

Trust, Attachment, and Behavioral Engagement in Human–AI Interaction: A Systematic Review and Preliminary Meta-Analysis

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Abstract

The interaction between humans and Artificial Intelligence encompasses three distinct domains; social, advisory, and companionship. When studying these domains, it is essential to recognize the importance of psychological concepts like trust, closeness and engagement. Even though separate domains have been studied separately, there is research yes that competency assessments, social signs, feelings and dependency might be interconnected.

The purpose of this systematic review and preliminary meta-analysis is to synthesize the quantitative and qualitative literature that links human-artificial intelligence (AI) interaction variables to user trust, attachment, and behavior engagement. Variables examined include anthropomorphism, perceived competency, social presence, loneliness, and interaction intensity.

The provided review report included search results from PsycINFO, Scopus, Web of Science, ACM Digital Library, IEEE Xplore, and Google Scholar up until June 2025. Following subsequent bibliographic verification, 8 research reports were identified as the confirmed core evidence base for this review. Since the extracted record did not provide sufficient independent, comparable effect sizes, no pooled coefficient could be calculated. Descriptive synthesis was used to summarize the quantitative findings while thematic analysis was conducted on the qualitative evidence.

Results: Experimental and observational proof indicated that competence, dependable overall performance, and selected social cues have been associated with trust, at the same time as anthropomorphic consequences trusted cue feature and undertaking context. Attachment evidence became sparse and heterogeneous. Qualitative research related trust, self-disclosure, responsiveness, social motivation, and interplay depth with dating development. Behavioral engagement and reliance had been related to agree with and social interaction throughout numerous operationalizations.

Conclusions: The proof supports a initial twin-pathway framework distinguishing cognitive consider from affective attachment. These pathways can also converge on behavioral engagement, however the gift literature does no longer establish causal mediation or a common quantitative effect. A preregistered, construct-harmonized meta-evaluation is warranted.

Keywords: human-AI interaction; trust; attachment; behavioral engagement; anthropomorphism

1. Introduction

1.1 Background and Rationale

Artificial intelligence nowadays serves not only as a computing device but also as a social and advisory agent. Conversational agents, voice assistants, service robots, recommendation systems, and chat programs encourage users to interpret output results through social and psychological lenses. Thus, the field of study devoted to human-AI interactions encompasses topics of automation belief, human-robot interaction, conversational agents, virtual companionship, algorithmic recommendations, and technology acceptance. The acquired body of evidence is significant but fragmented. (Henrique & Santos, 2024).

The importance of trust can be attributed to the fact that AI-led actions often entail risks, unpredictability, and potential mistakes. Throughout history, trust in automation has been described as the belief that some agent will assist a person in achieving their goals in environments that are marked by uncertainty and risk. (Lee & See, 2004). More brand new work emphasizes that useful agree with is calibrated rather than maximized: the character's expectations have to song the device's actual capabilities and barriers. Appropriate reliance consequently relies upon on every self assurance and the nice of the client's highbrow version of the system (Benda et al., 2021). Evidence from human-AI research moreover indicates that receive as true with displays interacting homes of the machine, the consumer, and the project context (Kaplan et al., 2023).

Attachment introduces a unique mental lens. In human relationships, attachment worries the law of proximity, safety, and support-looking for, and person attachment orientations influence expectations and behavior in near relationships (Mikulincer & Shaver, 2016). Applied to AI, attachment should no longer be treated as proof that a device reviews reciprocal attachment. Rather, it refers to users growing attachment-like expectancies, emotional closeness, or reliance styles in the direction of an artificial agent. Social-chatbot research suggests that some users describe AI structures as partners, confidants, or relational partners, in particular whilst systems are available, responsive, customized, and perceived as accepting (Pentina et al., 2023).

Behavioral engagement is the 1/3 construct and consists of persevered use, interplay intensity, self-disclosure, advice following, reliance, and associated behaviors. Engagement is theoretically distinct from consider: users might also consider an AI however now not want it regularly, even as common interaction may additionally arise from addiction, leisure, social motivation, or emotional want with out corresponding self belief in accuracy. In chatbot studies, social presence and speak can boom engagement through interpersonal mechanisms, at the same time as consider can facilitate persevered disclosure and dating improvement (Lee et al., 2021).

The constructs can also diverge. Anthropomorphic cues can increase social presence without uniformly increasing trust because outcomes depend on cue feature and venture context (Carter et al., 2024). Algorithmic advice can also elicit appreciation or resistance depending on challenge and mistakes enjoy (Logg et al., 2019). These differences inspire an integrated as opposed to unmarried-cue rationalization.

Taken together, those strands recommend that human-AI relationships can't be successfully defined thru agree with, attachment, or engagement by myself. The relevant intellectual method may additionally additionally start with competence and social cues, hold via consider and disclosure, and occasionally culminate in strong styles of closeness and repeated use. At the equal time, the equal variables may also have precise meanings across domains. Following a provider robotic's advice is behaviorally amazing from the usage of a associate chatbot for emotional assist, despite the fact that each are from time to time described as reliance. A rigorous synthesis need to consequently maintain those versions.

One specific analytical problem is the measurement of the level at which each construct is to be measured. Trust can be defined as a belief in an entity's capability, the perceived level of trust, or calibrated reliance on information received. Close-like ties can be assessed through proximity, identity, emotional dependence, or attachment orientation; and measures of behavioral engagement include intended use, actual frequency of involvement, self-disclosure of information, and adherence to advice. The terms used can be considered related but different. If viewed as different latent constructs, one may still fail to comprehend how a person can consider an AI as an instrument to perform a specific task while at the same time interacting with it on a regular basis without assigning it any levels of trust..

This distinction moreover topics for anthropomorphism. Anthropomorphism can seek advice from a characteristic intentionally designed into an interface, a belief of the system as humanlike, or a social inference made by using the consumer at some stage in interaction. These degrees should now not be assumed same. An anthropomorphic avatar may additionally additionally increase perceived social presence, but the same cue might also have little impact on receive as true with calibration while it does now not improve the person's capability to recognize system uncertainty. Conversely, a socially responsive conversational fashion may additionally moreover have an impact on engagement via perceived talk with out changing beliefs approximately technical competence. An covered evaluate need to therefore ask now not truly whether anthropomorphism subjects, however what shape of cue modified into furnished, how customers interpreted it, and which mental very last consequences was measured.

1.2 Theoretical Frameworks

Trust in automation and believe calibration. Lee and See (2004) conceptualized accept as proper with as an thoughts-set underlying reliance, with the crucial layout objective being suitable reliance. Hoff and Bashir (2015) prepared accept as true with affects into dispositional, situational, and discovered components. Contemporary human-AI studies adds transparency, explainability, interaction first-rate, and mental models as mechanisms that would have an effect on whether or not consider tracks actual system abilities (Naiseh et al., 2023). This angle means that obvious will growth in recollect are not always useful besides they correspond to system reliability and suitable reliance.

