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AI-Based Prediction of Social Anxiety: Interactions Among Intolerance of Uncertainty, Self-Focused Attention, Safety Behaviors, and Fear of Evaluation

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A B S T R A C T

Objective: The present study aimed to develop and evaluate an artificial intelligence-based predictive model of social anxiety severity by examining the individual and interactive effects of intolerance of uncertainty, self-focused attention, safety behaviors, and fear of evaluation.

Methods and Materials: This cross-sectional predictive study was conducted on a sample of 412 young adults recruited from universities and community settings in Canada. Participants completed standardized self-report measures assessing social anxiety, intolerance of uncertainty, self-focused attention, safety behaviors, and fear of evaluation. Data were collected through an online survey platform and subjected to preprocessing procedures including missing data imputation, outlier management, and feature standardization. The dataset was divided into training and testing subsets, and multiple machine learning algorithms, including Random Forest, Support Vector Machine, and Extreme Gradient Boosting (XGBoost), were implemented to predict social anxiety severity. Model performance was evaluated using R^2, root mean square error (RMSE), and mean absolute error (MAE), while SHAP (Shapley Additive Explanations) analysis was employed to interpret feature importance and interaction effects among predictors.

Findings: The results indicated that all predictors were significantly associated with social anxiety, with fear of evaluation emerging as the strongest predictor, followed by safety behaviors, intolerance of uncertainty, and self-focused attention. Among the tested models, XGBoost demonstrated the highest predictive accuracy ($R^2 = 0.74$), outperforming Random Forest and Support Vector Machine. Interaction analyses revealed that fear of evaluation combined with safety behaviors, as well as intolerance of uncertainty combined with self-focused attention, exerted the strongest synergistic effects on social anxiety severity, indicating the presence of nonlinear and interaction-based relationships among variables.

Conclusion: The findings underscore the importance of integrating cognitive and behavioral mechanisms in understanding social anxiety and highlight the utility of machine learning approaches in capturing complex interactions among psychological predictors. The study provides evidence for the central role of fear of evaluation and safety behaviors, particularly in interaction with intolerance of uncertainty and self-focused attention, and suggests that AI-based models can enhance predictive accuracy and inform personalized intervention strategies for social anxiety.

Keywords: *Social Anxiety; Intolerance of Uncertainty; Self-Focused Attention; Safety Behaviors; Fear of Evaluation*

1. Introduction

Social anxiety is a pervasive and debilitating psychological condition characterized by an intense fear of social situations in which individuals may be scrutinized, evaluated, or judged by others. It is associated with significant impairments in interpersonal functioning, academic performance, and overall quality of life, particularly among young adults and university populations. Contemporary cognitive-behavioral models conceptualize social anxiety as a multifaceted construct emerging from the interaction of maladaptive cognitive processes, heightened emotional reactivity, and avoidance-based behavioral strategies (Craske et al., 2022; White & Cheung, 2021). In recent years, there has been increasing scholarly interest in identifying the underlying mechanisms that contribute to the onset and maintenance of social anxiety, particularly through the integration of advanced analytical approaches such as machine learning, which allow for the modeling of complex, nonlinear interactions among psychological variables.

One of the most prominent cognitive constructs implicated in anxiety disorders is intolerance of uncertainty, defined as a dispositional incapacity to endure the aversive response triggered by the perceived absence of key, sufficient, or sustaining information. Individuals with high intolerance of uncertainty tend to interpret ambiguous situations as threatening, thereby amplifying anticipatory anxiety and avoidance behaviors (Moloodi et al., 2021; Morriss et al., 2022). Empirical evidence suggests that intolerance of uncertainty is not only central to generalized anxiety disorder but also plays a critical role in social anxiety by influencing how individuals perceive and respond to uncertain social cues (Chigwedere & Moran, 2022; Nishikawa et al., 2022). For instance, individuals high in intolerance of uncertainty are more likely to engage in catastrophic interpretations of social ambiguity, leading to heightened fear of negative evaluation and increased social withdrawal (Spiroiu & Maranzan, 2025; Uzun et al., 2025).

