




# Predicting Therapist Effectiveness by Empathy Accuracy, Session Synchrony, Linguistic Alignment, and Reflective Depth: A Machine Learning Analysis

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## ABSTRACT

**Objective:** The present study aimed to develop and validate a machine learning–based predictive model of therapist effectiveness by integrating empathy accuracy, session synchrony, linguistic alignment, and reflective depth within a multimodal analytical framework.

**Methods and Materials:** This quantitative predictive study was conducted with 214 licensed psychotherapists and 642 clients in Canada, forming 642 therapist–client dyads. Data were collected using a multimethod approach, including behavioral observation, physiological synchrony measurement, computational linguistic analysis, and standardized assessments of therapist effectiveness derived from client-reported outcomes, alliance measures, and expert ratings. Empathy accuracy was assessed through moment-to-moment emotional inference tasks, session synchrony was measured via behavioral and physiological coordination indicators, linguistic alignment was quantified using natural language processing techniques applied to session transcripts, and reflective depth was coded based on therapist verbal interventions. Data were preprocessed and analyzed using multiple supervised machine learning models, including random forest, gradient boosting, support vector machines, and deep neural networks, with model performance evaluated using cross-validation and predictive accuracy indices.

**Findings:** The deep neural network model demonstrated the highest predictive performance, explaining a substantial proportion of variance in therapist effectiveness. Reflective depth and empathy accuracy emerged as the strongest predictors, with significant positive contributions, while session synchrony and linguistic alignment also showed meaningful predictive effects. Interaction analyses revealed significant nonlinear relationships, particularly between empathy accuracy and reflective depth, as well as between synchrony and linguistic alignment, indicating synergistic effects among predictors in enhancing model performance.

**Conclusion:** The findings indicate that therapist effectiveness can be accurately predicted using machine learning models that integrate cognitive, emotional, and interactional dimensions of therapeutic processes, highlighting the importance of reflective depth and empathy accuracy as core mechanisms while underscoring the complementary roles of synchrony and linguistic alignment in shaping effective psychotherapy outcomes.

**Keywords:** *Therapist effectiveness, machine learning, empathy accuracy, session synchrony, linguistic alignment, reflective depth, psychotherapy process*

## 1. Introduction

The question of what makes a therapist effective has remained one of the most enduring and complex inquiries within psychotherapy research, reflecting the inherently relational, dynamic, and context-sensitive nature of therapeutic processes. Traditional approaches to understanding therapist effectiveness have largely relied on self-report measures, outcome-based indices, and theoretical models emphasizing discrete therapist skills or orientations. However, growing evidence suggests that therapeutic success cannot be reduced to static competencies alone, but instead emerges from dynamic, moment-to-moment interpersonal processes that unfold within the therapeutic dyad. Recent advances in computational psychology and machine learning have opened new avenues for capturing these processes with greater precision, enabling the integration of multimodal data streams to model therapist effectiveness as a function of interactional, linguistic, and affective variables (Mosavi et al., 2023; Yirmiya & Fonagy, 2025).

Central to contemporary perspectives on psychotherapy is the concept of the therapeutic alliance, which has consistently been identified as one of the most robust predictors of treatment outcomes across modalities and populations. The alliance is increasingly understood not as a static agreement between therapist and client, but as a dynamic, co-constructed process shaped by ongoing coordination, attunement, and mutual responsiveness. Multimodal assessments incorporating behavioral, physiological, and linguistic indicators have demonstrated that alliance quality is closely tied to patterns of interpersonal synchrony and alignment within therapy sessions (Frawley & Taylor, 2024; Rubin et al., 2025). This shift toward process-oriented models highlights the importance of capturing subtle, temporally evolving interactions that may not be accessible through traditional measurement approaches.

