dreammachine

SYSTEMS ARCHITECTURE FOR THE HUMAN MIND

LOG ID	BOOK REFERENCE	RCT FILTER	CONFIDENCE TIER
SEC 12.2.1	CHAPTER 12: DATA SOVEREIGNTY & GLOBAL OS (Production Environment)	ON	CONSENSUS

AUDITED CLAIM

SIMULATED TELEMETRY BUG (ALGORITHMIC PROXIES)

SYSTEMS MODEL — AS STATED IN THE BOOK

> Clinically, while AI and text-based digital support can reduce self-reported distress, in-person, face-to-face human interaction provides superior **physiological co-regulation**, facilitating autonomic linkage and **inter-brain synchrony** that digital systems cannot biologically replicate.

VALIDATION QUERY

Does in-person, face-to-face human interaction provide superior physiological co-regulation and emotional stress reduction compared to text-based digital communication or AI-simulated empathy?

EMPIRICAL FINDING

A comprehensive review of physiological co-regulation literature establishes that face-to-face human interaction provides superior **physiological co-regulation** compared to AI or text-based support. While digital mediation can reduce subjective distress, only in-person interaction facilitates the deep **autonomic linkage** and inter-brain synchrony necessary for embodied stress buffering and the physical transmission of empathetic resonance.

PRIMARY ANCHORS

→ **Brown et al., 2020, Personality and Social Psychology Bulletin**

→ **Wang & Shi, 2024, Cognition and Emotion**

ABOUT THIS RECORD

Each claim in the book is decompiled from its IT metaphor into a naked, falsifiable scientific claim, then anchored to a **primary peer-reviewed source**. Claim and anchor are queried against the Consensus academic database (200M+ papers) under a fixed protocol — top-tier **Q1/Q2 journals only**, preprints excluded, human studies only. If a hypothesis fails the audit, the build is rejected: the AI generates the syntax; the peer-reviewed grid validates the physics.

CONFIDENCE TIERS

- **CONSENSUS ◀ this log** — broadly established, highly replicated mechanics.
- **EMERGING** — plausible, actively researched; no universal consensus yet.
- **EXPERIMENTAL** — contested, extrapolated, or purely theoretical.

RCT FILTER — Controlled Studies is ON for interventions (a forced action must beat a control) and OFF for mechanisms (so foundational neuroscience isn't blocked).

Yes, **face-to-face human interaction** appears **superior for physiological co-regulation**, while digital and AI support can still reduce stress.

1. Introduction

Across this corpus, in-person face-to-face interaction shows the clearest advantages for **physiological co-regulation**: empathic listeners reduce distressed partners' sympathetic arousal, interpersonal regulation increases heart-rate synchrony, and social interaction experience increases inter-brain synchrony and emotional congruence (Brown et al., 2020; Wang & Shi, 2024; Wang et al., 2025). Face-to-face human support also often reduces distress more effectively than self-regulation or AI-only support, especially when the task requires emotional validation, tailored feedback, or complex fear-related processing (Levy-Gigi & Shamay-Tsoory, 2017; Spytska, 2025; Yang et al., 2026).

But the comparison is not one-sided. Text-based and AI-mediated interventions repeatedly improve depression, anxiety, or perceived stress, and some therapist-supported or human-supported digital programs achieve outcomes similar to face-to-face CBT on symptom scales (Zhong et al., 2024; Feng et al., 2025; Hedman-Lagerlöf et al., 2023). The main distinction is that these digital benefits are best established for **clinical symptom reduction**, not for the kind of real-time autonomic linkage, synchrony, and embodied co-regulation seen in live human interaction (Feng et al., 2024; Palmer et al., 2024; Kroczek & Mühlberger, 2025).

The evidence therefore supports a qualified answer: face-to-face human interaction appears better for **physiological co-regulation and emotionally rich stress buffering**, whereas digital text and AI can provide meaningful but usually narrower or less relationally deep stress reduction (Brown et al., 2020; Spytska, 2025; Terblanche et al., 2022).

