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# Factors shaping synthetic relationships in human-AI collaboration: a protocol for a systematic review and meta-analysis

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**ADMINISTRATIVE INFORMATION**

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**Conflicts of interest -** None declared.

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**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 17 December 2025 and was last updated on 17 December 2025.

## INTRODUCTION

**Review question / Objective** The aim of this systematic review and meta-analysis is to identify the technological, psychological, and social factors that motivate synthetic relationships and long-term orientation toward human-AI collaboration. Specifically, this review will address two main questions: (1) Which AI technical factors, human perceptual factors, and social factors contribute to motivating synthetic relationships toward human-AI collaboration? (2) How do the effects of these factors vary across different stages of collaboration?

**Rationale** Artificial intelligence (AI) is increasingly becoming embedded in daily life and work, shifting the human-AI dynamic from simple tool use to long-term synthetic relationships. While extensive research has focused on the initial adoption and acceptance of AI technologies (e.g., based on utility and ease of use), there is a critical lack of comprehensive evidence regarding the factors that motivate sustained, long-term collaboration. As AI agents acquire greater autonomy and social presence, it is essential to understand not just why people start using AI, but what drives them to maintain and deepen these relationships over time. Current literature is fragmented regarding which technological, psychological, and social factors facilitate this transition from acceptance to symbiosis. Therefore, this study is necessary to systematically synthesize empirical evidence, identify the key determinants of long-term orientation toward human-AI collaboration, and explore how these factors vary across different stages of the relationship. This will provide a theoretical framework for future human-AI symbiosis.

**Condition being studied** The review will investigate human-AI collaboration, specifically focusing on the formation of synthetic relationships where humans and AI agents coordinate over extended periods. It will address the shift from initial acceptance to long-term symbiosis. Key aspects include the psychological conditions (e.g., trust, empathy) and social factors (e.g., social

norms) necessary for sustaining these relationships beyond one-off interactions.

## METHODS

**Search strategy** We plan to conduct a systematic literature search restricted to publications from January 2020 to the present. The search strategy will employ a combination of Boolean operators (AND/OR) to link terms across three core dimensions: (1) Human participants (e.g., 'user', 'consumer', 'employee'); (2) AI technologies (e.g., 'artificial intelligence', 'chatbot', 'LLM', 'robot'); and (3) Interactional outcomes (e.g., 'collaboration', 'continuance intention', 'relationship', 'engagement'). Specific search strings will be adapted for each database interface.

**Participant or population** The review will include human participants of any age, gender, or ethnicity who are involved in collaboration with AI. The population covers diverse application fields, including business, healthcare, education, and daily life scenarios. Studies involving only simulated users, non-human subjects, or interactions where the human role is absent will be excluded.

**Intervention** The review will evaluate the interaction with a broad range of Artificial Intelligence (AI) technologies. The intervention includes, but is not limited to: (1) LLM; (2) AI systems; (3) Virtual agents; and (4) Embodied agents. The focus is on the collaborative interaction between humans and these diverse AI forms.

**Comparator** This review primarily investigates the factors influencing human-AI collaboration. Therefore, a traditional comparator is not applicable.

**Study designs to be included** The review will include empirical, quantitative study designs. Specifically, we plan to include randomized controlled trials (RCTs), quasi-experimental studies, and observational studies (including cross-sectional and longitudinal surveys). To be eligible for inclusion, the study must report primary data and provide sufficient statistical details to enable the calculation of effect sizes. Qualitative studies, theoretical reviews, and non-empirical commentaries will be excluded.

**Eligibility criteria** Studies will be screened and selected based on the following criteria:
Inclusion Criteria:
1. Study Design: The review will include empirical, quantitative studies (e.g., surveys, experiments) that provide primary data.
2. Research Topic: Studies must focus on human-AI collaboration.
3. Intervention: The study must focus on AI technologies, including LLM, AI systems, virtual agents, or embodied agents. We do not strictly require direct behavioral interaction; eligible studies include both those involving direct interaction and those utilizing survey-based methods (e.g., questionnaires) to assess users' perceptions, attitudes, or intentions toward AI without a mandatory real-time interactive task.
4. Data Requirements: To be eligible for meta-analysis, studies must report sufficient statistical information to allow for the calculation of effect sizes (e.g., correlation coefficients, t-tests, F-tests, or regression coefficients).
5. Language: English language publications only.
Exclusion Criteria:
1. Qualitative studies, theoretical reviews, opinion pieces, and editorials.
2. Studies lacking sufficient statistical data to compute effect sizes.