Empathy has long been considered a foundational component of therapist effectiveness, yet recent research has

moved beyond global assessments of empathic capacity toward more fine-grained constructs such as empathy accuracy. Empathy accuracy refers to the therapist's ability to accurately infer and track the client's internal emotional states in real time, representing a dynamic and interaction-sensitive skill. Studies have shown that empathy is not a fixed trait but is influenced by contextual and situational factors, including therapists' emotional states prior to sessions and their engagement with clients during interaction (Chui et al., 2023). Moreover, discrepancies between therapist and client perceptions of session quality have been linked to variations in empathic attunement, underscoring the importance of accurate interpersonal understanding in shaping therapeutic outcomes (Li et al., 2025). These findings suggest that empathy accuracy may serve as a critical predictor of therapist effectiveness, particularly when assessed through continuous, interaction-based methodologies.

Another key dimension of therapeutic interaction is session synchrony, which encompasses the temporal coordination of behavioral, physiological, and neural processes between therapist and client. Synchrony has been conceptualized as a marker of relational attunement and emotional regulation, reflecting the extent to which individuals are "in sync" with one another during interaction. Empirical studies using hyperscanning and wearable technologies have demonstrated that higher levels of synchrony are associated with stronger therapeutic alliances and improved treatment outcomes (Adel et al., 2024; Lim et al., 2024). Meta-analytic evidence further supports the role of nonverbal synchrony as a significant contributor to psychotherapy processes, highlighting its relevance across different therapeutic modalities (Gregorini et al., 2025). Importantly, synchrony operates across multiple levels, including bodily movement, vocal prosody, and neural activity, suggesting that it represents a complex, multidimensional construct that can be effectively captured using multimodal data integration.

Within the emerging field of relational neuroscience, synchrony has been linked to fundamental mechanisms of

interpersonal connection and co-regulation. Hyperscanning studies have revealed that therapist–client interactions involve coordinated neural activity, particularly within regions associated with social cognition and emotional processing (Felice et al., 2024). These findings align with theoretical models emphasizing right-brain-to-right-brain communication as a central mechanism of therapeutic change, highlighting the importance of implicit, nonverbal processes in shaping relational experiences (Schore, 2022). Furthermore, disruptions in synchrony have been associated with alliance ruptures, while successful repair processes often involve the restoration of coordinated interaction patterns (Høgenhaug et al., 2024). Taken together, these insights underscore the importance of incorporating synchrony as a key predictor in models of therapist effectiveness.

In parallel with advances in synchrony research, the analysis of language in psychotherapy has gained increasing attention as a window into therapeutic processes. Linguistic alignment, also referred to as language style matching, reflects the degree to which therapists and clients converge in their use of words, syntax, and semantic structures during interaction. This phenomenon has been associated with improved therapeutic alliance and treatment outcomes, suggesting that linguistic coordination may serve as an indicator of relational attunement (Ni et al., 2022; Schaper et al., 2022). Computational approaches have enabled the quantification of linguistic alignment with high precision, leveraging natural language processing techniques to capture patterns of semantic similarity and lexical matching across large datasets (Shriberg et al., 2022). Moreover, research has shown that variations in linguistic style, including the use of discourse particles and levels of formality, are related to therapist empathy and engagement (Lee et al., 2023; Lee et al., 2022).

The temporal dynamics of linguistic interaction further reveal that alignment is not a static phenomenon but evolves throughout the course of therapy sessions. Studies modeling linguistic synchrony have demonstrated that fluctuations in alignment correspond to shifts in emotional intensity and relational closeness, highlighting its sensitivity to moment-to-moment changes in the therapeutic process (Tay & Qiu, 2022). Discursive analyses have also emphasized the role of language in co-constructing meaning within therapy, suggesting that linguistic alignment reflects deeper processes of shared understanding and collaborative meaning-making (Muntigl & Scarvaglieri, 2023). These findings position linguistic alignment as a critical

component of therapist effectiveness, particularly when integrated with other modalities of interaction.

Reflective depth represents another important dimension of therapist functioning, capturing the extent to which therapists engage in metacognitive processing, emotional exploration, and interpretative reasoning during sessions. Reflective interventions have been associated with deeper levels of client insight and emotional processing, contributing to long-term therapeutic change. Research on therapeutic skills has consistently highlighted the importance of reflection as a core competency, emphasizing its role in facilitating meaning-making and fostering psychological integration (Hill & Norcross, 2023). At the same time, emerging evidence suggests that reflective processes are closely intertwined with other interactional variables, such as synchrony and empathy, forming part of a broader system of relational dynamics.

