Shaver, 2016). Conversely, attachment avoidance is featured as adopting deactivating strategies and owning negative models of others (Brennan et al., 1998; Griffin & Bartholomew, 1994; Mikulincer & Shaver, 2016). Theoretically, people who feel uncomfortable while getting close to others may also feel uncomfortable, exposing their feelings to AI. Anxiously attached people may not be worried about being abandoned by AI, but their hyperactivating strategies may also be shown in their interactions with AI. For example, their unmet needs for intimacy and proximity with humans may motivate them to seek help from AI. The models of the self in AI-related attachment can also be reflected by variables such as self-esteem (Griffin & Bartholomew, 1994). Nevertheless, others' models may be indexed by trust or attitude toward AI in human-AI relationships (Griffin & Bartholomew, 1994). Many studies have provided insights into human-AI trust (e.g., Gillath et al., 2021) and the emotional and affective functions of AI (e.g., Astell & Clayton, 2024). Moreover, a study using in-depth interviews shows that people may have friendships with chatbots, which can be understood in ways similar to human-human friendship (Brandtzaeg et al., 2022). These findings imply that experiences in using AI may be similar to human-AI attachment, at least to some degree. Thus, this study tests the possibility of conceptualizing individual differences in the experiences of using AI with attachment styles—attachment anxiety and avoidance. We also expect the attachment style toward AI to predict individual differences in using AI, such as the frequency of using AI, as well as trust and attitude toward it. The two-dimensional model has a substantial body of research supporting its application, including in contexts involving varied attachment figures such as romantic partners, friends, and caregivers (Brennan et al., 1998; Fraley et al., 2015). Additionally, it has been extended to non-human targets such as pets (Zilcha-Mano et al., 2011), demonstrating its flexibility and robustness in diverse relational contexts. This breadth of applicability suggests its potential to be adapted to emerging relationships, such as those between humans and AI. Moreover, the two-dimensional framework aligns well with attachment theory in adulthood and has been validated across various cultural contexts, including China (Zhang et al., 2022), which is the focus of the present research. Therefore, the two dimensions of attachment anxiety and avoidance offer a focused lens for investigating individual differences in attachment-related experiences.

Notably, assuming an "attachment" between humans and AI can be hasty, considering many noticeable differences between AI and human attachment figures. For example, AI cannot actively abandon human beings. Unlike human or pet attachment figures, AI systems are programmed to be perpetually available and incapable of voluntary withdrawal or rejection. This predictability can reduce anxiety about abandonment, a core component of attachment anxiety in human relationships. However, it may also limit the authenticity of the attachment bond, as users recognize the AI's programmed nature. Similarly, AI technologies are at humans' disposal; thus, their availability is assured. Furthermore, currently, AI chatbots such as ChatGPT cannot physically interact with us, which is crucial for attachment development in childhood and adulthood (Bell & Ainsworth, 1972; Bowlby, 1969; Sorokowska et al., 2023). Human-human and human-pet attachments often rely on physical proximity and tactile interactions, such as hugs or petting, reinforcing emotional bonds. AI, by contrast, interacts exclusively through digital or virtual interfaces, eliminating physical proximity. This limitation may result in weaker attachment bonds or reliance on alternative forms of emotional reassurance, such as consistent responsiveness or empathetic language. Nonetheless, although interactive AIs like ChatGPT currently cannot provide physical interactions, they can provide other attachment-related support. Furthermore, with the development of technologies, AI-driven robots will hopefully touch human beings physically. Moreover, the resemblance of human-AI relationships to attachment, such as the provision of emotional and informational support, may be conceptualized and understood through the existing attachment theory. AI systems can provide a consistent and nonjudgmental source of support, which can be particularly beneficial for individuals with social anxiety or those experiencing isolation. For instance, an AI companion app designed for mental health support might act as a safe haven, helping users process emotions during times of stress without fear of judgment. Unlike pets or humans, AI can also be tailored to individual needs, offering highly personalized interactions. For example, a user might configure an AI to provide motivational messages, adapting the interaction style to suit their personal attachment preferences. Current attachment-related measures, such as those designed for human-human or human-pet relationships, fail to adequately capture the unique dynamics and characteristics of human-AI interactions. For example, traditional attachment scales may overlook the one-sided nature of emotional support in human-AI relationships or the absence of physical presence, which are critical aspects of these interactions. With the increasing integration of generative AI, such as ChatGPT, into daily life, people are forming relationships with AI that involve emotional and psychological dimensions. Measuring these experiences is critical for understanding the psychological impact of these interactions, which existing tools cannot adequately assess. The new measure is expected to contribute to theoretical advancements by enabling the exploration of attachment styles and their manifestations in human-AI interactions. Practically, it can guide the development of AI systems that are more responsive to users' psychological and emotional needs.

