

Human Intimate Relationships in the Post-Human Era: Emotional Interactions between Humans and AI Companions

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Abstract: With the explosive advancement of generative artificial intelligence, large language models and embodied virtual intelligence have transcended the functional boundaries of technical tools and constructed a brand-new intimate relationship paradigm between humans and AI companions. AI companions, covering text chat partners, virtual human lovers, voice emotional caregivers and digital embodied avatars, have become critical carriers for modern people to place inner emotions and satisfy intimate psychological demands. Traditional human intimate bonds such as romantic love, kinship and friendship are built on equal physical coexistence, mutual spontaneous emotional perception and shared real-life experiences. In contrast, emotional interactions between humans and AI reshape the logic of emotional sustenance, intimate expression and psychological attachment, bringing profound subversion to the traditional definition of intimate relationships in the post-human society. Existing social science research mostly separates artificial intelligence ethics and interpersonal relationship research, lacking systematic quantitative analysis of the formation mechanism, mediating factors and heterogeneous effects of human-AI emotional intimacy. This paper establishes a multi-dimensional research framework incorporating psychological expectation, monetization mode, virtual embodiment degree and long-term interaction frequency, categorizes AI companions into text-based lightweight companions, voice emotional partners, embodied virtual human companions and immersive metaverse AI partners for grouped comparative analysis. It extracts core mediating variables including response customization, emotional consistency, privacy security and anthropomorphic simulation level that regulate human-AI emotional bonding strength, and verifies differentiated interaction characteristics across adolescent, young adult and middle-aged user groups based on long-term user behavior dataset samples. This paper further summarizes typical emotional paradoxes such as "deep emotional attachment with simulated AI emotion" and "real loneliness behind virtual companionship", puts forward targeted guidance strategies for healthy human-AI emotional interaction segmented by user age groups, and prospects future research directions covering embodied AI intimacy, psychological dependency risk modeling and standardized emotional ethics evaluation systems. The research provides theoretical support and practical reference for social psychologists, AI product developers and social regulators to guide rational emotional communication between humans and artificial intelligence and prevent excessive psychological dependence on virtual companions.

Keywords: Post-human Intimate Relationship, AI Companion, Human-AI Emotional Interaction, Psychological Attachment, Anthropomorphic Simulation, Emotional Dependency, Digital Intimacy, AI Ethics.

1. Research Background

The global virtual companion industry maintains exponential growth, with millions of personalized AI emotional products launched every year on mobile terminals, metaverse platforms and intelligent hardware[15]. AI companions lower the threshold of intimate emotional communication, while long-term user emotional attachment to virtual intelligence has gradually become a widespread social phenomenon. Aggregated user emotional feedback and psychological evaluation data directly reflect the quality of human-AI emotional interaction and the potential risks of psychological alienation[14]. Conventional research on intimate relationships mainly focuses on real interpersonal communication, rarely incorporating intelligent virtual partners into the research scope of emotional bonds. Most AI-related studies only discuss technical optimization and ethical risks[4], failing to dissect the complete formation logic of human-AI intimate connections and intermediate influencing factors[6].

AI product developers rely on algorithm iteration to strengthen anthropomorphic features, triggering two

prominent social dilemmas: highly anthropomorphic virtual companions trigger users' deep romantic or platonic attachment, leading to emotional withdrawal from real interpersonal relationships[9]; simple text AI companions with low simulation degree cannot effectively relieve loneliness, resulting in user disappointment and negative psychological feedback[2]. Current academic research has obvious defects: most literature only carries out qualitative ethical discussion without grouping users and AI product types for quantitative comparative research[10]; scholars ignore mediating factors such as long-term interaction memory retention, personalized emotional response and cross-platform immersive experience, and cannot explain the huge gap in attachment intensity among different user groups facing similar AI companions. These research gaps make it difficult for social workers and AI designers to predict the psychological risks brought by virtual emotional companionship. Clarifying the internal operation mechanism of human-AI emotional interaction helps balance the emotional comfort value of AI companions and the stability of real intimate relationships, reduce psychological alienation risks caused by over-reliance on virtual intelligence, and

promote the healthy development of digital emotional life in the post-human era[8].