Does in-person, face-to-face human interaction provide superior physiological co-regulation and emotional stress reduction compared to text-based digital communication or AI-simulated empathy? N = 5

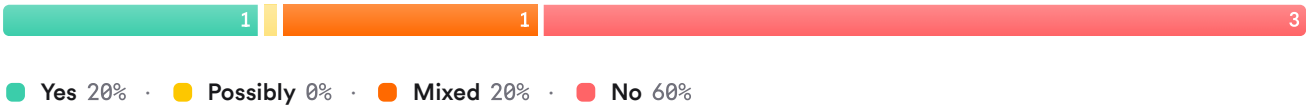

FIGURE 1 Consensus on face-to-face versus digital empathy effects

The meter should lean toward **yes, with qualification**. The strongest evidence for superiority concerns embodied synchrony and co-regulation, while the evidence for symptom reduction alone is more mixed because several digital and blended interventions perform well on self-report outcomes (Brown et al., 2020; Palmer et al., 2024; Hedman-Lagerlöf et al., 2023).

2. Methods

This Deep Search drew on Consensus's index of more than 170 million research papers spanning Semantic Scholar, PubMed, and other sources. The workflow identified 2,134 directly relevant papers from the user query, discovered 1,845 additional papers through citation crawling, screened 230 papers after machine-learned relevance filtering, judged 168 eligible after deduplication and thresholding, and included the top 50 most relevant papers for synthesis.

Search Strategy

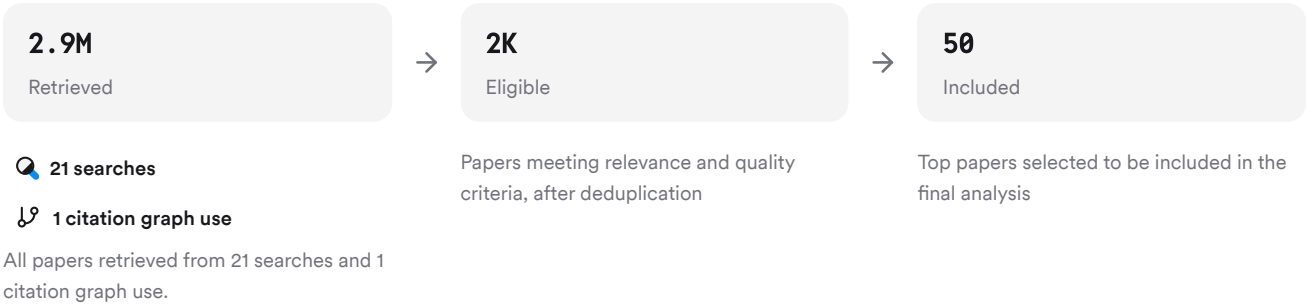

FIGURE 2 Search and screening flow for included papers

Searches combined direct modality comparisons, physiological synchrony terms, interpersonal emotion regulation, AI empathy, and digital stress-support intervention literatures.

3. Results

3.1 Key Papers

A few papers anchor the corpus because they directly test live interpersonal regulation, physiological linkage, or digital-versus-human support. Brown et al. establish that an empathic in-person listener lowers both negative affect and sympathetic arousal in distressed partners, Levy-Gigi and Shamay-Tsoory show interpersonal regulation outperforms intrapersonal regulation, and Hedman-Lagerlöf et al. define the strongest counterpoint by showing therapist-supported internet CBT can match face-to-face CBT on overall symptom outcomes (Brown et al., 2020; Levy-Gigi & Shamay-Tsoory, 2017; Hedman-Lagerlöf et al., 2023).

Paper	Summary
(Palmer et al., 2024)	Empathic listeners lower distress physiology (Brown et al., 2020)
(Oveis et al., 2018)	Interpersonal regulation beats self-regulation (Levy-Gigi & Shamay-Tsoory, 2017)
(Chen, 2026)	Therapist-supported ICBT matches face-to-face CBT (Hedman-Lagerlöf et al., 2023)

FIGURE 3 Key papers anchoring the evidence base

3.2 Physiological Co-Regulation

The most direct physiological evidence favors live human interaction. Friend dyads using interpersonal regulation showed stronger heart-rate and heart-rate-variability synchrony than controls while also improving targets' emotions (Wang & Shi, 2024). In stressful collaborative face-to-face work, one teammate's stress reappraisal improved both partners' cardiovascular responses, producing a challenge pattern that carried into later solo performance (Oveis et al., 2018). Parent-child data likewise show that one partner's regulation strategy changes the other partner's sympathetic responses and interaction warmth, indicating true bidirectional stress transmission rather than isolated self-soothing (Waters et al., 2020).