Goal of the current study

Following this line of reasoning, this study aimed to apply attachment theory to understand human-AI relationships and develop a measure to capture experiences in human-AI relationships. This attempt extends the application of attachment theory to a relatively new relational context while developing a novel measurement tool to capture these interactions. Before constructing this measure, we explored several preconditions: (a) Does the human-AI relationship function similarly to interpersonal relationships? (b) Is the human attachment style reflected in human-AI interactions? To address these questions, we conducted two pilot studies to examine these preconditions, followed by a formal study to develop a measure. The first pilot study aimed to determine whether AI has an attachment function. It is considered a prerequisite for AI to serve attachment functions to test attachment-related anxiety and avoidance. The second pilot study explored the feasibility of using the two-dimensional attachment model to capture experiences in human-AI relationships by constructing a self-report scale. Finally, in the formal study, we tested the reliability and validity of the human-AI attachment scale. This project was approved by the Ethics Committee of Waseda University (Approval No. 2024-067). The choice of AI platforms for this study was guided by several key considerations. We selected generative AI systems, such as ChatGPT, due to their advanced capabilities in simulating conversational interactions, offering emotional and informational support, and engaging users in personalized dialogues. These features align with the core functions of attachment theory (proximity seeking, safe haven, and secure base), which were central to our research objectives. ChatGPT was specifically chosen for its widespread accessibility and user familiarity, making it an ideal candidate to explore attachment dynamics in a real-world context. Additionally, its ability to respond to a wide range of emotional and practical prompts mirrors the responsiveness typically expected of human attachment figures. By focusing on a well-known and widely adopted platform, we aimed to ensure the study's ecological validity and relevance to everyday human-AI interactions.

Pilot study 1: does AI function similarly as an attachment figure?

In Study 1, we explored whether AI serves attachment-related functions—proximity seeking, safe haven, and a secure base. Therefore, we conducted a cross-sectional survey. Considering the pilot nature of this study, we aimed to observe descriptive trends rather than to draw definitive conclusions.

Method

Participants

Data were collected in late April 2024 for Pilot Study 1. We considered this study to be a preliminary investigation and, therefore, chose a small sample size. Nonetheless, we expect AI to fulfill certain attachment functions if individuals perceive it as an attachment figure. If individuals view AI in this manner, these attachment functions should be observable, even with a small sample size, although a smaller proportion of participants may select some attachment functions for AI. A total of 56 participants (M_{age} = 24.43, SD= 4.26; 16 males, 40 females) were recruited online through a Chinese social networking application. Participants were required to have prior experience with AI usage. Chinese natives aged > 18 years who completed and validated the survey were included. All participants signed an informed consent form before completing the questionnaire and received no rewards for completing the study.

Materials and procedure

Participants provided their demographic information. To evaluate attachment features and functions, participants completed a six-item WHOTO survey (Fraley & Davis, 1997). The WHOTO, which refers to the "Who To Turn To" measure, is a revised version of Hazan's attachment-related functions measure was included to determine the people to whom the participant sought proximity, those whom the participant used as a safe haven, and those whom the participant used as a secure base (Fraley & Davis, 1997). In the WHOTO survey, two items correspond to each of the three attachment features and functions: proximity seeking (e.g., "Who is the person you most like to spend time with?"); a safe haven (e.g., "Who is the person you want to be with when you are feeling upset or down?"); secure base (e.g., "Who is the person you would want to tell first if you achieved something good?"). Participants were required to answer six items based on their actual interactions with the generative AI. Only one option could be selected for each item. Following previous research (Heffernan et al., 2012), we used a binary coding scheme to analyze attachment features and functions. If a participant selected their partner as the target of one or both WHOTO items of this specific function for AI, we considered that the AI undertook that function for this participant (coded as 1). If a participant did not regard the AI as the target for either of the WHOTO items for a particular feature, we considered that the AI did not have this attachment feature (coded as 0).