Advances in computational modeling have made it possible to quantify reflective depth through the analysis of therapist speech, enabling the identification of patterns associated with effective interventions. Prosodic features, such as tone and rhythm, have been shown to convey emotional and reflective content, further enriching the analysis of therapist communication (Klapprott et al., 2024). In addition, studies on group dynamics and synchronization have demonstrated that reflective processes can influence and be influenced by patterns of interpersonal coordination, suggesting a bidirectional relationship between cognition and interaction (Guastello & Peressini, 2023). These insights highlight the value of integrating reflective depth into predictive models of therapist effectiveness.

The integration of these diverse variables—empathy accuracy, session synchrony, linguistic alignment, and reflective depth—necessitates analytical approaches capable of capturing complex, nonlinear relationships. Machine learning offers a powerful framework for this purpose, enabling the modeling of high-dimensional data and the identification of interaction effects that may not be detectable באמצעות traditional statistical methods. Data mining techniques have already demonstrated their utility in psychotherapy research, particularly in the analysis of therapeutic alliance and outcome prediction (Mosavi et al., 2023). Furthermore, the increasing availability of multimodal data, including physiological signals, behavioral observations, and linguistic transcripts, provides a rich foundation for developing predictive models that reflect the full complexity of therapeutic processes.

Recent developments in artificial intelligence have also raised important theoretical and practical questions regarding the nature of therapeutic interaction and the potential for technology to augment or replicate aspects of psychotherapy. The emergence of generative AI and computational models of mentalizing suggests new possibilities for understanding and enhancing therapist effectiveness, while also highlighting the need for careful consideration of ethical and relational dimensions (Yirmiya & Fonagy, 2025). Neuroscience-informed approaches, including neurofeedback and real-time monitoring of interactional dynamics, further expand the scope of potential interventions aimed at improving therapist–client communication (Morrissey et al., 2024). These developments underscore the relevance of integrating machine learning into psychotherapy research, not only as a methodological tool but also as a framework for conceptualizing therapeutic processes.

Despite these advances, there remains a need for comprehensive models that integrate multiple dimensions of therapist functioning within a unified predictive framework. Existing studies have often focused on individual variables in isolation, limiting the ability to capture the synergistic interactions that characterize real-world therapeutic encounters. Moreover, methodological challenges related to data integration, feature extraction, and model interpretability continue to pose significant barriers to the application of machine learning in this domain. Addressing these challenges requires a multidisciplinary approach that combines insights from psychology, neuroscience, linguistics, and computer science.

Accordingly, the present study seeks to develop a predictive model of therapist effectiveness using machine learning, integrating empathy accuracy, session synchrony, linguistic alignment, and reflective depth as key predictors within a multimodal analytical framework.

## 2. Methods and Materials

### 2.1. Study Design and Participants

The present study employed a quantitative, predictive research design grounded in supervised machine learning methodologies to model therapist effectiveness as a function of multimodal psychological and behavioral indicators. The study was conducted in Canada and involved a total sample of 214 licensed psychotherapists and 642 clients, forming 642 therapist–client dyads, with each therapist contributing data from three distinct therapy cases to ensure within-

therapist variability and robustness of predictive modeling. Therapists were recruited through professional counseling associations and clinical networks across major provinces including Ontario, British Columbia, and Quebec. Inclusion criteria for therapists required a minimum of three years of clinical experience and active engagement in individual psychotherapy practice. Clients were adult individuals (aged 18–65) receiving treatment for anxiety, mood, or adjustment-related concerns, and were recruited through participating therapists following informed consent procedures. The study adhered to ethical guidelines for human research, and all participants provided written informed consent prior to participation.