Fear of evaluation, particularly fear of negative evaluation, represents a core feature of social anxiety and has been extensively studied within cognitive frameworks. It refers to the apprehension and distress associated with the possibility of being judged unfavorably by others. This construct is closely linked to attentional biases, interpretive distortions, and heightened self-monitoring, all of which contribute to the maintenance of social anxiety symptoms (Bui & Moscovitch, 2024; Grant et al., 2021). Research indicates that fear of evaluation operates not only as a direct predictor of social anxiety but also as a mediator between broader cognitive vulnerabilities, such as intolerance of uncertainty, and anxiety outcomes (Spiroiu & Maranzan, 2025). Moreover, the social environment, particularly in contexts characterized by ambiguity or unpredictability, can exacerbate fear of evaluation, further intensifying anxiety responses.

Another critical cognitive mechanism in social anxiety is self-focused attention, which involves excessive monitoring of one's internal states, thoughts, and behaviors during social interactions. According to cognitive models, heightened self-focused attention disrupts the processing of external social cues and reinforces negative self-perceptions, thereby perpetuating anxiety (White & Cheung, 2021). Individuals with social anxiety tend to allocate disproportionate attentional resources to internal sensations, such as physiological arousal or perceived social inadequacies, which can lead to increased self-consciousness and impaired social performance. This inward attentional bias is often triggered in situations characterized by uncertainty or evaluative threat, suggesting a dynamic interaction between self-focused attention and other cognitive vulnerabilities such as intolerance of uncertainty and fear of evaluation (Nishikawa et al., 2022).

Behavioral responses, particularly safety behaviors, constitute another fundamental component in the maintenance of social anxiety. Safety behaviors are defined as actions or strategies employed to prevent, minimize, or cope with perceived social threats. While these behaviors

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may provide short-term relief, they ultimately reinforce anxiety by preventing individuals from disconfirming their negative beliefs about social situations (Reilly et al., 2021; Schenkel et al., 2021). Examples of safety behaviors include avoiding eye contact, rehearsing sentences mentally, or excessively seeking reassurance from others. Recent research has highlighted the complex role of safety behaviors, suggesting that their effectiveness may vary depending on contextual factors and individual differences, particularly in relation to intolerance of uncertainty and perceived threat levels (Church et al., 2022; Jessup et al., 2022). Furthermore, avoidance learning mechanisms have been shown to contribute to the persistence of safety behaviors, thereby sustaining anxiety over time (Wong et al., 2023).

The global context of uncertainty, particularly during the COVID-19 pandemic, has further underscored the relevance of these cognitive and behavioral processes in understanding anxiety disorders. Studies conducted during this period have consistently demonstrated elevated levels of anxiety, driven in part by increased uncertainty, perceived threat, and social isolation (Akan, 2024; Andreatta et al., 2023). Intolerance of uncertainty has emerged as a key mediator in the relationship between perceived unsafety and psychological distress, highlighting its central role in anxiety-related processes (Assaf, 2025; Bulut, 2022). Additionally, pandemic-related stressors have been associated with increased reliance on safety behaviors and heightened fear of evaluation, particularly in socially uncertain environments (Han et al., 2022; Shabani et al., 2022).

Beyond situational factors, recent research has also explored the broader psychological consequences of uncertainty, including its impact on mental health outcomes such as depression, loneliness, and health anxiety. For example, intolerance of uncertainty has been linked to increased cyberchondria, a phenomenon characterized by excessive online health-related searching, which in turn exacerbates anxiety symptoms (Mestre-Bach & Potenza, 2023; Wu et al., 2021). Similarly, uncertainty-related distress has been shown to negatively affect sleep quality and emotional well-being, further contributing to the development and maintenance of anxiety disorders (Gu et al., 2021; Meulders et al., 2021). These findings underscore the multifaceted nature of uncertainty as a transdiagnostic risk factor, influencing a wide range of psychological processes.