Neural hyperscanning studies converge with these autonomic findings. Interpersonal regulation recruits interpersonal brain coupling across prefrontal and temporoparietal systems (Liu et al., 2023). Successful regulation strengthens inter-brain synchronization and relationship closeness, especially when the regulation is more effective (Zhu et al., 2025).

3.3 Digital and AI Alternatives

Digital and AI systems can still reduce distress, but their effects are usually measured as symptoms or mood rather than real-time co-regulation.

Dimension	Text/Digital Human/AI	Human Support Comparator	Citations
Depression symptoms	Small-to-moderate improvement	Often better or similar with support	(Zhong et al., 2024)
Anxiety symptoms	Small improvement overall	Therapist often larger	(Spytska, 2025)
Stress symptoms	Mixed across meta-analyses	No clear AI advantage	(Feng et al., 2024; Schillings et al., 2023)
Expressed empathy	AI can augment text replies	Still expression, not physiology	(Sharma et al., 2022)
Human-supported digital care	Can reach noninferiority	Comparable CBT outcomes	(Palmer et al., 2024; Hedman-Lagerlöf et al., 2023)

FIGURE 4 Digital versus human support across outcome types

AI support works best as augmentation or structured delivery. AI feedback increased expressed empathy in peer-support text conversations by 19.6% (Sharma et al., 2022). Human-supported digital anxiety care was noninferior to face-to-face and typed CBT while using much less clinician time (Palmer et al., 2024). But AI-only effects on stress are inconsistent: one youth meta-analysis found no significant stress benefit after publication-bias adjustment, while another adolescent and young-adult meta-analysis found small-to-moderate stress reductions across a broader RCT set (Feng et al., 2024; Feng et al., 2025).

3.4 Important Exceptions

Not every face-to-face setting is less stressful. In a randomized field study of anatomy learning, face-to-face classes produced lower HRV and higher cortisol than Zoom-based classes, likely reflecting stronger task engagement and social-evaluative demand rather than better emotional buffering (Gellisch et al., 2022). Some text-mediated communication also performs as well as face-to-face for specific low-conflict relational acts: texting gratitude improved well-being about as much as face-to-face gratitude and involved less social risk (Sheldon & Yu, 2021).

AI-simulated empathy can help in narrow contexts. An empathic chatbot buffered mood after social exclusion (De Gennaro et al., 2020). Virtual counselors using eye contact, mimicry, and nodding reduced anger more than neutral virtual counselors (Choi et al., 2024). But digital humans do not consistently improve physiology or usability over text; one trial found no EEG differences and greater nervousness with the digital human than with a text-only chatbot (Thunström et al., 2023).