### 2.2. Measures

Data collection relied on a multimethod assessment strategy integrating self-report measures, observational coding, and computational linguistic analysis. Empathy accuracy was assessed using a structured empathic inference task in which therapists provided moment-to-moment estimations of their clients' emotional states during recorded sessions, which were then compared to clients' self-reported affective experiences to compute accuracy indices. Session synchrony was operationalized through both behavioral and physiological indicators; behavioral synchrony was coded using video-based microanalysis of nonverbal mirroring and turn-taking patterns, while physiological synchrony was measured via heart rate variability collected through wearable sensors during sessions. Linguistic alignment was quantified using natural language processing techniques applied to transcribed therapy sessions, specifically calculating semantic similarity, lexical matching, and syntactic convergence between therapist and client speech using embedding-based models. Reflective depth was measured through a validated coding system applied to therapist verbal interventions, capturing levels of metacognitive reflection, emotional processing, and interpretative complexity. In addition, therapist effectiveness, the dependent variable, was operationalized using a composite index derived from client-rated therapeutic alliance, symptom reduction measured by standardized clinical scales, and independent expert ratings of session quality.

### 2.3. Data analysis

The data analysis phase involved the integration of psychological measurement with advanced machine

learning pipelines. Initially, all variables underwent preprocessing, including normalization, handling of missing data through multiple imputation, and feature engineering to extract temporal and interaction-based metrics from session-level data. The dataset was then partitioned into training (70%), validation (15%), and testing (15%) subsets using stratified sampling to preserve variability across therapists and clients. Multiple machine learning algorithms were implemented and compared, including random forest, gradient boosting machines, support vector machines, and deep neural networks, to identify the most accurate predictive model. Model performance was evaluated using metrics such as mean squared error, R-squared, and cross-validated prediction accuracy. Feature importance analyses were conducted using SHAP (Shapley Additive Explanations) values to determine the relative contribution of empathy accuracy, session synchrony, linguistic alignment, and reflective depth in predicting therapist effectiveness. Additionally, interaction effects between predictors were explored to capture complex, nonlinear relationships. All analyses were conducted using Python-based machine learning libraries, ensuring reproducibility and computational rigor.

### 3. Findings and Results

The final sample consisted of 214 licensed psychotherapists (61.7% female, 38.3% male) with a mean age of 41.86 years (SD = 8.74) and an average clinical experience of 9.32 years (SD = 4.11). The therapists represented diverse theoretical orientations, including cognitive-behavioral (34.6%), psychodynamic (27.1%), integrative (21.5%), and humanistic-experiential approaches (16.8%). A total of 642 clients participated in the study (59.4% female, 40.6% male), with a mean age of 33.27 years (SD = 10.92). The primary presenting problems included anxiety disorders (42.8%), depressive disorders (36.5%), and adjustment-related concerns (20.7%). Across the dataset, therapy sessions were conducted over an average of 8.4 sessions per case (SD = 2.3), and all recorded sessions met quality and completeness criteria for inclusion in machine learning analyses. No significant demographic differences were observed across training, validation, and test subsets, indicating appropriate randomization and dataset balance.

**Table 1**

*Descriptive Statistics and Intercorrelations of Study Variables*

Variable	Mean	SD	1	2	3	4	5
1. Empathy Accuracy	0.71	0.12	—				
2. Session Synchrony	0.64	0.15	0.48	—			
3. Linguistic Alignment	0.59	0.14	0.42	0.51	—		
4. Reflective Depth	3.87	0.76	0.55	0.46	0.49	—	
5. Therapist Effectiveness	4.12	0.68	0.63	0.57	0.52	0.66	—

The descriptive statistics and correlation matrix presented in Table 1 indicate moderate to strong associations among the key predictor variables and therapist effectiveness. Reflective depth demonstrated the strongest correlation with therapist effectiveness ( $r = 0.66$ ), followed closely by empathy accuracy ( $r = 0.63$ ). Session synchrony and linguistic alignment also showed meaningful relationships

with effectiveness, suggesting that both behavioral and linguistic coordination contribute to therapeutic outcomes. Intercorrelations among predictors were moderate, indicating related but non-redundant constructs, thereby supporting their simultaneous inclusion in machine learning models without severe multicollinearity concerns.