Despite the substantial body of research examining individual predictors of social anxiety, there remains a critical gap in understanding how these variables interact dynamically to influence anxiety outcomes. Traditional statistical methods, while valuable, are often limited in their ability to capture complex, nonlinear relationships and high-order interactions among multiple predictors. In this context, machine learning approaches offer a powerful alternative, enabling the integration of diverse data sources and the identification of intricate patterns that may not be detectable באמצעות conventional analyses. Recent studies have demonstrated the utility of machine learning in predicting mental health outcomes, highlighting its potential to enhance both theoretical understanding and clinical practice (Hudson et al., 2022; Zhou et al., 2022).

Moreover, the application of explainable artificial intelligence techniques, such as SHAP (Shapley Additive Explanations), allows researchers to interpret model outputs and quantify the contribution of individual predictors, thereby bridging the gap between predictive accuracy and theoretical insight. This is particularly important in the context of social anxiety, where multiple cognitive and behavioral factors interact in complex ways to influence symptom severity. By leveraging these advanced analytical tools, researchers can gain a more nuanced understanding of the mechanisms underlying social anxiety and identify key targets for intervention.

In summary, the existing literature highlights the central roles of intolerance of uncertainty, self-focused attention, safety behaviors, and fear of evaluation in the development and maintenance of social anxiety. However, there is a need for integrative approaches that examine the interplay among these variables within a unified predictive framework. The present study aims to address this gap by employing machine learning techniques to model the severity of social anxiety based on these key predictors, thereby providing a comprehensive and data-driven understanding of their interactions.

The aim of this study is to develop and evaluate an AI-based predictive model of social anxiety severity by examining the interactive effects of intolerance of uncertainty, self-focused attention, safety behaviors, and fear of evaluation.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a cross-sectional predictive design grounded in a machine learning framework to model the severity of social anxiety symptoms based on multiple

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cognitive-behavioral predictors. The study population consisted of 412 participants recruited from universities and community settings across Ontario and British Columbia in Canada. Participants were selected using a stratified random sampling approach to ensure adequate representation across gender, age groups, and academic backgrounds. Inclusion criteria required participants to be between 18 and 35 years old, fluent in English, and without a current diagnosis of severe psychiatric disorders such as psychosis or bipolar disorder. Individuals currently undergoing intensive psychiatric treatment or pharmacotherapy for anxiety disorders were excluded to minimize confounding effects.

2.2. Measures

Data were collected using a comprehensive battery of standardized and psychometrically validated self-report instruments. Social anxiety was assessed using the Social Interaction Anxiety Scale (SIAS), which measures distress in social interaction contexts and has demonstrated strong internal consistency and construct validity. Intolerance of uncertainty was measured using the Intolerance of Uncertainty Scale–Short Form (IUS-12), capturing both prospective and inhibitory anxiety dimensions. Self-focused attention was assessed through the Self-Consciousness Scale–Revised (SCS-R), particularly focusing on the private self-consciousness subscale. Safety behaviors were evaluated using the Subtle Avoidance Frequency Examination (SAFE), which quantifies the frequency and reliance on behavioral strategies aimed at reducing perceived social threat. Fear of evaluation was measured using the Brief Fear of Negative Evaluation Scale (BFNE), a widely used instrument assessing apprehension about others' judgments. Demographic data including age, gender, educational level, and socioeconomic status were also collected. All instruments demonstrated acceptable reliability coefficients (Cronbach's alpha > 0.80) in the current sample. Data collection was conducted through a secure online survey platform, ensuring anonymity and reducing response bias.

2.3. Data analysis

Data analysis was conducted using a hybrid approach combining traditional statistical preprocessing and advanced machine learning techniques. Initially, data were screened for missing values, outliers, and normality assumptions. Missing data were handled using multiple imputation, while outliers were assessed through Mahalanobis distance and winsorized where necessary. Feature scaling was performed using standardization (z-scores) to ensure comparability across variables. The dataset was then partitioned into training (70%) and testing (30%) subsets using stratified sampling to preserve the distribution of social anxiety severity levels. Several machine learning algorithms were implemented, including Random Forest, Support Vector Machine (SVM) with radial basis kernel, and Extreme Gradient Boosting (XGBoost), to predict social anxiety scores. Model performance was evaluated using cross-validation (5-fold) and assessed based on metrics including R^2, root mean square error (RMSE), and mean absolute error (MAE). Hyperparameter tuning was conducted using grid search optimization. To enhance interpretability, Shapley Additive Explanations (SHAP) were applied to determine the relative importance and interaction effects of predictors, particularly examining how intolerance of uncertainty, self-focused attention, safety behaviors, and fear of evaluation jointly contributed to social anxiety prediction. All analyses were conducted using Python (version 3.10) with libraries including Scikit-learn, XGBoost, and SHAP, ensuring reproducibility and robustness of findings.