**Information sources** Electronic databases to be searched include: Web of Science, Scopus, PubMed, and the ACM Digital Library. We also intend to screen reference lists of included studies to identify additional relevant literature.

**Main outcome(s)** The primary outcome of interest is the synthetic relationship toward human-AI collaboration, which reflects the long-term orientation of users towards AI agents. We intend to categorize this outcome into two main components based on theoretical frameworks: "Attitudes and Continuance Intentions," which includes users' stated willingness to sustain engagement, loyalty, and positive attitudes towards future use; and "Behavioral Engagement Patterns," which refers to the actual frequency and depth of repeated interactions with AI systems over time. These outcomes will be measured at the point of data collection in the included primary studies, specifically looking for studies that assess post-adoption or sustained usage phases. We will extract quantitative data (e.g., correlation coefficients r, F-values, or t-values) that measure the association between motivational antecedents and these collaboration outcomes, and we plan to synthesize these using correlation coefficients (r) as the primary effect size metric.

**Data management** Search results will be imported into reference management software (e.g., EndNote) to remove duplicates. Two independent

reviewers will screen titles and abstracts, followed by a full-text review against the eligibility criteria. Disagreements regarding study inclusion will be resolved through discussion or consultation with a third reviewer. Data extraction will be conducted using a standardized data extraction form (e.g., using Microsoft Excel). We will extract information regarding study characteristics (author, year, country), independent variable, dependent variable, sample size, AI types, application field, and statistical effect sizes (e.g., Pearson's r). All statistical syntheses will be recorded and analyzed using the R statistical environment (meta package).

**Quality assessment / Risk of bias analysis** We will assess the robustness and reliability of the included studies through statistical diagnostics:
Outlier Analysis: We plan to conduct outlier analyses to assess the extent to which individual studies might disproportionately influence the overall results. We will use the leave-one-out diagnostic method. If any study is identified as an outlier, we will examine its influence on the pooled effect size.
Publication Bias: To assess the risk of publication bias across the synthesized studies, we plan to use Funnel plots for visual inspection. Additionally, we will perform Egger's regression test and Begg's rank correlation test to statistically evaluate asymmetry. If significant bias is detected, the trim-and-fill method will be applied to adjust the effect sizes.

**Strategy of data synthesis** We anticipate considerable heterogeneity among the included studies due to differences in study designs and measurement instruments. Therefore, all meta-analyses will be conducted using a random-effects model to account for variance attributable to both sampling error and genuine variability between studies.
Effect Measures: The correlation coefficient (r) will be used as the primary effect size metric. To ensure statistical stability during pooling, we will first transform these correlations using Fisher's Z transformation. After synthesis, the pooled results will be back-transformed to correlation coefficients for interpretation and reporting.
Heterogeneity Assessment: We will assess statistical heterogeneity using the Q test (significance level at $p < 0.05$) and quantify it using the I^2 statistic and the estimated between-study variance (tau^2).
Analysis Software: All statistical syntheses will be implemented using the R statistical environment, specifically utilizing the meta package. We also plan to conduct sensitivity analyses to evaluate the robustness of the pooled effects across different estimators (e.g., comparing Restricted Maximum Likelihood against other random-effects methods).

**Subgroup analysis** To explore potential sources of heterogeneity, we plan to conduct subgroup analyses if sufficient data are available. We intend to categorize studies based on the following broad characteristics:
AI type: AI Characteristics: We will examine whether the form and embodiment of the AI agent (e.g., virtual agents versus physical robots) moderate the strength of the relationship.
Application field: We plan to investigate if the impact of motivational factors varies across different application domains or industries where the human-AI collaboration takes place.
Subgroups will be defined based on the data extracted from the included studies.

**Sensitivity analysis** To evaluate the robustness of our meta-analytic results, we plan to conduct sensitivity analyses to determine if the findings are sensitive to specific methodological decisions or data characteristics. Specifically, we intend to compare the results obtained from the primary random-effects model with those from a fixed-effect model to assess whether the choice of the statistical model significantly influences the pooled effect sizes. Additionally, we plan to assess the influence of potential outliers by performing analyses, such as excluding extreme values or using leave-one-out diagnostics, to verify if the overall results remain consistent when influential studies or extreme data points are removed.

**Country(ies) involved** China.

**Other relevant information**
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