Results Timeline

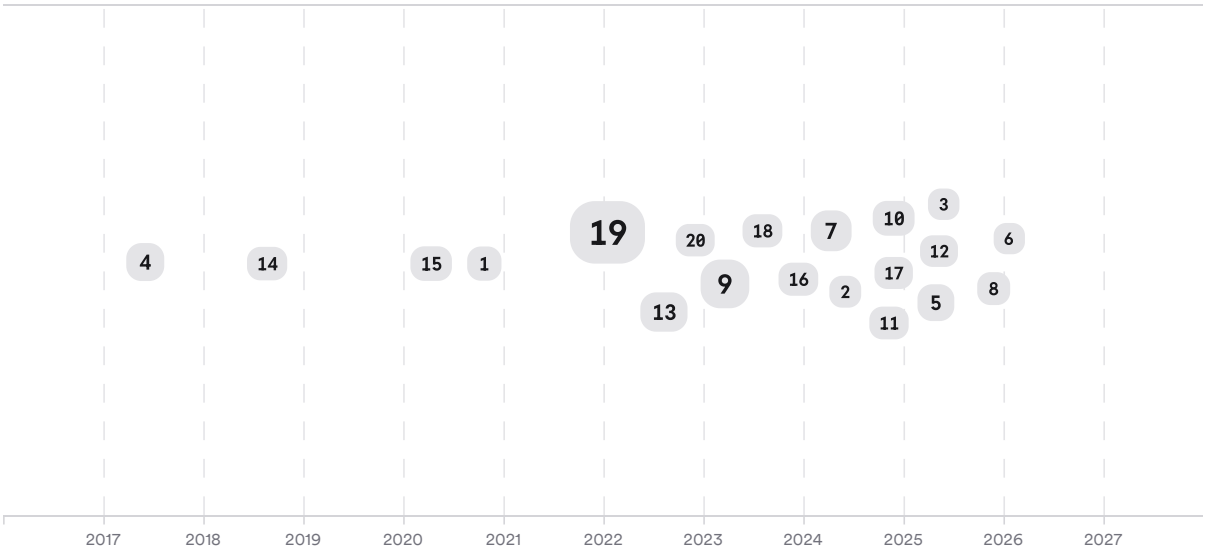

FIGURE 5 Timeline of included studies, larger markers indicate more citations

The timeline shows an early foundation in psychophysiology and interpersonal regulation, followed by rapid growth in chatbot and blended-care trials after 2017. More recent work increasingly tests virtual nonverbal cues and inter-brain synchrony, but direct head-to-head comparisons of live human versus AI empathy on physiology remain sparse (Butler et al., 2006; Feng et al., 2025; Zhu et al., 2025).

Top Contributors

Type	Name	Papers
Author	Yanmei Wang	[163874cd07835f6d9fe7c2194fe53884] [d462d0e45fb950a9a50ed27e742055d4] [dfcd65dde7c75b719c964cab597e6e65]
Author	Tessa V. West	[14c3fb2755ca5a2e87aaccc84d2434b2] [01785dcdae2556d59d759ff4c1ae6e77] [b926f871858c5bb6949899ee878e7db9]
Author	Wendy Mendes	[14c3fb2755ca5a2e87aaccc84d2434b2] [01785dcdae2556d59d759ff4c1ae6e77] [b926f871858c5bb6949899ee878e7db9]

Type	Name	Papers
Journal	*JMIR Mental Health*	[b85c554bbfc25c5386da89148721dee2] [77b7265ff7a051eda38583c5d1047d4a] [3ace18d160e75ade8f9bbd1cb433976a]
Journal	*Journal of Medical Internet Research*	[9cd5e036da4c50918411615c1d20adf5] [70a61d9a6ac65c12a30294cc010a2271] [77b00a4828ee5a888b54d7ab722a880f]
Journal	*NeuroImage*	[ca36a3885dc95d8cbf18dfaff9d04a1a] [dfcd65dde7c75b719c964cab597e6e65]

FIGURE 6 Authors and journals most frequent in included papers

4. Discussion

The strongest part of this literature is the **mechanistic consistency** around live interpersonal regulation. Across dyadic lab studies, empathic or well-regulating partners alter the other person's autonomic responses, synchrony, and emotional recovery in ways that fit classic social buffering and co-regulation models (Brown et al., 2020; Oveis et al., 2018; Waters et al., 2020). Newer hyperscanning studies reinforce that these are not only subjective impressions but also coupled neural processes (Liu et al., 2023; Zhu et al., 2025).

The digital literature is broader but less direct. Meta-analyses support small-to-moderate improvements in depression, anxiety, and sometimes stress for chatbots and mental-health apps, but effects vary by age group, engagement, follow-up duration, and whether the intervention includes human guidance (Zhong et al., 2024; Feng et al., 2024; Koelen et al., 2022). Human support adds a modest but real advantage in text-based internet treatment efficacy and adherence, which argues against a simple equivalence claim for AI-only empathy (Koelen et al., 2022).

The main limitation is that few studies directly compare **face-to-face human interaction versus text-based or AI-simulated empathy on the same physiological endpoints**. Much of the human literature measures synchrony and autonomic linkage, while much of the AI literature measures symptoms, usability, or perceived empathy. That mismatch makes the physiological superiority claim strong in mechanism but only moderate in direct comparative certainty (Loveys et al., 2021; Feng et al., 2024).