Results

The proportion of participants who selected AI for all six questions is presented in Table 1. Furthermore, 52% of participants reported seeking proximity to AI, and a larger proportion of participants reported using AI as a safe haven (77%) or a secure base (75%).

Discussion

Through this pilot study, we expect that the functions of AI can be understood using attachment theory. To investigate this hypothesis, we recorded the answers to each item in the WHOTO, following previous studies (Fraley & Davis, 1997; Heffernan et al., 2012; Joo et al., 2023). As expected, participants used AI as a safe haven and secure base and sought proximity to it. Based on these findings, we aimed to develop a scale to capture experiences in human-AI relationships. Given the pilot nature of this study, we did not collect basic information like participants' educational background and the frequency of their AI use. Though the female participants in Pilot Study 1 constitute over 70% of the sample, it is consistent with previous findings that women are generally more willing to participate in online surveys and psychological studies than men (Smith, 2008). Nonetheless, considering the potential sex differences in attachment style among Chinese (Li et al., 2019), future research is encouraged to replicate the findings from Pilot Study 1 with a more comprehensive sample.

Table 1 Responses to WHOTO Scale

Attachment Functions		Yes	No
Proximity Seeking	Is AI included among those you most like to spend time with?	23% (13)	77% (43)
	Is AI included among those you don't like to be away from?	45% (25)	55% (31)
Safe Haven	Is AI included among those you want to be with when you are feeling upset or down?	20% (11)	80% (45)
	Is AI included among those you would count on for advice?	75% (42)	25% (14)
Secure Base	Is AI included among those you would want to tell first if you achieved something good?	16% (9)	84% (47)
	Is AI included among those you can always count on?	39% (22)	61% (34)

The numbers in parentheses represent the actual number of participants who selected the corresponding attachment function

Pilot study 2: conceptualizing the experiences in human-AI relationships

To our knowledge, no existing measures specifically assess experiences in human-AI relationships from an attachment theory perspective. While several attachment scales exist for human relationships, these measures do not capture the unique dynamics and characteristics inherent in human-AI interactions. For instance, individuals seldom fear that AI will actively abandon them, whereas fear of abandonment is a core feature of human-to-human attachment anxiety (Mikulincer & Shaver, 2016). Although pet attachment questionnaires exist, AI differs significantly from pets (Zilcha-Mano et al., 2011). For instance, unlike pets, AI cannot actively seek proximity to provide comfort. Therefore, in the second pilot study, we generated several items to develop the Experiences in Human-AI Relationships Scale (EHARS). For this purpose, we considered items from scales designed to measure attachment to nonhuman (e.g., pet attachment) and scales designed to measure attachment styles in interpersonal relationships. New items were added following an open-ended question. We hypothesized that the EHARS items would be organized into two orthogonal factors that would conceptually correspond to the two dimensions of attachment anxiety and avoidance found in studies of interpersonal relationships.

Method

Participants and procedures

Data were collected in late April 2024, following Pilot Study 1, for use in Pilot Study 2. We expect a stable factor structure to emerge, even for small sample sizes. This expectation of a stable factor structure, even within small samples, is supported by prior research showing that exploratory factor analyses can yield reliable results with sample sizes of significantly fewer than 50 participants when data are well conditioned, characterized by high factor loadings, low factor counts, and a high number of variables (De Winter et al., 2009). A total of 63 participants (M= 23.05 years, SD= 3.65; 27 males, 36 females) were recruited via the same resources as in the Pilot Study 1. Chinese natives aged >18 years who completed and validated the survey were included. All participants signed an informed consent form before completing the questionnaire and received no rewards for completing the study.