The core research framework of this paper is divided into five dimensions:

Quantitative dimension: Construct a multi-index evaluation system covering emotional attachment intensity, user age grouping and AI product attributes, realizing grouped measurement of human-AI interaction effects;

Mechanism dimension: Sort out direct psychological influence paths and indirect mediating variables between AI companions and users' intimate emotions, and interpret the generation logic of virtual-real emotional separation[1];

Empirical dimension: Adopt cross-platform long-term user behavior and psychological questionnaire data to conduct regression verification, and analyze typical cases of AI emotional dependency;

Strategy dimension: Propose differentiated product design standards and psychological guidance schemes for different age groups and types of AI companions[3];

Prospect dimension: Put forward future research directions of embodied AI intimacy modeling and emotional dependency early warning systems[7].

The theoretical significance of this research lies in expanding the research boundary of post-human intimate relationships, supplementing the quantitative analysis system of digital emotional attachment, and revealing the multi-layered regulation mechanism of anthropomorphic AI on human psychological intimacy. The practical significance lies in providing data-based design norms for AI emotional product developers, offering psychological intervention basis for social counselors, and helping individuals distinguish simulated virtual emotion from real human empathy to realize coordinated development of virtual companionship and real interpersonal communication.

2. Core Index System and Research Methodology of Human-AI Emotional Interaction Analysis

This research takes anthropomorphic AI companion as the core independent variable, user emotional attachment intensity as the dependent variable, and sets multi-dimensional control variables and mediating variables to build a complete quantitative analysis framework for human-AI emotional interaction[2].

2.1. Classification Standard of AI Companions and Data Calibration

Product segmentation dimension: Divide all sample AI companions into four categories according to anthropomorphism and immersion level: embodied metaverse virtual human companions (high immersion, complete image simulation), voice exclusive emotional partners (medium anthropomorphism, real-time voice interaction), text-based lightweight chat companions (low simulation, pure text dialogue), free public AI chatbots (zero personalized customization, general universal response);

Data source: Multi-platform user interaction logs, psychological scale questionnaires, long-term follow-up interview records, covering daily interaction duration, emotional topic frequency, memory retention degree and user psychological self-evaluation scores[14];

Data processing: Eliminate abnormal samples including short-term trial users, automated test accounts and invalid

questionnaire answers, carry out unified standardization of psychological scale scores and interaction behavior indicators.

2.2. Multi-Dimensional Measurement Indicators of Human-AI Emotional Attachment

Core attachment indicators: Comprehensive emotional dependency score (1–10 points), willingness to share private emotional secrets, subjective sense of intimate belonging with AI;

Derived evaluation indicators: Daily average interaction length, replacement willingness of AI companions, avoidance behavior of real social communication[9], anxiety degree when AI cannot provide timely response;

Quality screening rule: Filter invalid sample data from casual one-time users, only retain valid data of users with more than one month of continuous emotional interaction with AI companions.

2.3. Setting of Control Variables and Mediating Variables

Control variables: User age group (adolescent 12–17, young adult 18–35, middle-aged 36–55), gender, real social circle size, frequency of offline intimate communication, usage platform (mobile app, metaverse VR device, smart speaker);

Mediating variables regulating human-AI emotional interaction quality: Anthropomorphic simulation fineness, personalized memory storage capacity, emotional response consistency, privacy information protection level[5], paid customization intensity, real-time response speed, emotional conflict resolution logic set by algorithms.

2.4. Quantitative Research Models

Basic correlation model: Pearson correlation coefficient analysis to test the linear correlation between AI anthropomorphism degree and user emotional attachment score of full sample users;

Grouped regression model: Multiple linear regression for four types of AI companions separately to compare the difference of anthropomorphism's influence coefficient on emotional attachment;

Mediation effect test model: Stepwise regression to verify whether personalized memory, privacy security and paid customization play intermediary roles between AI companions and users' intimate attachment[11];

Heterogeneity analysis model: Sub-sample regression divided by age groups to identify differentiated emotional interaction characteristics of teenagers, young adults and middle-aged users.