Still, the corpus points toward complementarity rather than replacement. Human connection remains strongest where being understood, emotionally validated, and physiologically co-regulated matters most, while digital systems expand access, lower stigma, and work especially well when blended with human oversight (Spytska, 2025; Yang et al., 2026; Palmer et al., 2024).

Claim	Evidence Strength	Reasoning	Papers
Face-to-face human interaction better supports physiological co-regulation than digital text or AI	Strong	Multiple dyadic physiology and hyperscanning studies show autonomic and neural coupling during live interaction	(Brown et al., 2020; Wang & Shi, 2024; Zhu et al., 2025)
Digital and AI interventions can reduce distress		Several RCTs and meta-analyses show small-to-moderate	(Zhong et al., 2024; Feng et al., 2025;

Claim	Evidence Strength	Reasoning	Papers
symptoms	Moderate	improvements in depression, anxiety, or stress	Eisenstadt et al., 2021)
Human-supported digital care can match face-to-face CBT on some symptom outcomes	Strong	Large meta-analysis and pragmatic study support noninferiority when human support is present	(Hedman-Lagerlöf et al., 2023; Palmer et al., 2024)
AI-simulated empathy alone matches human empathy for complex emotional support	Weak	Some supportive trials exist, but therapist and clinician-guided conditions often outperform AI on richer emotional outcomes	(Yang et al., 2026; Spytska, 2025; Terblanche et al., 2022)
Face-to-face interaction is always less stressful than digital interaction	Weak	At least one randomized field study found higher cortisol and lower HRV in face-to-face learning	(Gellisch et al., 2022)

FIGURE 7 Key claims and supporting evidence in corpus

5. Conclusion

Taken together, these papers support a qualified yes. In-person face-to-face human interaction appears superior for **physiological co-regulation** and often for emotionally rich stress reduction, but digital text and AI-mediated support can still produce meaningful symptom relief, especially when structured well or combined with human support (Brown et al., 2020; Hedman-Lagerlöf et al., 2023).

Research Gaps

The biggest gap is direct head-to-head testing of modalities on the same physiological endpoints. The corpus is rich in live-dyad synchrony studies and rich in digital symptom trials, but sparse where those two traditions fully meet.

Topic/Outcome	Physiology	RCT comparison	Long-term follow-up	AI-only empathy
Face-to-face co-regulation	10	4	3	GAP
Text-based stress reduction	2	8	5	6
Digital humans with nonverbal cues	3	3	1	4

Topic/Outcome	Physiology	RCT comparison	Long-term follow-up	AI-only empathy
Human-supported blended care	1	7	4	2

Open Research Questions

Future work should directly test modality, mechanism, and context together rather than treating symptom relief and co-regulation as separate literatures.

Question	Why
Does face-to-face human support outperform AI-simulated empathy on HRV, electrodermal activity, and cortisol during the same stress task?	This would directly test the corpus's strongest unresolved comparison using shared physiological endpoints.
Which elements of human support—presence, responsiveness, nonverbal cues, or empathic accuracy—drive superior co-regulation?	Current virtual-counselor and digital-human studies suggest nonverbal cues matter, but the active ingredients remain unclear.
When do blended human-plus-AI interventions outperform either modality alone for stress reduction?	Several studies favor hybrid care, but optimal division of labor between AI and humans is still unsettled.

In short, face-to-face human interaction looks best for **co-regulating physiology and distress in real time**, while digital and AI systems are better understood as useful complements than full replacements.

References

K., Vonk, J., Klein, A., Koning, A., Vonk, L., Vet, P. D., & Wiers, S. (2022). Man vs. machine: A meta-analysis on the added value of human support in text-based internet treatments ("e-therapy") for mental disorders.. *Clinical psychology review, 96*, 102179. https://doi.org/10.1016/j.cpr.2022.102179

Brown, C. L., West, T. V., Sanchez, A. H., & Mendes, W. (2020). Emotional Empathy in the Social Regulation of Distress: A Dyadic Approach. *Personality and Social Psychology Bulletin, 47*, 1004 - 1019. https://doi.org/10.1177/0146167220953987

Butler, E., Wilhelm, F., & Gross, J. (2006). Respiratory sinus arrhythmia, emotion, and emotion regulation during social interaction.. *Psychophysiology, 43 6*, 612-22. https://doi.org/10.1111/j.1469-8986.2006.00467.x