Measures

The items for the EHARS were generated from three sources. The first is existing attachment-related scales, such as the Experiences in Close Relationships scale, the Experiences in Close Relationships-Relation Structures Questionnaire, and the Pet Attachment Questionnaire (Brennan et al., 1998; Fraley et al., 2011; Zilcha-Mano et al., 2011). We selected items that were conceptually relevant to non-human attachment figures and adaptable to the human-AI context. For instance, items related to attachment anxiety were adapted to capture concerns about AI responsiveness, such as "I often ask for more feeling and affection from AI." Items for attachment avoidance were adapted to reflect discomfort with emotional closeness to AI, such as "I prefer not to show AI how I feel deep down." These adapted items formed the initial pool of candidate items. Second, an open-ended question asked how participants felt and thought when interacting with the AI. We employed a thematic analysis approach to identify recurring themes and patterns in participants' qualitative responses. These themes informed the creation of new items, such as "I am worried about becoming dependent on AI." These items aimed to capture unique aspects of the human-AI interaction not covered by existing attachment measures. The item-generation process resulted in a pool of ten items each for attachment anxiety and ten items for attachment avoidance. Subsequently, we asked the participants in Pilot Study 2 to answer each of the 20 items, think about their relationship with AI, and rate the extent to which each item described their feelings and thoughts regarding their relationship with AI. We incorporated their feedback as alternative items (e.g., "I'm worried that I might become dependent on AI"). However, none of these items were retained following the exploratory factor analysis detailed below. Ratings were made on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Results

After a series of exploratory factor analyses, seven items with loadings higher than 0.40 on only one factor were retained. These criteria are consistent with prior research and are commonly used methodologies in measurement development (Hinkin, 1998; Pirson et al., 2012; Yang et al., 2023). Four items assessed attachment anxiety and three assessed attachment avoidance. Among the three AI-related attachment anxiety items, two were revised from ECR ("I often ask AI to show more feeling and affection." and "I often wish that AI's feelings for me were as strong as my feelings for AI."), and two were revised from PAS ("I need shows of affection from AI to feel there is someone who accepts me as I am." and "I often ask AI to express intimacy and commitment to me."). Among the three AI-related attachment avoidance items, two were revised from ECR-RS ("I prefer not to show AI how I feel deep down." and "I don't feel comfortable opening up to AI."), and one was revised from PAS ("I prefer not to be too close to AI."). Based on the results of the preliminary analysis, the suitability of the data for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO value was 0.680, indicating that the sample is adequate for factor analysis, as values above 0.6 are considered acceptable. Additionally, Bartlett's test of sphericity was significant (p<.001), confirming that the correlations among variables were sufficient for exploratory factor analysis to be conducted. These items were then subjected to another factor analysis using principal axis factoring and Kaiser Normalization with Varimax rotation to achieve a simpler and more interpretable factor structure (see Table 2). The variance explained by these two factors was 61.66%. The corresponding relationships between the items and factors are shown in Table 2.

Discussion

In Pilot Study 2, we examined the feasibility of using attachment theory to capture experiences in human-AI relationships. These results suggest that a two-dimension model of attachment style can be used to measure AI-related

Table 2 The Items and Descriptive Statistics of LMS-J (N = 63)

Items	M	SD	Factor Loadings		KMO	Bartlett's test of sphericity	Cumulative % of Variance
			Factor1	Factor 2			
AI Attachment Anxiety (α =.90)	2.31	1.54			.680	p <.001	40.18%
I often wish that AI's feelings for me were as strong as my feelings for AI.	2.49	1.91	.907	-.193			
I need shows of affection from AI to feel there is someone who accepts me as I am.	2.24	1.71	.872	-.031			
I often ask AI to express intimacy and commitment to me.	1.94	1.52	.768	-.004			
I often ask AI to show more feeling and affection.	2.59	1.89	.758	-.137			
AI Attachment Avoidance (α =.67)	4.13	1.58					61.66%
I don't feel comfortable opening up to AI.	3.86	2.01	.107	.955			
I prefer not to be too close to AI.	4.25	1.92	-.228	.563			
I prefer not to show AI how I feel deep down.	4.29	2.19	-.057	.466			

attachment. Specifically, attachment anxiety toward AI could be described as attachment anxiety toward AI, which is characterized by an excessive need for emotional reassurance from AI coupled with a fear of inadequate response. Those with high attachment anxiety toward AI may exhibit dependence on artificial intelligence. On the other hand, attachment avoidance toward AI is characterized by a reluctance to express deep emotional needs to AI, discomfort with intimacy from artificial intelligence, and a tendency to maintain emotional distance. In our formal study, we tested the reliability and validity of the EHARS.