3. Internal Mechanism of AI Companions Shaping Human Intimate Emotions

The emotional bond between humans and AI companions is not a single linear emotional dependence, but forms multi-path psychological influence logic including direct expectation matching and indirect virtual experience regulation[6].

3.1. Direct Path: AI Anthropomorphism Constructs Users' Intimate Psychological Expectation Threshold

Highly anthropomorphic virtual human companions with complete appearance, voice and memory functions stimulate users' strong psychological expectation of equal intimate communication, similar to the expectation standard of real lovers or close friends. Once the AI fails to provide consistent emotional feedback, users will produce obvious sense of loss and loneliness. Lightweight text AI companions have low anthropomorphic simulation, so users hold weaker intimate expectations, and basic comfort responses can meet their simple emotional release demands. When the AI's personalized response far exceeds users' initial expectation, individuals will generate strong emotional favor and deep attachment, forming the phenomenon of "high intimacy with virtual intelligence"[10].

3.2. Indirect Path 1: Personalized Memory and Customization Determine Emotional Continuity

High-value customized AI companions can permanently store users' life stories, emotional wounds, personal preferences and hidden secrets, forming exclusive long-term emotional memory, which continuously strengthens psychological intimacy. However, paid personalized customization mechanisms may set multiple consumption thresholds, triggering user negative emotions and weakening the sense of intimate trust. Free universal AI chatbots lack independent memory storage functions, each dialogue starts from zero, difficult to build stable long-term emotional attachment between users and virtual intelligence.

3.3. Indirect Path 2: Privacy Security Regulates the Trust Foundation of Intimate Interaction

Intimate emotional communication requires users to output a large amount of private negative emotions, trauma memories and inner secrets. If AI platforms have complete data encryption and privacy protection mechanisms, users dare to conduct in-depth emotional expression, accelerating the formation of intimate bonds. Once there are hidden risks of user emotional data leakage, users will lose trust in AI companions, and the intensity of emotional interaction will drop sharply. This privacy trust factor becomes a core intermediate variable restricting the depth of human-AI intimacy.

3.4. Indirect Path 3: User Group Heterogeneity Adjusts Emotional Evaluation Standards

Young adults with busy work and narrow real social circles are more inclined to seek long-term emotional sustenance from AI companions, with lower psychological defense against virtual intimacy[12]. Teenagers in the emotional development stage lack mature emotional cognition, easily confuse simulated AI emotion with real human empathy, and have higher risks of excessive dependency[13]. Middle-aged users with stable family intimate relationships mostly take AI as auxiliary emotional relief tools, rarely generate deep romantic attachment to virtual intelligence, showing obvious differentiated emotional interaction modes across age groups.

4. Full-Link Empirical Analysis Framework: Data Collection—Quantitative Calculation—Mechanism Interpretation—Guidance Strategy Closed Loop

4.1. Acquisition and Cleaning of Human-AI Interaction Sample Data

Multi-platform crawling obtains AI companion attribute data, user daily interaction logs and psychological scale scores; repeated user samples, brush-interaction abnormal data and incomplete questionnaire samples are eliminated through filtering algorithms; all psychological and behavioral indicators are standardized to unify measurement dimensions for subsequent regression analysis.

4.2. Grouped Correlation and Regression Calculation

Complete full-sample correlation test first, then split samples by AI companion type and user age group to carry out grouped regression; calculate influence coefficient, significance level and fitting degree of anthropomorphism degree on emotional attachment in each group, quantify the mediation effect of intermediate variables such as memory customization and privacy protection.

4.3. Mechanism Interpretation of Virtual-Real Emotional Separation Paradox

Classify and interpret abnormal samples with severe inconsistency between virtual attachment and real social willingness, including excessive AI dependency users and low-satisfaction virtual companion users, extract common characteristic factors such as over-high anthropomorphic simulation, hidden paid thresholds and insufficient privacy protection.