Chen, P.-J. (2026). AI-enhanced virtual reality simulation for nursing students' empathy: Automated scoring and inter-rater reliability in a randomised controlled study.. *Nurse education today, 159*, 106968. https://doi.org/10.1016/j.nedt.2025.106968

Choi, D.-Y., Park, J., Loeser, M., & Seo, K. (2024). Improving counseling effectiveness with virtual counselors through nonverbal compassion involving eye contact, facial mimicry, and head-nodding. *Scientific Reports, 14*. https://doi.org/10.1038/s41598-023-51115-y

De Gennaro, M., Krumhuber, E. G., & Lucas, G. M. (2020). Effectiveness of an Empathic Chatbot in Combating Adverse Effects of Social Exclusion on Mood. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.03061

Eisenstadt, M., Liverpool, S., Infanti, E., Ciuvat, R., & Carlsson, C. (2021). Mobile Apps That Promote Emotion Regulation, Positive Mental Health, and Well-being in the General Population: Systematic Review and Meta-analysis. *JMIR Mental Health, 8*. https://doi.org/10.2196/31170

Feng, X., Tian, L., Ho, G. W., Yorke, J., & Hui, V. (2025). The Effectiveness of AI Chatbots in Alleviating Mental Distress and Promoting Health Behaviors Among Adolescents and Young Adults: Systematic Review and Meta-Analysis. *Journal of Medical Internet Research, 27*. https://doi.org/10.2196/79850

Feng, Y., Hang, Y., Wu, W., Song, X., Xiao, X., Dong, F., & Qiao, Z. (2024). Effectiveness of AI-Driven Conversational Agents in Improving Mental Health Among Young People: Systematic Review and Meta-Analysis. *Journal of Medical Internet Research, 27*. https://doi.org/10.2196/69639

Gellisch, M., Wolf, O. T., Minkley, N., Kirchner, W., Brüne, M., & Brand-Saberi, B. (2022). Decreased sympathetic cardiovascular influences and hormone-physiological changes in response to Covid-19-related adaptations under different learning environments. *Anatomical Sciences Education, 15*, 811 - 826. https://doi.org/10.1002/ase.2213

Hedman-Lagerlöf, E., Carlbring, P., Svärdman, F., Riper, H., Cuijpers, P., & Andersson, G. (2023). Therapist-supported Internet-based cognitive behaviour therapy yields similar effects as face-to-face therapy for psychiatric and somatic disorders: an updated systematic review and meta-analysis. *World Psychiatry, 22*. https://doi.org/10.1002/wps.21088

Kroczek, L. O. H., & Mühlberger, A. (2025). Neural mechanisms underlying the interactive exchange of facial emotional expressions. *Social Cognitive and Affective Neuroscience, 20*. https://doi.org/10.1093/scan/nsaf001

Levy-Gigi, E., & Shamay-Tsoory, S. (2017). Help me if you can: Evaluating the effectiveness of interpersonal compared to intrapersonal emotion regulation in reducing distress.. *Journal of behavior therapy and experimental psychiatry, 55*, 33-40. https://doi.org/10.1016/j.jbtep.2016.11.008

Liu, Z., Lu, K., Hao, N., & Wang, Y. (2023). Cognitive reappraisal and expressive suppression evoke distinct neural connections during interpersonal emotion regulation.. *The Journal of neuroscience : the official journal of the Society for Neuroscience*. https://doi.org/10.1523/jneurosci.0954-23.2023

Loveys, K., Sagar, M., Zhang, X., Fricchione, G., & Broadbent, E. (2021). Effects of Emotional Expressiveness of a Female Digital Human on Loneliness, Stress, Perceived Support, and Closeness Across Genders: Randomized Controlled Trial. *Journal of Medical Internet Research, 23*. https://doi.org/10.2196/30624

Oveis, C., Gu, Y., Ocampo, J., Hangen, E. J., & Jamieson, J. P. (2018). Emotion regulation contagion: Stress reappraisal promotes challenge responses in teammates.. *Journal of experimental psychology. General*. https://doi.org/10.1037/xge0000757