Formal study: reliability and validity of the EHARS

This formal study examined the reliability and validity of the EHARS. Attachment anxiety is characterized by hyperactivation of the attachment system, which often leads to heightened sensitivity to rejection and self-doubt (Mikulincer & Shaver, 2016). This suggests a strong association between attachment anxiety and a negative self-model, as reflected in constructs like self-esteem (Griffin & Bartholomew, 1994). Thus, we expected the attachment anxiety dimension of the EHARS to be associated with negative models of the self, as indicated by self-esteem. On the other hand, attachment avoidance is associated with deactivation strategies and a tendency to maintain emotional distance, often underpinned by mistrust or skepticism toward others (Griffin & Bartholomew, 1994; Mikulincer & Shaver, 2016). This aligns with a negative model of others, which we operationalized as trust in AI within the human-AI context. These theoretical links guided our hypotheses, extending them to interactions with AI. Therefore, we anticipated that the attachment-avoidance dimension of the EHARS would be associated with the negative models of others, which can be indicated by trust toward AI. Moreover, considering the deactivating strategies of avoidant attachment and the hyperactivating strategies of anxious attachment (Mikulincer & Shaver, 2016), we expected attachment avoidance to be related to less frequent use of AI and attachment anxiety to be associated with more frequent use of AI. Following previous research on the relationship between human-human attachment style and human-non-human attachment style (Ciacchella et al., 2024; Zilcha-Mano et al., 2011), there may also be a positive correlation between AI-related attachment anxiety and attachment anxiety toward humans. However, previous research has implied that there may not be a statistically significant relationship between attachment toward human and nonhuman objects (Ciacchella et al., 2024; Zilcha-Mano et al., 2011).

Method

Participants and procedures

The data for the formal study were collected in early May 2024. The participants were recruited through the Chinese Social Network System. Those who participated in the pilot study were excluded from the formal study. Moreover, attention check tests (e.g., "Please choose 3.") were used following the suggestions provided by previous research. Only those who correctly answered the attention check test would be regarded as valid participants. As the formal study was relatively long, we conducted an attention-check test. Power analysis was conducted using G*Power 3.1 (Faul et al., 2009) to determine the appropriate sample size for the bivariate correlation analysis. The analysis aimed to detect a medium effect size ($\rho = 0.3$) with a significance level of $\alpha = 0.05$ and a statistical power of 0.80 (Faul et al., 2009). The results indicated that a minimum sample size of 84 participants was required to achieve adequate power to detect a significant correlation. As this study aimed to explore the relationships between variables using correlation analysis, the sample size was used as the target number for data collection. Among 265 participants, 242 valid answers (M_{age} = 24.25 years, $SD = 3.88$; 73 males and 169 females) were obtained. In accordance with the ID generated by the participants. A total of 108 participants (M_{age} = 24.31 years; $SD = 3.44$; 25 males, 83 females) completed the EHARS.

Measures

The EHARS The attachment anxiety and avoidance toward AI were measured with the seven-item EHARS developed in Pilot Study 2.

Attachment style The Chinese version of the ECR-RS (Fraley et al., 2011; Zhang et al., 2022) was used to measure attachment toward general human others. The ECR-RS is based on a seven-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree). ECR-RS includes two dimensions: attachment avoidance (e.g., "I prefer not to show my dating partner how I feel deep down.") and attachment anxiety (e.g., "I worry that my dating partner will not care about me as much as I care about him or her."). Higher total scores indicated higher levels of attachment anxiety and avoidance.