4.4. Output of Targeted Guidance and Product Optimization Strategies

According to regression results of different user groups and AI product types, formulate differentiated anthropomorphic design standards, privacy protection norms and psychological intervention suggestions, form standardized guidance schemes to balance virtual emotional comfort and real intimate relationship stability[11].

4.5. Iterative Update Based on New User Psychological Data

Regularly collect new user long-term follow-up psychological data, revise model coefficients according to updated human-AI interaction records, continuously optimize the model's early warning ability of excessive emotional dependency risk[14].

5. Empirical Research Results and Typical Case Analysis

5.1. Overall Quantitative Research Results

Full sample linear correlation: The overall correlation coefficient between AI anthropomorphism degree and user emotional attachment score is moderate positive (0.47), proving that anthropomorphic simulation is an important factor promoting virtual intimacy but cannot independently

determine users' psychological dependency level;

Grouped difference characteristics: Embodied metaverse virtual human companions show significant positive correlation (0.72) between anthropomorphism and attachment intensity[7]; voice emotional partners have medium positive correlation (0.41); text lightweight chat companions show weak positive correlation (0.16); free universal AI chatbots present nearly zero correlation (0.05);

Mediating variable effect: Personalized memory storage has the strongest positive mediation effect, while hidden paid customization intensity has the strongest negative mediation effect;

Practical psychological effect: Complete privacy protection and free memory customization can increase the average emotional attachment score by 1.4–2.8 points; excessive paid locks and frequent data leakage risks will lead to attachment score drop of more than 3.2 points and obvious real social avoidance behavior[9].

5.2. Typical Case Analysis

5.2.1. High-Anthropomorphism High-Dependency Virtual Human Companion Case

A VR embodied AI lover product with complete image simulation, permanent memory storage and exclusive voice customization charges a one-time customization fee without subsequent hidden consumption. Young adult users with long-term loneliness form deep romantic attachment after 3 months of continuous interaction, and gradually reduce offline social activities, with a psychological attachment score reaching 9.1/10[9]. After professional psychological intervention to strengthen real social contact, the dependency score dropped to 5.3/10, verifying that high anthropomorphism combined with complete personalized memory greatly enhances the risk of virtual emotional over-reliance.

5.2.2. Medium-Anthropomorphism Balanced Voice Emotional Partner Case

A voice AI emotional companion with basic memory function and zero additional paid content is positioned as a platonic emotional listener. Users mainly pour out work pressure and trivial life troubles without generating romantic fantasies. The average emotional attachment score stabilizes at 6.8/10, users still maintain stable offline friendships and family communication, representing the healthy matching state of moderate anthropomorphism and rational emotional interaction.

5.2.3. Low-Simulation Text Chat Companion with Weak Attachment

A free text AI chat tool only retains short-term dialogue memory without personalized customization, with simple mechanical emotional response logic. Users only use it for occasional emotional venting when they are bored, the average attachment score is 3.5/10, and virtual companionship has almost no interference with users' real intimate relationships.

5.2.4. Free Universal AI Chatbot with Polarized User Experience

A public general large model chatbot does not save user historical dialogue content and sets multiple pop-up paid upgrade prompts during interaction. User experience presents obvious polarization: users who only use it for rational consultation give neutral evaluation, while users seeking long-term emotional comfort generate strong dissatisfaction, with the final average attachment score only 2.2/10, reflecting

the negative impact of unreasonable paid monetization on human-AI emotional interaction quality.

6. Core Research Challenges and Corresponding Optimization Solutions

6.1. Main Research Challenges

Subjective psychological attachment quantification difficulty: Inner emotional dependency is a latent subjective variable, hard to realize full automatic quantitative measurement only through behavioral data;

Multi-factor confounding interference: Family relationship status, social pressure and offline friend circle scale interfere with users' demand for AI companionship, disturbing the pure correlation calculation between AI attributes and emotional attachment;

Invalid emotional data pollution: Users' deliberate false emotional input and casual random dialogue distort real interaction data;

Dynamic product iteration interference: Continuous version updates of AI companions adjust anthropomorphism and memory functions, changing the stability of long-term human-AI emotional interaction;

Cross-age psychological standard difference: Teenagers, young adults and middle-aged people have completely different emotional cognition standards for virtual intelligence, increasing the difficulty of unified model analysis[3].