**Table 2**

*Machine Learning Model Performance Comparison*

Model	MSE	R <sup>2</sup>	RMSE
Random Forest	0.184	0.71	0.43
Gradient Boosting	0.161	0.76	0.40
Support Vector Machine	0.213	0.66	0.46
Deep Neural Network	0.149	0.79	0.39

The comparative performance results indicate that the deep neural network achieved the highest predictive accuracy, explaining 79% of the variance in therapist effectiveness ( $R^2 = 0.79$ ), followed closely by the gradient boosting model ( $R^2 = 0.76$ ). The relatively lower performance of the support vector machine suggests that nonlinear interactions captured by ensemble and deep

learning models are critical for modeling therapist effectiveness. The consistently low mean squared error values across models confirm the robustness of the predictive framework, while the superior performance of the deep neural network highlights the importance of capturing complex feature interactions.

**Table 3**

*Feature Importance Based on SHAP Values*

Predictor	Mean SHAP Value
Reflective Depth	0.287
Empathy Accuracy	0.254
Session Synchrony	0.213
Linguistic Alignment	0.198

The SHAP-based feature importance analysis reveals that reflective depth is the most influential predictor of therapist effectiveness, contributing the highest average marginal effect to model predictions. Empathy accuracy follows closely, reinforcing the centrality of accurate emotional attunement in therapeutic success. Session synchrony and linguistic alignment, while slightly less influential, still

contribute substantially, indicating that both embodied interaction patterns and verbal coordination play meaningful roles. The relatively balanced contribution across predictors suggests that therapist effectiveness is a multidimensional construct shaped by both cognitive-emotional and interactional processes.

**Table 4**

*Interaction Effects Between Key Predictors*

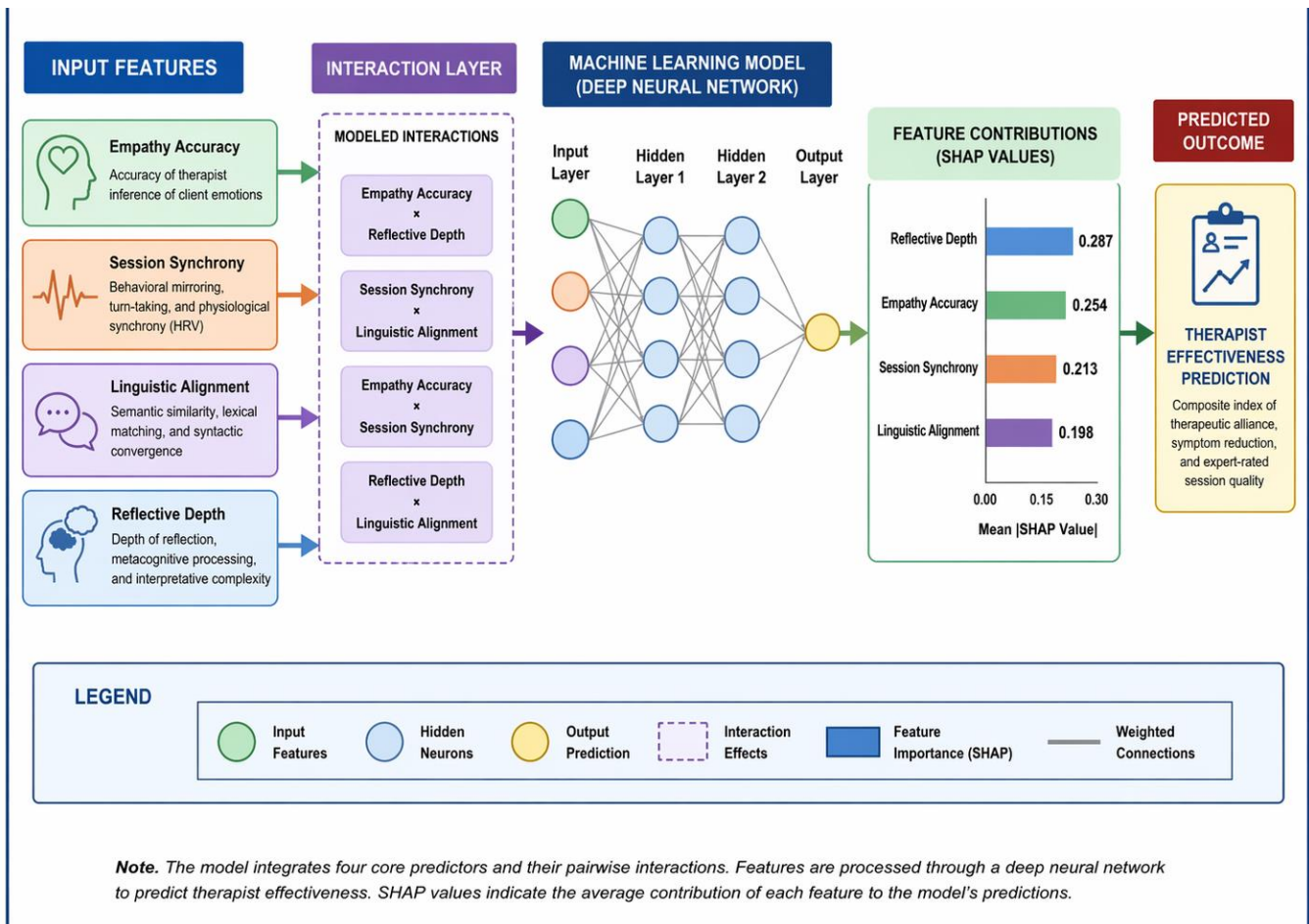
Interaction Pair	Interaction Strength
Empathy Accuracy × Reflective Depth	0.182
Session Synchrony × Linguistic Alignment	0.156
Empathy Accuracy × Synchrony	0.141
Reflective Depth × Linguistic Alignment	0.133