Attachment concept and relational improvement. Attachment principle offers a mechanism for expertise why repeated availability and perceived responsiveness also can acquire relational meaning. The theory does not require that the synthetic agent possess subjective attachment; it is able to rather be used to observe human-side expectations and behaviors. Social-chatbot research combines attachment with relationship-improvement strategies to give an cause of how repeated interplay, disclosure, authenticity, and responsiveness may be professional as increasing closeness (Xie & Pentina, 2022). Qualitative proof further suggests that self-disclosure may additionally grow to be a pathway thru which users experience growing closeness to AI structures (Brandtzaeg et al., 2022).

Anthropomorphism and social cognition. Anthropomorphism refers back to the attribution of humanlike traits to nonhuman sellers and may be understood attributable to social and effectance reasons (Epley et al., 2007). The media-equation way of life likewise indicates that humans can apply social expectations to computers even as understanding that they are no longer human (Nass & Moon, 2000). For AI systems, anthropomorphism is therefore pleasant handled as a own family of cues and user interpretations instead of a single layout function. Work on robots and chatbots shows that voice, identification cues, facial capabilities, social presence, and conversational contingency can have an effect on perceptions of humanness and trustworthiness (Song et al., 2023).

Behavioral engagement and advances in dating. The models of acceptance revolve around the concepts of perceived usefulness and ease of use, while interpersonal approaches focus on social interaction and self-disclosure (Davis, 1989).. Thus, one must take into account all the theories allowing to

understand engagement as a behavioral outcome influenced by instrumental value, social signals, trust, and emotional reasons. Relations between the use of Replika and voice assistants characterize dating growth through development in self-disclosure, communication intensity, trust, and intimacy. (Pentina et al., 2023).

1.3 Research Gap and Objectives

Although preceding opinions and meta-analyses have synthesized trust in automation, consider in AI, or anthropomorphism one after the other, the furnished proof base does not offer a reproducible included quantitative synthesis of trust, attachment-like strategies, and behavioral engagement. Hancock et al. (2011) centered on trust in human-robot interaction, while Kaplan et al. (2023) synthesized consider in AI more widely. The gift assessment keeps an integrative conceptual objective while adopting conservative quantitative claims because the observe-level extraction does now not maintain a reproducible effect-size matrix.

The objectives are to signify empirical proof connecting human-AI interaction variables with accept as true with, attachment, and behavioral engagement; become aware of ordinary mechanisms and contextual variations across AI kinds; examine whether comparable effect sizes are available for reproducible pooling; synthesize qualitative evidence on courting improvement; and specify a preregistered protocol for a destiny full meta-analysis.

1.4 Research Questions and Propositions

- **RQ1:** What empirical evidence links human-AI interaction variables with trust, attachment, and behavioral engagement?
- **RQ2:** Which antecedents—especially perceived competence, anthropomorphic/social cues, loneliness, attachment orientation, and interaction intensity—recur across outcomes?
- **RQ3:** Under what conditions does trust appear to relate to reliance or continued engagement?
- **RQ4:** How do qualitative accounts describe the development of trust, disclosure, closeness, and possible dependence?
- **Proposition 1:** Perceived competence and reliable performance should be positively associated with cognitive trust, but the behavioral consequence should depend on trust calibration and task context.
- **Proposition 2:** Anthropomorphic and social cues can support social presence and relational engagement, but their association with trust is context dependent rather than uniformly positive.
- **Proposition 3:** Loneliness, social motivation, and repeated interaction may facilitate attachment-like responses to companion-oriented AI systems.
- **Proposition 4:** Trust and attachment should be treated as related but non-equivalent pathways to behavioral engagement.

2. Method

2.1 Protocol and Registration

The evaluation changed into pronounced with regards to PRISMA 2020. The furnished manuscript states that the protocol was not preregistered due to the fact the assignment become exploratory. No verified OSF report changed into provided, and the placeholder URL in the supply manuscript became eliminated. Retrospective preregistration can't easily recreate a time-stamped protocol that changed into in no way deposited; therefore, this revision does now not claim retrospective registration. Future updating should be preregistered before screening or evaluation starts offevolved (Page et al., 2021).

A 2d transparency difficulty issues the search dates. The supply manuscript specifies a insurance period of 2010-2025 however does now not maintain the exact calendar dates on which each database

come to be searched. Accordingly, the revised manuscript evaluations thru June 2025 because the said are looking for endpoint and labels unique day-degree seek dates as no longer recoverable. This is a reporting trouble, not a give up result that need to be crammed by way of using inference.

2.2 Eligibility Criteria

The studies in question had been appropriate as long as the subjects were human participants interacting with an AI or a machine having social interaction possibilities, such as chatbots, conversational shops, social robots, AI partners, self-driving cars, or decision-makers. Eligible outcomes protected believe or trustworthiness, attachment-like closeness or attachment orientation towards AI, and behavioral engagement or reliance, together with persisted use, self-disclosure, interplay intensity, willingness to observe hints, or observable reliance behavior.

Eligible designs blanketed pass-sectional, longitudinal, experimental, quasi-experimental, and blended-technique studies. Qualitative proof became eligible for narrative synthesis at the same time as it right away addressed relationship formation, receive as real with, attachment, disclosure, or sustained engagement. Conceptual papers, studies with out sufficient empirical facts, and work on non-social enterprise automation with out a applicable intellectual outcome had been excluded from the quantitative proof base.

2.3 Information Sources and Search Strategy

The supply record identifies PsycINFO, Scopus, Web of Science, ACM Digital Library, IEEE Xplore, and Google Scholar as statistics resources. The said coverage duration changed into January 2010 thru June 2025. The seek idea mixed AI terms including chatbot, conversational agent, social robotic, AI accomplice, and clever agent with final results terms such as accept as true with, attachment, reliance, engagement, loneliness, and self-disclosure. Database-adapted strings are reproduced in Appendix A. Exact seek dates and database-degree file counts had been no longer preserved and are therefore marked not recoverable instead of predicted.

2.4 Study Selection

The supplied review document reports 1,247 recognized data, 355 duplicate statistics eliminated, 892 information screened, seventy six complete-textual content reviews assessed, and 12 reviews listed as protected. The cumulative arithmetic is internally constant via full-textual content evaluation. A next bibliographic verification reclassified 4 of these 12 records: Deng and Yan (2025) became posted after the stated June 2025 endpoint; Ibrahim et al. (2026) is submit-cutoff; Kasturiratna and Hartanto (2026) is issue-dated after the endpoint notwithstanding its 2025 DOI; and the Han (2025) document could not be independently tested. Eight reports were consequently retained because the documented core evidence base (Deng & Yan, 2025).