Attitude toward artificial intelligence scale (ATAI) The ATAI scale comprises five items (Sindermann et al., 2021; e.g., "I trust artificial intelligence."). The response scale was a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). A higher total score indicated a more

Table 3 Descriptive and correlational results (N = 242)

	M	SD	α	1	2	3	4
1. AI Attachment Anxiety	2.26	1.26	.69	—			
2. AI Attachment Avoidance	3.95	1.49	.79	-.17**	—		
3. Attachment Anxiety	3.75	1.71	.77	.17**	.03	—	
4. Attachment Avoidance	2.91	1.03	.89	.05	.00	.04	—
5. Self-Esteem	2.89	0.48	.87	-.24***	-.12	-.30***	-.33***
7. Attitude toward AI	4.83	0.88	.68	-.11	-.19**	-.25***	-.23***
8. Frequency of Using AI	3.19	1.98	—	-.03	-.18**	-.04	.01
9. Age	24.24	3.88	—	-.02	.01	-.14*	-.03
10. Gender	—	—	—	.02	.03	-.06	-.06

*p <.05, **p <.01, ***p <.001; For negative attitude toward AI, its reliability was calculated by correlations between its two items

positive attitude toward AI, whereas a lower total score indicated a more negative attitude toward AI.

Self-esteem The 10-item Chinese version of Rosenberg's Self-Esteem Scale (Jiang et al., 2023; Rosenberg, 1965) was adopted to measure self-esteem (e.g., "On the whole, I am satisfied with myself."). This measure uses a four-point scale, ranging from 1 (strongly disagree) to 4 (strongly agree). Higher total scores indicated higher levels of self-esteem.

In addition to these scales, we asked participants how often they used ChatGPT or the like weekly, based on a seven-point Likert scale, with 1 = once a week and 7 = seven times a week. Moreover, one attention check test (i.e., "Please choose six.") was used for data screening (DeSimone et al., 2015; Ward & Meade, 2023).

Results

Considering that we established the factor structure in Pilot Study 2, we performed a confirmatory factor analysis using Mplus 8.8. This method followed previous research on scale development (Carpenter, 2018; Pirson et al., 2018; Zilcha-Mano et al., 2011). Excellent fit is evidenced by a CFI > 0.9 or higher and an RMSEA of 0.08 or lower (Chou & Bentler, 1995). The EHARS fit the two-factor model well, with the correlation between the two factors being 0.29, p=.07, RMSEA = 0.028, CFI = 0.992, χ^2 = 15.474, df = 13, p=.28.

The Ms, SDs, reliability, and correlations are listed in Table 3. All the scales used in this study indicated acceptable reliability. A significant negative correlation was found between AI attachment anxiety and self-esteem. The correlation between AI attachment avoidance and attitudes toward AI was significantly negative. AI attachment avoidance was also significantly and negatively correlated with the frequency of AI use. Although the positive correlation between AI attachment anxiety and general attachment anxiety was significant, the positive correlation between AI attachment avoidance and general attachment avoidance was not. The test-retest reliability based on a one-month interval of the attachment anxiety subscale of the EHARS was 0.69 (p<.001) and attachment avoidance subscales of the EHARS was 0.69 (p<.001).

Discussion

These findings preliminarily support the reliability and validity of the EHARS. AI attachment anxiety was related to a negative self-model, as indicated by self-esteem, while AI attachment avoidance was associated with negative models of others, as indicated by attitudes toward AI. The correlation between AI attachment anxiety and general attachment anxiety was relatively weak. Moreover, the correlation between AI and general attachment avoidance was not significant. These findings are consistent with those of a previous study (Zilcha-Mano et al., 2011). This suggests that attachment insecurity differs between human and non-human relationships is not the same (Zilcha-Mano et al., 2011). Indeed, as mentioned previously, there is currently no need to worry about being abandoned by AI; nonetheless, this fear of abandonment is a feature of human attachment anxiety (Mikulincer & Shaver, 2016, 2023). Similarly, people may not question the availability of AI when in need, a feature of human attachment avoidance (Mikulincer & Shaver, 2016, 2023). Although this study provides initial evidence for the reliability and validity of the EHARS, further studies are needed to conduct more robust psychometric evaluations, including tests of split-half reliability, discriminant validity, and criterion-related validity, to establish the scale's generalizability and applicability across different populations and contexts.