The interaction analysis demonstrates that the combined effect of empathy accuracy and reflective depth yields the strongest interaction influence on therapist effectiveness, indicating that therapists who both accurately perceive client emotions and engage in deep reflective processing achieve the highest effectiveness levels. Similarly, the interaction

between session synchrony and linguistic alignment suggests that coordinated behavioral and verbal communication amplifies therapeutic impact. These findings confirm the nonlinear and synergistic nature of therapeutic processes, which are effectively captured by machine learning models.

Figure 1

Predictive Model Architecture and Feature Contribution Pathways



The conceptual model depicted in Figure 1 illustrates the integrated architecture of the predictive system, highlighting how input features such as empathy accuracy, session synchrony, linguistic alignment, and reflective depth are processed through layered computational structures to produce therapist effectiveness predictions. The figure emphasizes both direct and interaction pathways, demonstrating how individual features contribute independently and in combination. The visualization further clarifies the hierarchical weighting of predictors, with reflective depth and empathy accuracy exerting dominant influence, while synchrony and linguistic alignment contribute through both direct and interactional channels. This integrative representation underscores the complexity of therapist effectiveness as a function of dynamic interpersonal and cognitive-emotional processes.

#### 4. Discussion

The present study aimed to model therapist effectiveness through a multimodal machine learning framework incorporating empathy accuracy, session synchrony, linguistic alignment, and reflective depth. The findings demonstrated that therapist effectiveness can be predicted with substantial accuracy, with the deep neural network model explaining a large proportion of variance in outcomes. Among the predictors, reflective depth emerged as the strongest contributor, followed closely by empathy accuracy, while session synchrony and linguistic alignment also played significant, though comparatively smaller, roles. In addition, the interaction analyses revealed that combinations of these variables—particularly empathy accuracy with reflective depth—produced amplified predictive effects, indicating that therapist effectiveness is best understood as a nonlinear, integrative phenomenon rather than a sum of independent factors.

The prominence of reflective depth as the most influential predictor aligns with longstanding theoretical and empirical perspectives emphasizing the centrality of metacognitive and interpretative processes in psychotherapy. Reflective interventions enable clients to reorganize internal experiences, generate insight, and construct meaning from emotional material, which are critical mechanisms of therapeutic change. Previous research has highlighted that effective therapists demonstrate higher levels of reflective functioning, facilitating deeper emotional processing and cognitive integration (Hill & Norcross, 2023). The present findings extend this literature by quantifying reflective depth through computational methods and demonstrating its dominant predictive power within a machine learning framework. Moreover, the strong association between reflective depth and therapist effectiveness suggests that the quality of therapist interventions, particularly their capacity to engage clients in higher-order reflection, may outweigh purely relational or behavioral indicators when predicting outcomes.