3. Findings and Results

The final sample consisted of 412 participants. The mean age of the participants was 24.37 years (SD = 4.82), ranging from 18 to 35 years. In terms of gender distribution, 218 participants (52.91%) identified as female, 186 (45.15%) as male, and 8 (1.94%) as non-binary or preferred not to disclose. Regarding educational status, 271 participants (65.78%) were undergraduate students, 96 (23.30%) were graduate students, and 45 (10.92%) were employed individuals not currently enrolled in academic programs. Socioeconomic status, assessed through self-report, indicated that 124 participants (30.10%) reported low income, 198 (48.06%) reported average income, and 90 (21.84%) reported high income levels. The majority of participants (78.64%) were single, while 21.36% reported being in a committed relationship. The overall mean score for social anxiety (SIAS) in the sample was 36.58 (SD = 11.27), indicating moderate levels of social anxiety across the sample.

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Table 1

Descriptive Statistics and Correlations Among Study Variables

Variable	Mean	SD	1	2	3	4	5
1. Social Anxiety	36.58	11.27	1				
2. Intolerance of Uncertainty	28.91	7.84	0.61**	1			
3. Self-Focused Attention	31.47	6.92	0.54**	0.49**	1		
4. Safety Behaviors	42.36	9.15	0.66**	0.58**	0.52**	1	
5. Fear of Evaluation	27.84	8.03	0.72**	0.63**	0.57**	0.69**	1

Table 1 presents the descriptive statistics and Pearson correlation coefficients among the primary study variables. As shown, all predictor variables demonstrated moderate to strong positive correlations with social anxiety. Fear of evaluation exhibited the strongest correlation with social anxiety ($r = 0.72$, $p < .01$), followed by safety behaviors ($r = 0.66$, $p < .01$), intolerance of uncertainty ($r = 0.61$, $p < .01$), and self-focused attention ($r = 0.54$, $p < .01$). Additionally, the intercorrelations among predictors were statistically significant, indicating potential multicollinearity; however, subsequent variance inflation factor (VIF) analyses confirmed that all values remained below the critical threshold of 5, supporting the suitability of these variables for inclusion in machine learning models. The distribution of variables approximated normality following preprocessing procedures.

Table 2

Performance Metrics of Machine Learning Models for Predicting Social Anxiety

Model	R^2	RMSE	MAE
Random Forest	0.68	6.12	4.85
Support Vector Machine	0.64	6.58	5.11
XGBoost	0.74	5.47	4.29

Table 2 summarizes the predictive performance of the three machine learning models. Among the tested algorithms, XGBoost demonstrated the highest predictive accuracy, accounting for 74% of the variance in social anxiety scores ($R^2 = 0.74$), with the lowest RMSE (5.47) and MAE (4.29). The Random Forest model also showed strong performance ($R^2 = 0.68$), whereas the Support Vector Machine exhibited comparatively lower predictive accuracy ($R^2 = 0.64$). These results indicate that ensemble-based gradient boosting methods outperform other models in capturing complex nonlinear relationships among psychological predictors.

Table 3

Feature Importance Based on XGBoost Model

Predictor	Importance Score
Fear of Evaluation	0.34
Safety Behaviors	0.27
Intolerance of Uncertainty	0.21
Self-Focused Attention	0.18

Table 3 presents the relative importance of predictors derived from the XGBoost model. Fear of evaluation emerged as the most influential predictor (importance = 0.34), followed by safety behaviors (0.27), intolerance of uncertainty (0.21), and self-focused attention (0.18). These findings suggest that cognitive-affective concerns related to negative social judgment play a central role in determining social anxiety severity, with behavioral avoidance strategies and uncertainty-related cognition also contributing substantially.