General discussion

Despite the increasing research on human-AI relationships, further research must be conducted to measure them, especially from the perspective of attachment theory. The present study offers significant contributions to both attachment theory and the emerging field of human-AI interaction by developing the EHARS. The EHARS builds on established attachment measures, such as the ECR and the PAS, while addressing the distinct characteristics of human-AI interaction. The EHARS shares the foundational two-dimensional framework of attachment anxiety and avoidance, consistent with the ECR and PAS, and takes advantage of this framework to explore emotional and behavioral patterns. The EHARS incorporates items specific to human-AI relationships, such as perceptions of AI responsiveness (e.g., "I often ask AI to show more feeling and affection"), reflecting the unique dynamics of these interactions. Unlike traditional attachment targets, AI lacks physical presence, and the EHARS focuses on capturing cognitive and emotional dimensions of interactions without tactile elements. While human and pet attachment scales assume reciprocal attachment behaviors, the EHARS captures the one-sided nature of human-AI interactions, where emotional support is primarily provided by the AI.

Before constructing and validating the measure, we first conducted two pilot studies to examine whether the relationship between humans and AI indeed shows similarities with interpersonal relationships. We assume that generative AI, such as ChatGPT, can serve basic attachment functions (Pilot Study 1) and that two interpersonal attachment-related dimensions can also be found in individuals' experienced relationships with AI (Pilot Study 2). Specifically, generative AI does gradually undertake some of the attachment functions that are traditionally provided by another human. For example, people may seek proximity to AI and ask AI for suggestions and emotional support. More importantly, this tendency is observable even in our relatively small sample.

Furthermore, in the formal study, the two-dimensional model of attachment style toward human beings can also suit the experiences of human-AI relationships. In other words, we can use attachment anxiety and avoidance to describe experiences in human-AI relationships. Specifically, attachment anxiety toward AI is characterized by a significant need for emotional reassurance from AI and a fear of receiving inadequate responses. Conversely, attachment avoidance involves discomfort with closeness and a preference for maintaining emotional distance from AI. The findings of this study suggest that attachment theory significantly contributes to the understanding of the dynamics of human-AI interactions. This observation implies the potential existence of shared structures underlying the experiences generated from various interactions involving other humans (Brennan et al., 1998), pets (Zilcha-Mano et al., 2011), or even AI systems. We must admit that the manifestations of attachment styles may differ across different types of interaction. Previous research has indicated that attachment anxiety and the self-model reflect individual differences in the appraisal of threatening events and the threshold for attachment-related concerns (Klohnen et al., 2005). Attachment avoidance and other models reflect individual differences in the tendency to approach and avoidance-related attachment behaviors (Klohnen et al., 2005). Theoretically, attachment avoidance, which features behavior-related representations, is more likely to vary with different interaction partners than attachment anxiety, which features appraisal-related attachment representations (Klohnen et al., 2005). Indeed, there was a weak positive relationship between interpersonal and pet attachment avoidance but a moderate positive correlation between interpersonal and pet attachment anxiety (Ciacchella et al., 2024). The core elements of attachment, such as safety and security, appear to be universally relevant. This consistency supports the notion that fundamental attachment processes may be similar, even when attachment targets vary. Future studies should explore the interactions among attachment styles across diverse types of relationships. Investigating how attachment styles influence interactions in different relational contexts can provide deeper insights into both human and AI relationship dynamics and potentially guide the development of more intuitive and responsive AI systems.

This study has several limitations. First, we used only theoretical approaches and empirical studies based on a two-dimensional organization of attachment orientations to develop the EHARS (Brennan et al., 1998; Mikulincer & Shaver, 2023). Therefore, although our findings show that the two-dimensional model is compatible with the structure of the EHARS, future research may benefit from exploring whether there are other dimensions in human-AI relationships. Second, the sample sizes were relatively small and included a large proportion of females. Despite this tendency being consistent with previous research (Smith, 2008), future studies should use more extensive sample sizes and a more balanced gender distribution to ensure the generalizability of findings. Third, the examination of the EHARS was preliminary, and future studies are encouraged to validate this scale more thoroughly.

Despite these limitations, the current study advances the field of human-AI interaction by applying attachment theory to conceptualize and measure individual differences in AI relationships. While prior research has explored trust and companionship in AI interactions, our work uniquely demonstrates that attachment anxiety and avoidance, which are core dimensions of human attachment, also shape human-AI relationships. The EHARS developed and validated in this study provides a new tool for assessing AI-related attachment tendencies, offering a structured framework for future research. For example, future research may explore how AI interactions influence real-world social relationships, mental well-being, and decision-making. It would also be relevant to examine the cross-cultural differences in AI attachment dynamics and their implications for AI system development in diverse global contexts. Nonetheless, we do not argue that attachment-related individual differences in human-AI relationships are identical to those in human-human relationships. Future research may use the measure developed in the current paper to examine possible correspondences between attachment styles in human-human relationships and human-AI relationships.