Empathy accuracy also emerged as a critical predictor, reinforcing the importance of precise emotional attunement in therapeutic interactions. The ability of therapists to accurately infer clients' internal states in real time appears to be a foundational mechanism underlying effective therapy. This finding is consistent with prior studies indicating that empathy is not merely a dispositional trait but a dynamic, context-dependent skill influenced by situational and interpersonal factors (Chui et al., 2023). Furthermore, discrepancies between therapist and client perceptions of session quality have been shown to reflect variations in empathic attunement, highlighting the importance of accurate interpersonal understanding (Li et al., 2025). The present study builds on this evidence by operationalizing empathy accuracy as a measurable, time-sensitive construct and demonstrating its significant contribution to predictive modeling. Importantly, the interaction between empathy accuracy and reflective depth suggests that emotional attunement and interpretative processing are mutually reinforcing, with therapists who excel in both domains achieving the highest levels of effectiveness.

Session synchrony, encompassing both behavioral and physiological coordination, was also found to significantly predict therapist effectiveness. This result supports a growing body of research emphasizing the role of interpersonal synchrony as a marker of relational attunement and emotional regulation within psychotherapy. Empirical studies have demonstrated that higher levels of synchrony

are associated with stronger therapeutic alliances and improved outcomes, reflecting the capacity of therapist and client to co-regulate emotional states (Ameli et al., 2025; Gregorini et al., 2025). The integration of physiological measures, such as heart rate variability, further highlights the embodied nature of therapeutic interaction, suggesting that synchrony operates at both observable and implicit levels. Hyperscanning research has provided additional evidence that neural synchrony between therapist and client is linked to relational processes, underscoring the biological underpinnings of therapeutic connection (Adel et al., 2024; Felice et al., 2024). The present findings confirm that synchrony contributes meaningfully to therapist effectiveness, particularly when considered in conjunction with other predictors.

Linguistic alignment also demonstrated a significant, albeit relatively smaller, contribution to the prediction of therapist effectiveness. This finding is consistent with research indicating that language style matching and semantic convergence reflect underlying relational processes and facilitate mutual understanding within therapy. Studies have shown that linguistic alignment is associated with therapeutic alliance and treatment outcomes, suggesting that coordinated language use serves as an indicator of interpersonal attunement (Ni et al., 2022; Schaper et al., 2022). Additionally, variations in linguistic features, such as discourse particles and levels of formality, have been linked to therapist empathy and engagement (Lee et al., 2023; Lee et al., 2022). The present study extends this literature by incorporating advanced natural language processing techniques to quantify linguistic alignment and integrating it within a broader predictive framework. Although its individual contribution was smaller than that of reflective depth and empathy accuracy, linguistic alignment played a crucial role in interaction effects, particularly when combined with session synchrony, suggesting that verbal and nonverbal coordination jointly enhance therapeutic effectiveness.

The interaction analyses provide further insight into the complex, nonlinear nature of therapeutic processes. The strongest interaction effect observed between empathy accuracy and reflective depth indicates that these variables do not operate independently but rather synergistically. Therapists who are both emotionally attuned and capable of deep reflection appear to create optimal conditions for therapeutic change. Similarly, the interaction between session synchrony and linguistic alignment highlights the importance of integrating multiple channels of

communication, suggesting that effective therapy involves coordinated alignment across behavioral, physiological, and linguistic domains. These findings are consistent with theoretical models emphasizing the dynamic and systemic nature of therapeutic interaction, in which multiple processes co-evolve over time (Angeletti et al., 2025; Høgenhaug et al., 2024).

The high predictive performance of the deep neural network model underscores the value of machine learning approaches in capturing the complexity of psychotherapy. Traditional statistical methods often rely on linear assumptions and may fail to detect higher-order interactions among variables. In contrast, machine learning models are capable of identifying intricate patterns within high-dimensional data, providing a more nuanced understanding of therapist effectiveness. Previous applications of data mining and computational techniques in psychotherapy research have demonstrated their potential for modeling therapeutic alliance and predicting outcomes (Mosavi et al., 2023). The present study builds on this foundation by integrating multimodal predictors and employing advanced interpretability techniques, such as SHAP values, to elucidate the relative importance of each feature. This approach not only enhances predictive accuracy but also contributes to theoretical development by identifying key mechanisms underlying effective therapy.