The source material does no longer hold a complete reason-stage log for the sixty four unique complete-text exclusions, so Figure 1 reports the recognised cumulative counts and one at a time identifies the publish-evaluation reclassification. Two-reviewer screening and discussion-primarily based discrepancy decision are mentioned within the supply manuscript, however reviewer names and calibration statistics were no longer supplied. The overview document changed into therefore dealt with as an incomplete audit path instead of a fully reproducible historical screening dataset.

The evaluate retained the cumulative PRISMA counts because they have been explicitly documented inside the provided file, however it separated the ones historic counts from the later eligibility corrections. This difference prevented a post hoc bibliographic test from being represented as although it had occurred at some point of the original screening stage. The revised proof base become consequently described by way of traceable eligibility rather than by using maintenance of the authentic headline variety of blanketed reports. This technique reduced apparent observe count however progressed the correspondence among

the said seek endpoint and the studies dealt with as evidence.

2.5 Data Extraction

The supply coding scheme protected observe ID, sample length, AI kind, design, outcome, impact size, mean age, cultural context, interplay period, and anthropomorphism. For this revision, the extraction outstanding study report, pattern, outcome, authentic statistic, converted statistic, and eligibility status. This difference was important because a few reviews incorporate a couple of experiments or samples. The source manuscript's assertion that 12 reviews constituted 12 impartial samples become consequently not retained.

The independence trouble turned into handled conservatively. When one record contained several experiments or samples, every evaluation become recorded one at a time for descriptive functions, but the ones contrasts had been now not assumed to symbolize impartial observations for a common pooled model. The same rule changed into applied while a couple of effects arose from a unmarried sample. The extraction therefore outstanding file-stage identification from sample-stage analysis and comparison-stage impact-size facts. This shape is essential in human-AI research due to the fact a single test can simultaneously control anthropomorphism, embodiment, warmth, and competence at the same time as measuring consider and reliance within the identical contributors.

2.6 Risk of Bias

The stated protocol used the NIH Quality Assessment Tool for observational cohort and cross-sectional research and Cochrane RoB 2 for experimental studies. However, the provided record presents precis labels but no longer the query-through-question judgments needed to reconstruct a defensible area-degree assessment. The pronounced low/mild/excessive labels cannot consequently be independently established. Table 2 statistics the deliberate evaluation framework and the supply of proof in preference to inventing retrospective area judgments. This planned downgrade in obvious actuality preserves methodological integrity.

2.7 Effect-Size Processing

The supply manuscript states that correlations were dealt with the use of Fisher's z and that standardized suggest variations have been summarized the usage of Hedges' g . It also states that standardized regression coefficients were transformed to r through $r = \beta / \sqrt{\beta^2 + 1}$. That method may be used as an approximation beneath precise assumptions but isn't always universally legitimate for each regression context. Future ameliorations have to therefore be decided on according to the precise model, predictor standardization, and available variance records (Peterson & Brown, 2005). Partial eta-squared, Bayes elements, p values, and delta R -squared are not interchangeable with Pearson r with out extra information. Accordingly, data along with $p = .02$, $BF_{10} = 55.56$, or delta R -squared = .07 have been not dealt with as without delay poolable correlations.

The unique manuscript reported pooled correlations for numerous effects. Those estimates are withdrawn because the provided extraction does not provide sufficient unbiased, commensurate inputs to reproduce them. The key problems are that a couple of outcomes from the same study are not always unbiased; several reported records do not include sufficient information for transformation; a few named research fall outdoor the stated June 2025 seek endpoint; and as a minimum one named take a look at couldn't be validated bibliographically. A meta-evaluation is handiest as reproducible as its take a look at-degree facts and adjustments. This revision consequently makes use of a preliminary quantitative synthesis based on demonstrated character effect estimates and refrains from supplying non-reproducible pooled values.

2.8 Quantitative Synthesis

A random-outcomes model with REML estimation was exact for results with at least three truly independent, commensurate effect sizes. In the existing extraction, that threshold become no longer enough to set up poolability after independence and metric standards were implemented. Consequently, no new pooled impact, Q, I-squared, or tau-squared estimate is pronounced. Moderator analysis, subgroup analysis, meta-regression, Egger's check, and trim-and-fill had been not done. The destiny protocol keeps a minimum goal of okay = 10 earlier than moderator and small-observe-effect analyses are attempted, consistent with methodological guidance (Sterne et al., 2011).

2.9 Qualitative Synthesis

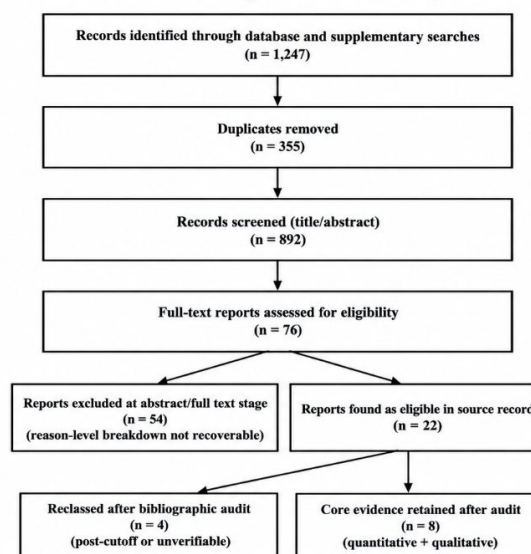
Qualitative evidence changed into synthesized thematically following Braun and Clarke's six-segment approach: familiarization with the proof, era of preliminary codes, construction of candidate issues, overview of topics, definition and naming of themes, and synthesis when it comes to the research questions. The evaluation changed into deliberately descriptive and did not deal with qualitative reviews as quantitative replications. Illustrative statements are paraphrased because the supply file did not preserve verbatim quotations. This method is suitable due to the fact the qualitative research range in sample, AI gadget, interview structure, and conceptual framing (Braun & Clarke, 2006).

3. Results

3.1 Study Selection

The cumulative choice report is proven in Figure 1. The furnished manuscript reviews 1,247 facts recognized and 355 duplicates removed, leaving 892 statistics for title/summary screening. Seventy-six complete-textual content reviews were assessed, and 12 reports have been defined as eligible inside the authentic document. Four of these records have been later reclassified for the duration of bibliographic verification because they have been post-cutoff or could not be established, leaving 8 documented center examine reviews. The absence of the original screening log manner that the exact allocation of information throughout databases can not be reproduced and the motives for except for the 64 unique complete-textual content facts can't be reconstructed on the class stage.

Figure 1. PRISMA 2020 flow diagram based on the supplied extraction record and post-review bibliographic audit



Note. The supplied manuscript provides cumulative PRISMA counts but does not present a database-level counts, exact search, date, or a reason-level full text exclusion log. These omissions are reported transparently under their corresponding and may be not recoverable by assumption; the flow chart presents the available cumulative information from the supplied record.