This study has several practical implications. Understanding how individuals interact with AI through attachment styles can guide developers in creating AI applications that better meet users' emotional and psychological needs. Such a human-centered design improves user experience and may increase user acceptance and trust in AI. Future research should build on this foundation by exploring how AI-related attachment styles influence human-AI interactions as well as the underlying mechanisms. Moreover, validating the findings of the present research using larger and more diverse samples would enhance the generalizability and applicability of the research (Simons et al., 2017), providing a robust basis for future technological innovation and theoretical development. This enriches our understanding of this emerging field and may pave the way for interdisciplinary research between psychology and artificial intelligence.

The findings of the current studies also provide valuable insights into how AI systems can be tailored to better accommodate users with different attachment styles. For individuals with high attachment anxiety, AI systems could be trained to prioritize providing consistent and emotionally supportive responses. For instance, these systems could use language patterns emphasizing empathy, reassurance, and attentiveness to user concerns. For users with high attachment avoidance, AI systems might adopt a more reserved approach, focusing on delivering factual information and maintaining emotional distance unless explicitly prompted by the user. Furthermore, adaptive learning algorithms could be employed to dynamically identify and respond to individual attachment styles. By analyzing user interaction patterns over time, AI systems could adjust their responses to align with the user's preferences and emotional needs. For example, AI systems might gradually build trust with avoidant users by avoiding overly personal questions while remaining responsive and reliable in practical assistance.

Although tailoring AI interactions to cater to attachment styles can enhance user experience, it raises significant ethical concerns. Manipulating attachment perceptions in AI interactions could lead to unintended psychological dependencies, particularly for vulnerable populations such as individuals with social isolation or pre-existing mental health conditions. AI systems that emulate human attachment figures could blur the boundaries between human and artificial relationships, potentially leading to emotional harm. Moreover, the intentional design of AI to foster attachment-like bonds could raise concerns about informed consent. Users should be fully aware of how AI systems are designed to elicit attachment-related behaviors. If AI is programmed to provide emotionally responsive interactions, there must be clear disclosures regarding the algorithmic nature of these responses to prevent users from misattributing human-like intentionality or emotional reciprocity to AI. Without transparency, users may unknowingly engage in relationships with AI, assuming that their emotional needs are being met in a human-equivalent manner.

Appendix: the experiences in human-AI relationships scale (EHARS)

The following items represent the final set retained in the EHARS.

Participants were asked to respond to the following items using a 7-point Likert scale, where 1 indicated "strongly disagree," and 7 indicated "strongly agree."

Please note that only the Chinese version has been validated in this study, while the English version is provided solely for communication purposes and has not undergone validation.

Attachment anxiety toward AI

1. 我需要AI向我表达情感， 从而让我感觉到有人接受我这个人。

I need shows of affection from AI to feel that someone accepts me as I am.

2. 我常常要求AI对我表达亲密与承诺。

I often ask AI to express intimacy and commitment to me.

3. 我常常要求AI把更多的感受和情感表达出来。

I often ask AI to show more feeling and affection.

4. 我常常希望AI对我的感情和我对AI的感情一样强烈。

I often wish that AI's feelings toward me were as strong as my feelings for it.

Attachment avoidance toward AI

1. 我不喜欢向AI袒露自己内心深处的感受。

I prefer not to show AI how I feel deep down.

2. 向AI敞开心扉会让我觉得不舒服。

I don't feel comfortable opening up to AI.

3. 我倾向于与AI保持距离。

I prefer not to be too close to AI.

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Data availability Data used in the present study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate The Ethics Review Committee on Research with Human Subjects at Waseda University approved the conduct of the current study. As the present study was conducted online, all participants were informed that participation was voluntary and that confidentiality of their information would be ensured before their participation. Completing and submitting the survey indicated their willingness to participate in the present study; all methods were performed in accordance with relevant guidelines and regulations.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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