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Table 4

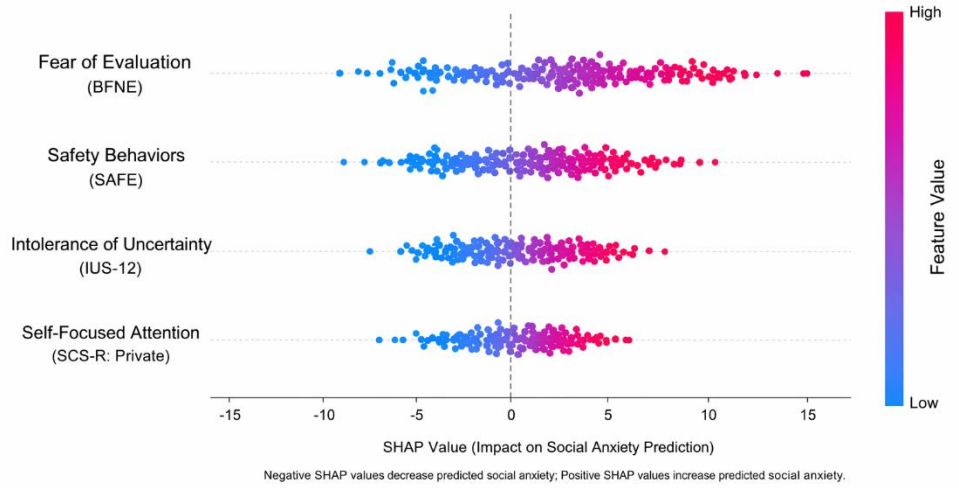
SHAP Interaction Effects Among Key Predictors

Interaction Pair	SHAP Interaction Value
Fear of Evaluation × Safety Behaviors	0.19
Intolerance of Uncertainty × Self-Focused Attention	0.15
Safety Behaviors × Self-Focused Attention	0.13
Fear of Evaluation × Intolerance of Uncertainty	0.17

Table 4 illustrates the interaction effects among predictors based on SHAP values. The strongest interaction was observed between fear of evaluation and safety behaviors (0.19), indicating that individuals with high fear of evaluation who also engage frequently in safety behaviors exhibit disproportionately higher levels of social anxiety. Similarly, intolerance of uncertainty and self-focused attention showed a notable interaction effect (0.15), suggesting a synergistic cognitive mechanism wherein heightened internal monitoring amplifies uncertainty-related distress.

Figure 1

SHAP Summary Plot of Predictor Contributions to Social Anxiety



The SHAP summary plot demonstrates the distribution and magnitude of each predictor's contribution to social anxiety predictions across all participants. Fear of evaluation consistently exhibited the highest impact, with higher values strongly associated with increased predicted social anxiety scores. Safety behaviors and intolerance of uncertainty also showed substantial contributions, particularly in higher ranges of the variables. Self-focused attention displayed a more moderate but still meaningful influence, with its effects becoming more pronounced in interaction with other predictors. The figure further illustrates the nonlinear and interaction-based structure of the predictive model, highlighting the advantage of machine learning approaches in capturing complex psychological dynamics beyond linear assumptions.

4. Discussion

The present study aimed to develop an AI-based predictive model of social anxiety severity by examining the interactive roles of intolerance of uncertainty, self-focused attention, safety behaviors, and fear of evaluation. The findings demonstrated that all four predictors were significantly and positively associated with social anxiety, with fear of evaluation emerging as the most influential variable, followed by safety behaviors, intolerance of uncertainty, and self-focused attention. Furthermore, the machine learning analysis revealed that the XGBoost model provided the highest predictive accuracy, explaining a substantial proportion of variance in social anxiety scores. Importantly, interaction analyses using SHAP values indicated that combinations of cognitive and behavioral

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variables—particularly fear of evaluation with safety behaviors, and intolerance of uncertainty with self-focused attention—exerted synergistic effects on social anxiety severity.