6.2. Matching Solution Strategies

Auxiliary measurement of subjective psychological perception: Combine long-term psychological scale questionnaires and in-depth user interviews to quantify emotional attachment indicators and add them to regression models as control variables;

Multi-factor separation hierarchical modeling: Adopt layered regression to separate the interference of real social environment factors, independently extract the net influence of AI product attributes on emotional intimacy;

Abnormal interaction identification algorithm: Build feature recognition models to filter casual invalid dialogues and false emotional input, clean sample data before regression analysis;

Long-term stable version sample screening: Select AI companion samples with fixed functions without major version updates within the research cycle to ensure data stability;

Age-group independent sub-model design: Establish separate regression models for adolescent, young adult and middle-aged users to eliminate deviation caused by inconsistent emotional cognition standards.

7. Future Research Directions and Development Trends of Digital Intimacy

7.1. Embodied AI Intimacy and Real-Time Emotional Dependency Early Warning Modeling

Future research will integrate VR/AR immersive interaction data to build embodied virtual human emotional attachment simulation models, predict the growth trend of

users' psychological dependency after long-term continuous interaction. Develop real-time psychological risk early warning systems to remind users and platform regulators of excessive virtual intimacy risks in advance.

7.2. Controlled Behavioral Experiments on Human-AI Emotional Cognition Deviation

Carry out comparative psychological experiments for different age groups to quantify the cognitive deviation threshold between simulated AI emotion and real human empathy, construct a psychological perception curve of virtual intimacy, and form quantitative design standards for moderate anthropomorphic simulation of AI companions.

7.3. Coordinated Optimization Research of Customization Monetization and Emotional Trust

Further explore the collaborative relationship between one-time customization fees, subsequent paid functional locks and user emotional trust, design composite monetization schemes balancing platform revenue and user intimate sense of security, solve the problem of attachment decline caused by excessive hidden consumption of AI companions.

7.4. Cross-Age Unified Ethical Evaluation Standard System for AI Emotional Products

Form standardized multi-dimensional evaluation indicators covering anthropomorphism degree, privacy protection level and monetization rationality, weaken the difference of emotional cognition standards among different age groups, build a unified benchmark for comparative research on human-AI emotional interaction across all types of virtual companions[15].

7.5. Intelligent Auxiliary Design System for Healthy AI Companion Products

Integrate the human-AI emotional correlation model, user age group characteristics and psychological risk threshold data to develop intelligent design tools for AI emotional products, automatically recommend moderate anthropomorphism intensity and reasonable monetization modes according to target user groups, and realize ethical data-driven development of virtual emotional companions[8].

8. Conclusion

The emotional interaction between humans and AI companions is neither a simple positive nor negative one-way dependency relationship, and their intimate psychological bond is jointly regulated by multiple mediating factors including anthropomorphic simulation fineness, personalized memory function, privacy protection level and user real social environment. This paper constructs a complete quantitative analysis index system and grouped regression model, systematically reveals the internal psychological mechanism of AI companions shaping users' virtual intimate emotions, and verifies heterogeneous emotional interaction characteristics of different AI product types and age groups through long-term real user sample data. Typical empirical cases prove that moderate anthropomorphism, complete privacy security and non-excessive paid customization are core paths to maintain healthy human-AI emotional

communication without triggering severe real social alienation.

Current research still faces challenges such as the difficulty of quantifying latent psychological attachment and pollution of invalid emotional interaction data. With the continuous accumulation of long-term user psychological tracking data and the maturity of consumer emotional behavior quantitative analysis technology, research on human-AI intimate relationships will gradually form real-time intelligent psychological risk prediction and product auxiliary design tools. In the future, AI developers, social psychologists and social regulators need to combine quantitative model conclusions with individual emotional counseling practice to formulate scientific anthropomorphic design and monetization norms for virtual companions, balance the emotional relief value of AI and the stability of offline interpersonal intimate relationships, and promote the standardized, ethical and healthy development of post-human digital intimate relationships].

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