Palmer, C. E., Marshall, E., Millgate, E., Warren, G., Ewbank, M., Cooper, E., Lawes, S., Smith, A., Hutchins-Joss, C., Young, J., Bouazzaoui, M., Margoum, M., Healey, S., Marshall, L., Mehew, S., Cummins, R., Tablan, V., Catarino, A., Welchman, A. E., & Blackwell, A. D. (2024). Combining Artificial Intelligence and Human Support in Mental Health: Digital Intervention With Comparable Effectiveness to Human-Delivered Care. *Journal of Medical Internet Research, 27*. https://doi.org/10.2196/69351

Schillings, C., Meissner, E., Erb, B., Bendig, E., Schultchen, D., & Pollatos, O. (2023). Effects of a Chatbot-Based Intervention on Stress and Health-Related Parameters in a Stressed Sample: Randomized Controlled Trial. *JMIR Mental Health, 11*. https://doi.org/10.2196/50454

Sharma, A., Lin, I. W., Miner, A. S., Atkins, D. C., & Althoff, T. (2022). Human–AI collaboration enables more empathic conversations in text-based peer-to-peer mental health support. *Nature Machine Intelligence, 5*, 46-57. https://doi.org/10.1038/s42256-022-00593-2

Sheldon, K. M., & Yu, S.-C. (2021). Methods of gratitude expression and their effects upon well-being: Texting may be just as rewarding as and less risky than face-to-face. *The Journal of Positive Psychology, 17*, 690 - 700. https://doi.org/10.1080/17439760.2021.1913639

Spytska, L. (2025). The use of artificial intelligence in psychotherapy: development of intelligent therapeutic systems. *BMC Psychology, 13*. https://doi.org/10.1186/s40359-025-02491-9

Terblanche, N., Molyn, J., De Haan, E., & Nilsson, V. (2022). Comparing artificial intelligence and human coaching goal attainment efficacy. *PLoS ONE, 17*. https://doi.org/10.1371/journal.pone.0270255

Thunström, A. O., Carlsen, H., Ali, L., Larson, T., Hellström, A., & Steingrimsson, S. (2023). Usability Comparison Among Healthy Participants of an Anthropomorphic Digital Human and a Text-Based Chatbot as a Responder to Questions on Mental Health: Randomized Controlled Trial. *JMIR Human Factors, 11*. https://doi.org/10.2196/54581

Wang, Y., & Shi, Y. (2024). Interpersonal emotion regulation and physiological synchrony: cognitive reappraisal versus expressive suppression. *Cognition and Emotion, 39*, 663 - 674. https://doi.org/10.1080/02699931.2024.2371092

Wang, H., Gao, X., Xu, C., & Chen, W. (2025). The enhancement effect of social interaction on emotional contagion: an EEG-Based hyperscanning study. *Social Neuroscience, 20*, 180 - 194. https://doi.org/10.1080/17470919.2025.2535011

Waters, S., Karnilowicz, H., West, T. V., & Mendes, W. (2020). Keep it to yourself? Parent emotion suppression influences physiological linkage and interaction behavior.. *Journal of family psychology : JFP : journal of the Division of Family Psychology of the American Psychological Association*. https://doi.org/10.1037/fam0000664

Yang, X., Huo, Y., Wang, Y., Li, M., Zhang, R., Liu, L., Chen, Y., & Wang, Y. (2026). AI-Enhanced Versus Clinician-Guided Expressive Writing for Improving Psychological Well-Being in Cancer Survivors: A Randomized Controlled Trial. *Psycho-Oncology, 35*. https://doi.org/10.1002/pon.70386

Zhong, W., Luo, J., & Zhang, H. (2024). The therapeutic effectiveness of artificial intelligence-based chatbots in alleviation of depressive and anxiety symptoms in short-course treatments: A systematic review and meta-analysis.. *Journal of affective disorders*. https://doi.org/10.1016/j.jad.2024.04.057

Zhu, T., Zhang, X., Jin, L., Wang, L., & Wang, Y. (2025). Positive resonance: Successful interpersonal emotion regulation facilitated relationship closeness by enhanced inter-brain synchronization. *NeuroImage*, 121042. https://doi.org/10.1016/j.neuroimage.2025.121042