The strong predictive role of fear of evaluation is consistent with established cognitive-behavioral models, which conceptualize it as the central mechanism underlying social anxiety. Individuals who anticipate negative judgment from others are more likely to engage in maladaptive cognitive processing, including attentional biases and interpretive distortions, which intensify anxiety responses (Bui & Moscovitch, 2024; Grant et al., 2021). The present findings extend this literature by demonstrating that fear of evaluation not only directly predicts social anxiety but also interacts dynamically with behavioral strategies such as safety behaviors. This interaction suggests that individuals with heightened evaluative fears may increasingly rely on safety behaviors to manage perceived threats, thereby reinforcing anxiety over time. This interpretation aligns with previous evidence indicating that safety behaviors, although intended to reduce anxiety, paradoxically maintain and exacerbate social fears by preventing corrective learning (Reilly et al., 2021; Schenkel et al., 2021).

The significant contribution of safety behaviors as a predictor further underscores their central role in the maintenance of social anxiety. The results indicate that individuals who frequently engage in avoidance or protective strategies exhibit higher levels of anxiety, particularly when such behaviors co-occur with elevated fear of evaluation. This finding is consistent with theoretical accounts emphasizing the role of avoidance learning in anxiety disorders, whereby individuals fail to update threat-related beliefs results in a reliance on safety strategies (Wong et al., 2023). Moreover, the observed interaction between safety behaviors and other cognitive variables supports recent research suggesting that the impact of these behaviors is context-dependent and influenced by underlying cognitive vulnerabilities (Church et al., 2022; Jessup et al., 2022). Thus, the present study highlights the importance of considering both behavioral and cognitive factors in a unified framework when examining social anxiety.

Intolerance of uncertainty also emerged as a significant predictor, both independently and in interaction with other variables. The findings suggest that individuals who struggle to tolerate ambiguity are more likely to perceive social situations as threatening, leading to increased anxiety. This is consistent with prior research demonstrating that intolerance of uncertainty contributes to maladaptive interpretations of ambiguous stimuli and heightened anticipatory anxiety (Moloodi et al., 2021; Morriss et al., 2022). Notably, the interaction between intolerance of uncertainty and self-focused attention indicates that the combination of cognitive rigidity and heightened internal monitoring may amplify anxiety responses. Individuals high in both constructs may become trapped in a cycle of internal evaluation and uncertainty-driven worry, thereby intensifying social fears. This interpretation is supported by studies showing that intolerance of uncertainty is linked to negative interpretations of social events and increased sensitivity to evaluative threat (Nishikawa et al., 2022; Spiroiu & Maranzan, 2025).

Self-focused attention, while exhibiting a comparatively lower individual contribution, played a meaningful role in the overall predictive model, particularly through its interactions with other variables. The findings suggest that excessive inward attention may exacerbate the effects of intolerance of uncertainty and safety behaviors, thereby contributing to social anxiety. This aligns with cognitive models proposing that self-focused attention disrupts external information processing and reinforces negative self-perceptions (White & Cheung, 2021). When individuals focus excessively on their internal states, they may become more sensitive to perceived social threats and less capable of accurately interpreting social cues. This inward attentional bias, particularly in uncertain or evaluative contexts, may therefore serve as a critical mechanism linking cognitive vulnerabilities to anxiety outcomes.

The superior performance of the XGBoost model highlights the value of machine learning approaches in psychological research. Unlike traditional statistical methods, which mostly assume linear relationships, machine learning algorithms can capture complex, nonlinear interactions among variables. The high predictive accuracy observed in this study suggests that social anxiety is best understood as the product of dynamic interactions among multiple cognitive and behavioral factors. This is consistent with recent research advocating for the use of advanced analytical techniques to model psychological phenomena, particularly in contexts characterized by high dimensionality and interdependence among predictors (Hudson et al., 2022; Zhou et al., 2022). Furthermore, the use of SHAP analysis allowed for the identification of both main effects and interaction effects, providing a more nuanced understanding of the mechanisms underlying social anxiety.