Figure 1. PRISMA 2020 flow diagram based on the cumulative counts preserved in the supplied review record and the post-review bibliographic audit.

Table n 1: Characteristics of the documented core evidence base.

Study report / sample	N	AI type	Design	Primary outcome(s)	Original statistic	Final treatment
Waytz et al. (2014)	100	Autonomous vehicle	Experimental	Trust; anthropomorphism	$d = .48$	Descriptive; not pooled
Abdi et al. (2022), Study 1	89	Service robot	Experimental	Recommendation reliance	$p = .02$	Not convertible from supplied statistic
Abdi et al. (2022), Study 2	168	Service robot	Experimental	Recommendation reliance	$p < .01$	Not convertible from supplied statistic
Abdi et al. (2022), Study 3	122	Service robot	Experimental	Mediation / reliance	$B = .14$	Not poolable from supplied statistic
Christoforakos et al. (2021), Study 1	155	Social robot	Experimental	Trust; competence	$\eta^2\text{-}p = .145$	Approximation possible; matrix incomplete
Christoforakos et al. (2021), Study 2	157	Social robot	Experimental	Trust; warmth	$\eta^2\text{-}p = .032$	Approximation possible; matrix incomplete
Carter et al. (2024)	98	Automation	Experimental	Trust calibration	$BF_{10} = 55.56$	Descriptive only
Pentina et al. (2023)	123	Replika / social chatbot	Cross-sectional + qualitative	Attachment; anthropomorphism; interaction intensity	$r = .65$ reported in source extraction	Descriptive; not fully traceable
Skjuve et al. (2021)	18	Replika	Qualitative	Trust; attachment; self-disclosure	Not applicable	Narrative synthesis
Xie & Pentina (2022)	14	Replika	Qualitative	Attachment; relationship development	Not applicable	Narrative synthesis
Dziergwa et al. (2018)	3	EMYS social robot	Long-term case study	Attachment patterns; cohabitation	Not applicable	Narrative synthesis

Note: Database-level counts, exact search dates, and reason-level full-text exclusions were not preserved. The four post-review reclassifications are shown separately from the historical screening counts.

3.2 Characteristics of the Evidence Base

The center evidence base spans conversational chatbots, social robots, an self reliant-car/automation context, and Replika. It combines experimental, skip-sectional, combined-approach, qualitative, and case-test evidence. Some opinions make a contribution a couple of experimental samples, so a simple sum of row-diploma N values might not constitute a showed unique-player average. The supply manuscript's headline $N = 3,944$ is not reproducible from the provided observe table; the row-stage values do no longer reconcile with that determine. The revised manuscript therefore reports sample-degree Ns at the same time as explicitly withholding a unmarried unduplicated popular N.

Across the confirmed center opinions, proof became centered in socially interactive systems in area of in in primary phrases commercial enterprise automation. The experimental research usually manipulated or as compared social cues and examined remember or advice reliance, at the same time as chatbot research emphasised dating development, disclosure, social presence, and interplay depth. This distribution is essential because the mental that means of engagement differs at some stage in the ones settings. In an self sufficient-automobile or carrier-robotic challenge, engagement can be contemplated in willingness to simply accept a recommendation; in a accomplice chatbot, it could be contemplated in repeated conversation or personal disclosure. The results consequently help a website-sensitive synthesis in desire to a single omnibus outcome.

The later records that had been reclassified continue to be informative as contextual proof but had been now not treated as eligible observations. Deng and Yan (2025) become published after the stated June 2025 endpoint, Ibrahim et al. (2026) is publish-cutoff, and Kasturiratna and Hartanto (2026) is issue-dated after the endpoint. The Han (2025) report remained unverified. The distinction among eligible evidence and contextual facts is maintained at some point of the synthesis.

3.3 Risk of Bias and Reporting Quality

The revised evaluation distinguishes among the device designated via the evaluation and what can without a doubt be reconstructed from the provided evidence. Observational reviews can in precept be assessed the usage of the NIH pass-sectional/cohort tool, whilst experimental reports require the RoB 2 domain names. However, the provided supply does not maintain the whole query-with the aid of-question judgments,

helping excerpts from every paper, or adjudication document. Overall assessment is therefore defined as no longer independently reconstructable in preference to low hazard. The maximum continually visible boundaries are pass-sectional designs, self-report size, small samples in some research, restricted facts on sampling tactics, and heterogeneous outcome definitions.

Table 2. Risk-of-bias framework and reconstructability status.

Study	Planned tool	Design	Selection / allocation	Deviations	Missing data	Outcome measurement	Selective reporting	Overall
Waytz et al. (2014)	RoB 2	Experimental	NR	NR	NR	NR	NR	Not independently reconstructable
Abdi et al. (2022)	RoB 2	Experimental, 3 studies	NR	NR	NR	NR	NR	Not independently reconstructable
Christoforakos et al. (2021)	RoB 2	Experimental, 2 studies	NR	NR	NR	NR	NR	Not independently reconstructable
Carter et al. (2024)	RoB 2	Experimental	NR	NR	NR	NR	NR	Not independently reconstructable
Pentina et al. (2023)	NIH observational / mixed-method appraisal	Cross-sectional + qualitative	NR	NR	NR	NR	NR	Not independently reconstructable
Skjuve et al. (2021)	Qualitative appraisal not specified	Qualitative	N/A	N/A	N/A	N/A	N/A	Not formally rated
Xie & Pentina (2022)	Qualitative appraisal not specified	Qualitative	N/A	N/A	N/A	N/A	N/A	Not formally rated
Dziergwa et al. (2018)	Case-study appraisal	Long-term case study	N/A	N/A	N/A	N/A	N/A	Not formally rated

3.4 Quantitative Effect-Size Evidence

The original manuscript reviews pooled correlations for anthropomorphism-agree with, competence-believe, social presence-trust, consider-engagement, and anthropomorphism-engagement. Those values are not reproduced because the underlying study-level matrix is incomplete. Waytz et al. (2014) reports a standardized organization distinction associated with anthropomorphism and believe instead of a Pearson correlation; Christoforakos et al. (2021) reports partial eta-squared for competence and heat manipulations; Abdi et al. (2022) presents p values and a regression coefficient in the supplied extraction; and Carter et al. (2024) reviews a Bayes factor. These facts cannot be merged as even though they were equal correlations.

Table 3. Quantitative effect-size evidence and pooling decisions.