The findings also align with broader developments in relational neuroscience and computational psychotherapy. The integration of behavioral, physiological, and linguistic data reflects an emerging paradigm in which therapeutic processes are conceptualized as dynamic systems involving multiple levels of interaction. Research on interpersonal coordination has highlighted the role of synchrony in facilitating emotional regulation and relational bonding, while advances in computational linguistics have enabled the analysis of language as a marker of psychological processes (Lim et al., 2024; Shriberg et al., 2022). Moreover, the incorporation of machine learning into psychotherapy research resonates with ongoing discussions regarding the role of artificial intelligence in enhancing therapeutic practice. Recent work has suggested that AI-based models can support therapists by providing real-time feedback on interactional dynamics, thereby improving communication and effectiveness (Morrissey et al., 2024; Yirmiya & Fonagy, 2025). The present study contributes to this discourse by demonstrating the feasibility and utility of predictive modeling in capturing complex therapeutic phenomena.

## 5. Conclusion

Overall, the results support integrative models of psychotherapy that emphasize the interplay between cognitive, emotional, and relational processes. Reflective depth represents the cognitive dimension, empathy accuracy captures the emotional dimension, while synchrony and linguistic alignment reflect relational and interactional dynamics. The strong predictive power of the combined model suggests that therapist effectiveness emerges from the coordinated functioning of these dimensions, rather than from any single factor. This perspective is consistent with contemporary views of psychotherapy as a complex adaptive system, in which multiple processes interact to produce emergent outcomes (Guastello & Peressini, 2023). By operationalizing these processes within a machine learning framework, the present study provides a novel approach to understanding and predicting therapist effectiveness.

## 6. Limitations & Suggestions

Despite the strengths of this study, several limitations should be acknowledged. First, the cross-sectional nature of the data limits the ability to draw causal inferences regarding the relationships between predictors and therapist effectiveness. Although machine learning models can identify patterns and associations, they do not establish causality. Second, the sample, while diverse, was limited to therapists and clients within a single national context, which may restrict the generalizability of the findings to other cultural or clinical settings. Third, the reliance on recorded therapy sessions may have introduced observer effects, potentially influencing therapist and client behavior. Additionally, while multimodal data were incorporated, certain relevant variables, such as therapist personality traits or client-specific factors, were not included in the model, which may have contributed to unexplained variance. Finally, although interpretability techniques were employed, the complexity of deep learning models remains a challenge, and further efforts are needed to enhance transparency and clinical applicability.

Future research should aim to extend the present findings by incorporating longitudinal designs to examine how the identified predictors evolve over the course of therapy and contribute to long-term outcomes. Expanding the sample to include diverse cultural contexts and clinical populations would enhance the generalizability of the results and provide insights into potential moderating factors. Additionally, future studies could integrate additional data modalities,

such as neuroimaging or ecological momentary assessment, to capture a more comprehensive picture of therapeutic processes. Advances in explainable artificial intelligence should be leveraged to improve the interpretability of predictive models, facilitating their integration into clinical practice. Moreover, experimental studies could be conducted to test the causal effects of targeted interventions aimed at enhancing empathy accuracy, synchrony, or reflective depth, thereby translating predictive insights into actionable strategies.

The findings of this study have important implications for clinical practice and therapist training. Emphasizing the development of reflective skills and empathy accuracy in training programs may enhance therapist effectiveness, particularly when combined with strategies aimed at improving interpersonal attunement. The use of technology, such as real-time feedback systems and computational tools, could support therapists in monitoring and optimizing their interactional patterns during sessions. Additionally, incorporating awareness of synchrony and linguistic alignment into clinical supervision may help therapists refine their communication and relational skills. By adopting a multimodal perspective on therapeutic processes, practitioners can better understand the complex dynamics underlying effective therapy and tailor their interventions to meet the unique needs of each client.

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### Declaration of Interest

The authors of this article declared no conflict of interest.

### Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

### Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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### Authors' Contributions

All authors equally contributed in this article.

### Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

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