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The broader context of uncertainty, particularly in light of recent global events such as the COVID-19 pandemic, provides an important backdrop for interpreting these findings. Elevated levels of uncertainty during this period have been associated with increased anxiety, fear, and reliance on maladaptive coping strategies (Akan, 2024; Andreatta et al., 2023). The present results support this perspective by demonstrating the central role of intolerance of uncertainty in predicting social anxiety. Additionally, previous studies have shown that uncertainty-related distress is linked to a range of psychological outcomes, including loneliness, depression, and health anxiety, further highlighting its transdiagnostic significance (Gu et al., 2021; Shabani et al., 2022). The interaction effects observed in this study suggest that the impact of uncertainty is amplified when combined with other cognitive and behavioral vulnerabilities, emphasizing the need for integrative models of anxiety.

The findings also contribute to the growing literature on the role of cognitive-emotional processes in anxiety disorders. For instance, the mediating role of intolerance of uncertainty in the relationship between perceived unsafety and psychological distress has been well documented (Assaf, 2025; Bulut, 2022). Similarly, fear of evaluation has been shown to mediate the relationship between cognitive biases and social anxiety subtypes (Spiroiu & Maranzan, 2025). By incorporating these variables into a single predictive model, the present study provides a comprehensive framework for understanding how multiple mechanisms interact to influence social anxiety. This integrative approach is particularly valuable for informing intervention strategies, as it highlights multiple potential targets for treatment.

From a clinical perspective, the results have important implications for the assessment and treatment of social anxiety. The identification of fear of evaluation and safety behaviors as key predictors suggests that interventions targeting these constructs may be particularly effective. For example, cognitive-behavioral therapy techniques such as cognitive restructuring and exposure therapy can be used to challenge maladaptive beliefs and reduce reliance on safety behaviors (Craske et al., 2022; White & Cheung, 2021). Additionally, interventions aimed at increasing tolerance of uncertainty, such as acceptance-based approaches, may help individuals develop more adaptive responses to ambiguous social situations. The use of machine learning models in clinical settings may also facilitate personalized treatment planning by identifying individual risk profiles and tailoring interventions accordingly.

5. Conclusion

Overall, the present study provides a comprehensive and integrative analysis of the cognitive and behavioral mechanisms underlying social anxiety, highlighting the value of machine learning approaches in advancing psychological research and practice.

6. Limitations & Suggestions

Despite its contributions, the present study is not without limitations. The cross-sectional design limits the ability to draw causal inferences regarding the relationships among variables. Although machine learning models can identify patterns and associations, they do not establish temporal precedence or causality. Additionally, the reliance on self-report measures may introduce response biases, such as social desirability or recall bias, which could affect the accuracy of the data. The sample, while diverse in terms of demographic characteristics, was limited to young adults in Canada, which may limit the generalizability of the findings to other populations or cultural contexts. Furthermore, although multiple machine learning algorithms were employed, the study did not include deep learning models, which may capture even more complex patterns in the data.

Future research should adopt longitudinal designs to examine the temporal dynamics of the relationships among intolerance of uncertainty, self-focused attention, safety behaviors, and fear of evaluation. Such designs would allow for the investigation of causal pathways and the identification of potential mediators and moderators over time. Additionally, future studies could incorporate multimodal data sources, including behavioral observations, physiological measures, and ecological momentary assessments, to provide a more comprehensive understanding of social anxiety. The integration of deep learning techniques and larger, more diverse datasets may further enhance predictive accuracy and generalizability. Finally, cross-cultural research is needed to explore how cultural factors influence the expression and predictors of social anxiety.

In practical terms, the findings underscore the importance of early identification and intervention for individuals at risk of social anxiety. Screening tools that incorporate key predictors identified in this study may help clinicians identify high-risk individuals and implement targeted

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interventions. Educational and workplace settings may also benefit from programs designed to reduce fear of evaluation and promote adaptive coping strategies in social situations. Moreover, digital mental health interventions, including AI-based assessment tools, hold promise for increasing accessibility and scalability of evidence-based treatments. By leveraging advances in artificial intelligence, it may be possible to develop personalized, data-driven approaches to the prevention and treatment of social anxiety.

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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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