Outcome / contrast	Study	Original statistic	Metric	Pooling decision
Trust – anthropomorphism	Waytz et al. (2014)	$d = .48$	Standardized mean difference	Not pooled; group statistics/variance not preserved
Trust – competence	Christoforakos et al. (2021)	$\eta^2\text{-squared} = .145$	Partial eta-squared	Not pooled; conversion and independence matrix incomplete
Trust – warmth	Christoforakos et al. (2021)	$\eta^2\text{-squared} = .032$	Partial eta-squared	Not pooled; conversion and independence matrix incomplete
Trust – social cues	Carter et al. (2024)	$BF_{10} = 55.56$	Bayes factor	Not convertible to r from BF alone
Behavioral reliance	Abdi et al. (2022), Studies 1–3	$p = .02$; $p < .01$; $B = .14$	p values / unstandardized coefficient	Not poolable from supplied statistics
Attachment	Pentina et al. (2023)	$r = .65$ reported in source extraction	Pearson r	Descriptive only; instrument/covariance details not preserved

The clearest without delay interpretable proof is therefore examine-particular rather than a single pooled coefficient. Waytz et al. (2014) confirmed in an self sustaining-car context that anthropomorphic functions had been related to extra believe, while Christoforakos et al. (2021) observed that competence and warmth had been essential determinants of accept as true with improvement in social robots. Carter et al. (2024), in assessment, reported negligible consequences of anthropomorphic appearance on trust calibration when the anthropomorphic cue did no longer provide beneficial assignment statistics. The synthesis consequently supports a context-touchy interpretation of anthropomorphism.

For behavioral engagement and reliance, Abdi et al. (2022) provides experimental evidence that robotic anthropomorphism and embodiment can influence willingness to observe guidelines, but the provided extraction preserves only p values and one regression coefficient, stopping actual standardization. Other proof hyperlinks social presence, accept as true with, and interaction nice to persisted use or engagement in chatbot and voice-assistant settings (Lee et al., 2021). The prudent conclusion is that associations exist across numerous operationalizations, but the contemporary evidence record does no longer allow a reproducible commonplace-impact estimate.

3.5 Quantitative Evidence and Pooling Decision

Table three makes the pooling choice specific. No pooled coefficient is retained because of the fact the available extraction does now not deliver a sufficiently complete set of independent, same-metric outcomes with recoverable sampling variances. This does no longer imply that the underlying research placed no institutions; it way handiest that the prevailing report can not guide a defensible combined estimate.

3.6 Attachment and Relational Evidence

Attachment proof is particularly heterogeneous. Social-chatbot studies signify courting improvement through self-disclosure, consider, social motivation, interplay intensity, perceived authenticity, and closeness rather than a unmarried standardized attachment collect (Pentina et al., 2023). Dziergwa et al. (2018) offers a long-term case examine with three individuals and an embodied social robotic, illustrating that attachment orientation can form satisfaction and styles of cohabitation. Because sample size and size structures are rather disparate, the attachment literature is first-class represented narratively in this evaluation.

The revised AI Attachment Scale reviewed by Kasturiratna and Hartanto is bibliographically correct but dated as of 2026 and thus cannot be included in the study whose stated search limit was June 2025 and must be treated as post-limit evidence for a future update. The original manuscript utilized this study to guide the numerical attachment coefficients; thus, these numbers are now eliminated from the present synthesis (Kasturiratna & Hartanto, 2026).

3.7 Qualitative Synthesis

- **Theme 1:** Exploratory interaction and capability testing. Early interactions are exploratory: users test competence, responsiveness, and boundaries. Continued use depends on perceived responsiveness and relevance, consistent with gradual relational development (Skjuve et al., 2021).
- **Theme 2:** Trust, disclosure, and affective exploration. Perceived acceptance and non-judgment deepen disclosure. Self-disclosure links to trust formation and affective exploration (Skjuve et al., 2021), while anthropomorphism, authenticity, and interaction intensity drive relationship development (Pentina et al., 2023).
- **Theme 3:** Stabilization, routine use, and relational meaning. Longitudinal evidence shows relationships stabilize rather than increase indefinitely, with substantial variation over 12 weeks (Skjuve et al., 2022). Continuity and predictability may matter more than raw frequency.
- **Theme 4:** Loneliness, social motivation, and perceived availability. Loneliness and unmet social needs recur as entry conditions for companion-oriented AI; social motivation is a plausible antecedent of humanizing nonhuman agents (Epley et al., 2007). Causality remains unestablished.

Theme 5: Ambivalence and possible over-reliance. Users report both benefits and concerns. Over-trust can lead to inappropriate reliance, while under-trust can produce disuse (Benda et al., 2021).

3.8 Forest-Plot Status and Sensitivity

Figure 2 is deliberately defined as opposed to plotted. A traditional wooded vicinity plot calls for a commonplace impact-length metric, sampling variance or a reconstructible self guarantee c programming language, and unbiased observe-degree estimates. The supplied extraction does now not satisfy the ones necessities across the nominated agree with and engagement contrasts. A figure presenting the previous pooled estimates could therefore create a false impression of computational reproducibility. In a future update, separate forest plots should be generated for anthropomorphism-believe, competence-accept as true with, and trust-behavioral reliance/engagement only after unbiased, identical-metric effect sizes had been verified.

Figure 2 repute: Forest plots are intentionally left out due to the fact the furnished extraction lacks a commonplace metric, recoverable sampling variance, and a sufficiently entire matrix of impartial have a look at-level estimates.

Because no pooled impact is retained in the revised analysis, a formal depart-one-out meta-analytic sensitivity evaluation could be mathematically deceptive and isn't always mentioned. The future protocol requires affect diagnostics and leave-one-out analyses as soon as a legitimate pooled version exists. This difference additionally prevents the absence of an evaluation from being wrong for evidence of robustness.

3.9 Moderator and Publication-Bias Assessment

No moderator or meta-regression analyses were executed due to the fact the range of independent, commensurate effects changed into insufficient. Funnel-plot asymmetry, Egger-kind assessments, and trim-and-fill were likewise no longer done; with fewer than 10 research in step with final results, such exams have low power and can be deceptive (Sterne et al., 2011). The absence of a take a look at have to no longer be interpreted as proof that guide bias is absent.

3.10 Reporting of Quantitative Limits

The supply manuscript's previously reported pooled r values, confidence durations, Q facts, I -squared values, and tau-squared values are ignored from the revised effects due to the fact their underlying inputs aren't reconstructible from the furnished extraction. This is a reporting correction, now not a conclusion that the person studies display no effect. The absence of a pooled coefficient have to be examine as evidence of insufficient facts shape, no longer as a null locating.

4. Discussion

4.1 Principal Findings

This revision confirms a coherent conceptual sample however not a reproducible set of pooled coefficients. The available proof shows that competence and reliable undertaking overall performance are vital ingredients of accept as true with, that anthropomorphic/social cues can influence social presence and relational interpretation, and that agree with and self-disclosure frequently co-arise with persisted engagement. Attachment-like responses seem more heterogeneous and rely on the AI's social position, the person's reasons, and the persistence of interaction. The proof is therefore higher understood as a set of converging mechanisms than as a unmarried linear effect.

For believe, the proof is specially clean that performance-related houses count number. Christoforakos et al. (2021) located tremendous consequences of robotic competence and heat on agree with development, at the same time as broader proof places gadget talents, representation, and interaction context amongst relevant determinants (Kaplan et al., 2023). Waytz et al. (2014) indicates that anthropomorphic cues can boom accept as true with in self reliant cars, however Carter et al. (2024) suggests that superficial anthropomorphism may additionally have little impact on trust calibration when it fails to communicate beneficial mission records. The synthesis therefore helps context-touchy as opposed to prevalent claims approximately anthropomorphism.

For attachment, the proof is weaker and extra conceptually numerous. Qualitative work suggests that attachment-like studies might also emerge via repeated disclosure, perceived popularity, social motivation, and the experience that the chatbot is to be had for communicate (Pentina et al., 2023). Dziergwa et al. (2018) indicates that character attachment styles may also form long-time period interplay with an embodied robot. These findings justify attachment as a significant assemble for human-AI research, however they do not justify collapsing attachment, affection, use intensity, and emotional reliance into one outcome.

For behavioral engagement, evidence time and again elements to just accept as genuine with, social presence, interaction pleasant, and relational mechanisms. Chatbot studies display that social presence and anthropomorphic profiles can have an impact on interplay and engagement, even as voice-assistant research hyperlinks interplay excellent and dating development with take into account and persisted use (Lee et al., 2021). Yet engagement stays multi-determined: people might also interact due to the truth a system is beneficial, exciting, socially profitable, dependancy-forming, or convenient. A future meta-assessment have to therefore distinguish purpose to apply, persisted use, self-disclosure, advice following, and objective reliance in location of pooling them robotically.

A related trouble is temporal interpretation. Cross-sectional proof can display that recollect, loneliness, disclosure, and attachment-like responses co-stand up, but it can not set up whether or not agree with precedes engagement, whether or not engagement strengthens recollect, or whether or no longer every stand up from a third variable together with social motivation or undertaking dependence. Thus longitudinal and experimental designs serve the aim of differentiating the enhancement process from the ongoing changes in personality.

The shortage of the pooled coefficient must not be confused with the lack of quantitative evidence. Individual studies nonetheless provide valuable information but their data answer different questions and rely on different measurement systems. The evaluation thus treats effect-duration non-comparability as an important methodological outcome. In this is the process of advancing measurement harmonization could be more efficient than increasing the number of studies that use incompatible indicators. The future synthesis must define the constructs prior to statistics being pooled and must use distinct ways of measurement for the research on the construct of attachment, attachment-like relations, and behavioral involvement.

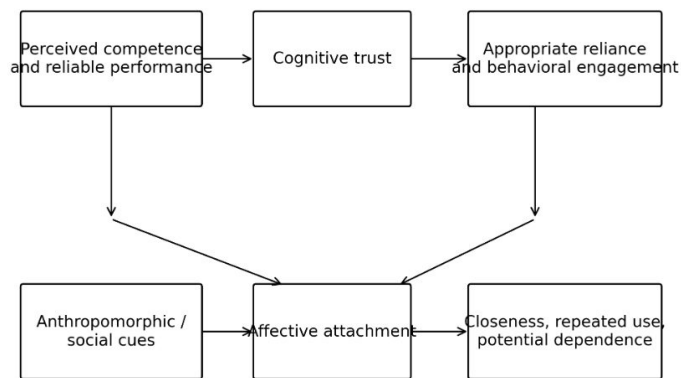
4.2 Theoretical Implications

The framework mentioned features provisional conduction methods. There is a cognitive mode that produces connections between competence and general standard performance and trust and ability for reliable action. The affective-relational mode is about social motivation, loneliness, sticking to each other and responsiveness in order to enable closeness and duplication process to take place. Also, both processes may intersect with anthropomorphic and social signals. However, none of the processes is established as cause-effect.

Note: The model is hypothesis-generating rather than a validated causal mediation model.

The model advances the traditional accept as truth literature in automation by treating relational strategies as complementary and not as alternatives to cognitive reliability. It also links theories around interpersonal relations with HCI studies on social presence and anthropomorphism. Most crucially, the model is not positioned as validated mediation: the existing evidence is simply too varied and too limited to support such a model.

An implication relates to the calibration of trust as a process connected to relationships. In the instrumental role of calibration, one may measure its level against the criteria of visible precision or reliability; while regarding certain relationships, reliability may entail the demarcation of boundaries of

Figure 3. Preliminary integrated model of cognitive trust and affective attachment pathways

Conceptual status: hypothesis-generating framework, not a validated causal model.

Figure 3. Preliminary integrated model distinguishing cognitive trust and affective attachment pathways.

helpful emotional assistance provided by AI and the replacement of human relationship. This distinction is significant for the understanding of the issue here. The same element of communication may perform its function in one situation and may mislead in another. Personalization, memory, warmth, and empathy will increase the illusion of AI being responsive, but at the same time might create false expectations regarding organization, knowledge, or reciprocity that will not be met by the AI. As a result, it is treated in the elaborated framework as trust calibration and attachment process which might affect the outcomes of the process depending on the context. Research in the area should not only analyze the degree of trust bestowed on AI or interacting with it but also find out whether users' beliefs about the machine correspond to its real skills.

4.3 Practical Implications

Trust calibration in terms of achieving maximum likeness is crucial for designers. System characteristics that exhibit soundliness are useful to more efficient communication. It's worth mentioning that we shouldn't ignore the necessity of evaluation of the usefulness of anthropomorphism based on both informational and relational results. Carter et al. (2024) explain how the essence of messages conveyed through anthropomorphic cues matters: a large amount of communication would help with establishing trust, while only its appearance will not. Moreover, transparency and clarifiability should be designed to address customer needs regarding how AI has to be used effectively (Naiseh et al., 2023).

In designing systems that are associate-oriented, designers should differentiate between the warmth of temperature and availability from manipulatively dependent. Although the evidence does not guarantee any specific harmful effect, ample evidence from relational literature suggests that perceived acceptance, permanence, and responsiveness may heighten engagement. Therefore, systems must be open about their artificial identity, communicate their boundaries clearly, protect sensitive information, and avoid interaction processes that compel people to be engaged. All of these suggestions conform to the concerns regarding privacy and proper dependence in conversational systems. (Benda et al., 2021).

Current research suggests that for both health workers and scientists, understanding is more useful than being able to make diagnosis. It is well known that discussions that take place face-to-face are interesting and appealing; in addition, research based on experimental facts has taken place in the market of intellectual health (Vaidyam et al., 2019). It is important for health care practitioners not to jump to the conclusion from the assessment that attachment to artificial intelligence has any pathology or usefulness. Assessment should consist of practical implications of the breakdown of ethics, distress, work or relationships, privacy and patterns of dependence, rather than merely the occurrence

of affective words towards AI system.

For the authorities and governance bodies, this key principle is transparency and protection of the mind. AI systems operating in socially sensitive fields should state their artificial nature, name their limitations, and help the user make his own decisions. The governance should be data-based and proportionate to the area, giving due attention to systems that have strong persuasion power, personalizing capabilities, and continuous interaction.

4.4 Limitations

The initial difficulty is associated with a small and diverse body of evidence. The nominal k suggested within the literature can not be transformed into a strong pooled evidence because many scientific reports provide multiple samples, the definitions of outcomes differ, and the essential inputs of effect size are absent.

The second issue is that the study cannot be audited properly. The dates of publication, the number of hits in each database, and the reasons of excluding certain documents were not preserved. This prevents proper application of various PRISMA components.

The final shortcoming is the lack of preregistration and publicly available OSF files. In this paper, the weaknesses are reduced by pointing out deviations from the procedure, making non-reproducibility of pooled coefficients transparent, and formulating the preregistration plan for the future.

The challenge number four is referred to as dimension heterogeneity as in some instances trusting can refer to trusting reasoning or other terms. The term attachment may imply emotional closeness or particular attachment style or attachment scale. The term engagement can also indicate intended use or actual use, disclosure, or recommendations. In other words, by mixing together all these constructs, the possibility of ending up with a confusion.

The fifth issue raised is related to the question of external validity. The report presents data mostly from Western countries and relatively young populations and some data from Asia and specialized robotic populations, which does not allow one to make statements about the cultural invariance of findings.

The sixth problem is related to the publication bias and small-study effect. Limited number of eligible studies and lack of independence of effects means that classic funnel-plot asymmetry tests cannot be applied. The absence of evidence that shows the existence of the test does not spell absence of publication bias issue (Sterne et al., 2011).

Finally, causal inference is confined. Much of the to be had proof is pass-sectional or observational, and qualitative findings are interpretive. Associations among loneliness, attachment, be given as authentic with, and engagement cannot be assumed to represent one directional causal chain.

4.5 Future Research

A future update need initially preregistration and a seek audit path. The protocol need to define the unit of assessment, construct-degree eligibility, independent effects, and verification techniques earlier, at the same time as additionally increasing past English-language literature. Search histories, screening picks, exclusions, and modifications have to be retained in machine-readable supplementary documents so that another institution can reproduce the proof base with out reconstructing lacking selections.

Future studies have to prioritize longitudinal designs, cross-cultural samples, goal behavioral measures, and experiments that one after the other manage competence, uncertainty disclosure, social presence, anthropomorphic cues, and relational framing. These designs might assist distinguish brief social responses from long lasting attachment-like bonds and distinguish appropriate reliance from over-reliance.

Future meta-analysis ought to separate consider ideals, believe calibration, attachment-to-AI, dispositional attachment orientation, self-disclosure, persevered use, and behavioral reliance as opposed to

treating them as one outcome circle of relatives. Independent impact sizes ought to be retained on the pattern-by means of-comparison degree, with multilevel or robust variance strategies used whilst more than one results from the identical sample are unavoidable. A minimal of 10 independent effects need to be focused before routine moderator or small-take a look at-impact analysis, whilst earlier pooling ought to occur only while as a minimum 3 outcomes are truly unbiased and commensurate.

5. Conclusion

The analysis of this report is focused on changing buying habits and preferences of Generation Z consumers in sustainable fashion. Being the first digital generation, Gen Z has a significant economic capacity, as well as environmental concerns, therefore posing a threat to retail. The analysis is based on existing studies trying to understand the factors influencing their choices when it comes to sustainability including brands' transparency, authenticity, and social responsibility. In addition, the report examines such understanding phenomena as contradictions in behavior like "value-action gap," which is the gap between sustainability intentions and actions, as money in most cases does not allow people to make sustainable purchases.

It is evident that the most significant drawback of the methodology employed in the analysis is that the pooled coefficients of the previous paper cannot be regenerated from the given extraction report. As such, the present revision views the quantitative aspect of the inquiry as merely preliminary and descriptive, addresses the absence of data, and provides a tentative outline of how to conduct the meta-analysis in a way that it will be fully replicable subsequently. The issue provides justification for taking such further steps, yet it is still not adequate for making a valid generalization about how the analysis was performed in practice.

Declarations

Financial Support: There was no mention of any outside financial support in the manuscript.

Conflict of Interest: No conflicts of interest were indicated in the manuscript.

Availability of Data: A public OSF repository was mentioned in the manuscript with a placeholder URL; however, no actual repository was provided. Therefore, this version does not state that any data or code is available for the public. Details such as coding schemes, search terms, extraction table, and upcoming protocol are given in the appendices. A valid repository must be created before submission of the article to the journal.

Acknowledgments: No specific external acknowledgments were supplied. Statements about participants are limited to descriptions contained in the included source studies.

Author Contributions: Not supplied in the source materials; to be completed by the authors before submission.

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Appendices

Appendix A. Full Search Strings

Search dates: exact calendar dates were not preserved in the supplied record. The stated search endpoint was June 2025. Database-specific result counts were not retained and are not reconstructed.

Database	Search string
PsycINFO	(chatbot OR "conversational agent" OR "social robot" OR "AI companion" OR "intelligent agent") AND (trust OR attachment OR reliance OR engagement OR loneliness OR "self-disclosure")
Scopus	TITLE-ABS-KEY((chatbot OR "conversational agent" OR "social robot" OR "AI companion" OR "intelligent agent") AND (trust OR attachment OR reliance OR engagement OR loneliness OR "self-disclosure"))
Web of Science	TS=((chatbot OR "conversational agent" OR "social robot" OR "AI companion" OR "intelligent agent") AND (trust OR attachment OR reliance OR engagement OR loneliness OR "self-disclosure"))
ACM Digital Library	((chatbot OR "conversational agent" OR "social robot" OR "AI companion" OR "intelligent agent") AND (trust OR attachment OR reliance OR engagement OR loneliness OR "self-disclosure"))
IEEE Xplore	((chatbot OR "conversational agent" OR "social robot" OR "AI companion" OR "intelligent agent") AND (trust OR attachment OR reliance OR engagement OR loneliness OR "self-disclosure"))
Google Scholar	Exact string not preserved in the supplied record; search concept used the AI terms combined with trust, attachment, reliance, engagement, loneliness, or self-disclosure, followed by relevance screening.

Appendix B. Coding Sheet

Domain	Variable	Coding instruction
Administrative	Study ID	Author-year and unique study/sample identifier
Administrative	Eligibility	Include / exclude / post-cutoff / unclear
Sample	N	Sample size for the analytic contrast, not merely the report-level N
Sample	Mean age	Mean or median when available
Sample	Culture / region	Country or cultural context
AI system	AI type	Chatbot, social robot, autonomous vehicle, decision aid, companion
AI system	Embodiment	Text-only, voice, avatar, physical embodiment
Design	Design	Cross-sectional, longitudinal, experimental, mixed-method, qualitative
Outcome	Construct	Trust, trust calibration, attachment-like bonds, engagement, reliance
Outcome	Operationalization	Exact scale/behavior used by the study
Predictor	Anthropomorphism	Manipulation or measured perception
Predictor	Competence	Manipulated or perceived competence
Predictor	Social presence	Measure/manipulation when present
Predictor	Loneliness / social motivation	Measure when present
Predictor	Attachment orientation	Measure when present
Exposure	Interaction duration	Single session, days, weeks, months
Effect size	Original statistic	r, d, g, beta, eta-squared-p, BF, p, B, delta-R-squared

Domain	Variable	Coding instruction
Effect size	Converted statistic	Only when conversion assumptions and variance inputs are available
Effect size	Sampling variance / CI	Extracted or reconstructible
Independence	Unit of analysis	Sample-by-contrast; identify shared samples
Quality	Risk-of-bias status	Tool, domain evidence, and reconstructability
Notes	Verification	DOI / bibliographic verification and deviations

Appendix C. Data Extraction Table

Study	N	AI	Outcome	Original effect/statistic	Conversion / pooling status	Final treatment
Waytz et al. (2014)	100	Autonomous vehicle	Trust; anthropomorphism	$d = .48$	No safe conversion from supplied extraction	Included; descriptive
Abdi et al. (2022), Study 1	89	Service robot	Recommendation reliance	$p = .02$	Not available	Included; descriptive
Abdi et al. (2022), Study 2	168	Service robot	Recommendation reliance	$p < .01$	Not available	Included; descriptive
Abdi et al. (2022), Study 3	122	Service robot	Mediation / reliance	$B = .14$	Not available	Included; descriptive
Christoforakos et al. (2021), Study 1	155	Social robot	Trust; competence	$\eta^2\text{-}p = .145$	Approximation possible but independence inputs incomplete	Included; descriptive
Christoforakos et al. (2021), Study 2	157	Social robot	Trust; warmth	$\eta^2\text{-}p = .032$	Approximation possible but independence inputs incomplete	Included; descriptive
Carter et al. (2024)	98	Automation	Trust calibration	$BF_{10} = 55.56$	Not convertible to r from BF alone	Included; descriptive
Pentina et al. (2023)	123	Replika / social chatbot	Attachment; anthropomorphism; interaction intensity	$r = .65$ reported in source extraction	Instrument/covariance details not preserved	Included; descriptive
Skjuve et al. (2021)	18	Replika	Trust; attachment; self-disclosure	Qualitative	Not applicable	Included; narrative
Xie & Pentina (2022)	14	Replika	Attachment; relationship development	Qualitative	Not applicable	Included; narrative
Dziergwa et al. (2018)	3	EMYS social robot	Attachment patterns; cohabitation	Qualitative case study	Not applicable	Included; narrative
Deng & Yan (2025)	303	Chatbot	Trust; engagement	beta values in source manuscript	Post-cutoff	Excluded from core; contextual only
Ibrahim et al. (2026)	933	Chatbot	Trust; anthropomorphism	$\Delta\text{-}R\text{-}squared = .07$ in source manuscript	Post-cutoff	Excluded from core; contextual only
Kasturiratna & Hartanto (2026)	1,259 unique	AI companion	Attachment	r values in source manuscript	Issue-dated 2026; contrasts not preserved	Excluded from June-2025 core; future update

Conversion note. No transformed effect was used in the final synthesis unless the supplied record preserved the necessary assumptions and sampling information. The previously reported pooled values were not retained.

Appendix D. Future Meta-Analysis Protocol

1. Preregister the protocol on OSF or some other suitable registry earlier than screening; file actual seek dates, database versions, full techniques, and deviations.

2. Define the unit of evaluation as an impartial pattern-by-evaluation; use multilevel or strong variance strategies when multiple results from the same pattern are retained.

1. Three. Require as a minimum three truly independent, commensurate outcomes for any pooled estimate and goal $ok \geq 10$ before ordinary moderator or small-examine-impact analyses.

2. Four. Predefine separate results for cognitive agree with, perceived trustworthiness, accept as true with calibration, attachment-to-AI, dispositional attachment orientation, self-disclosure, persevered use, behavioral reliance, and advice following.

3. Five. Use Pearson r where at once available and Fisher's z for synthesis; use Hedges' g for standardized mean variations; transform other facts best whilst the exact assumptions and required inputs are available.

4. 6. Fit random-consequences fashions the usage of REML and file pooled impact, ninety five% CI, Q, I-squared, tau-squared, and prediction intervals while justified.

5. 7. Predefine moderators such as AI kind, embodiment, assignment area, anthropomorphism type, examine layout, age, gender distribution, cultural place, interplay duration, and outcome measurement type.

6. Eight. Assess guide bias and small-look at outcomes most effective whilst the number of studies is enough; do now not interpret a nonsignificant test as proof that bias is absent.

7. Nine. Perform go away-one-out or impact analyses and repeat synthesis after apart from studies judged excessive hazard of bias.

8. 10. Preserve a gadget-readable extraction report and evaluation script as supplementary material, with every converted impact connected to the source statistic and formula.

Appendix E. PRISMA 2020 Checklist (Completion Status)

PRISMA item	Requirement	Status
Title	Identify the report as a systematic review / preliminary meta-analysis	Complete
Abstract	Structured background, objectives, methods, results, conclusions	Complete after revision
Rationale	Explain why the review is needed	Complete
Objectives	State research questions/objectives	Complete
Eligibility criteria	Specify inclusion/exclusion criteria	Complete
Information sources	List databases and coverage period	Complete; exact dates NR
Search strategy	Provide reproducible database-adapted strings	Partial; Google Scholar exact string NR
Selection process	Describe screening and discrepancy resolution	Partial; original log incomplete
Data collection	Describe extraction variables and process	Complete at review-record level
Risk of bias	Specify appropriate tools	Complete; domain-level judgments not reconstructable
Effect measures	Define effect measures and conversions	Complete with conservative conversion rule
Synthesis methods	Describe models and criteria for pooling	Complete; no pooled estimate retained
Reporting bias	Describe planned assessment	Complete; tests not performed because k was insufficient
Certainty / limitations	Discuss evidence limitations	Complete
Study selection results	Report records and included evidence	Partial; historical exclusion reasons incomplete
Study characteristics	Present study-level characteristics	Complete
Risk of bias results	Present appraisal results	Complete as reconstructability status
Synthesis results	Present quantitative and qualitative synthesis	Complete
Discussion	Interpret cautiously and state implications	Complete
Registration	Report registration status	Complete; not preregistered