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Predicting Romantic Relationship Instability in Emerging Adults Through LightGBM Models of Attachment Anxiety, Jealousy Cognitions, Social Media Surveillance, Emotional Dependency, and Impulsivity

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A B S T R A C T

Objective: The present study aimed to predict romantic relationship instability in emerging adults through Light Gradient Boosting Machine (LightGBM) models based on attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, and impulsivity.

Methods and Materials: The study employed a cross-sectional predictive correlational design using machine learning methodology. The statistical population consisted of emerging adults aged 18 to 29 years residing in major urban regions of Canada during 2025–2026. A total of 1,137 participants were selected through online and university-based recruitment procedures. Data were collected using the Relationship Stability Scale, Experiences in Close Relationships-Revised questionnaire, Multidimensional Jealousy Scale, Social Media Surveillance Scale, Emotional Dependency Questionnaire, and Barratt Impulsiveness Scale-Version 11. Data analysis was conducted using Python and machine learning libraries including Scikit-learn and LightGBM. The dataset was divided into training and testing subsets using an 80/20 split procedure. Model performance was evaluated using accuracy, precision, recall, F1-score, area under the curve (AUC), and log-loss indices. SHAP analysis was additionally used to examine predictor importance and model interpretability.

Findings: The findings demonstrated significant positive correlations among all study variables and romantic relationship instability. Emotional dependency showed the strongest correlation with relationship instability, followed by attachment anxiety, jealousy cognitions, social media surveillance, and impulsivity ($p < 0.01$). The LightGBM model demonstrated high predictive performance with a testing accuracy of 0.88 and an AUC value of 0.91, indicating excellent discriminative ability. SHAP analysis revealed that emotional dependency and attachment anxiety were the most influential predictors of romantic instability. Hierarchical regression analysis further indicated that the predictor variables collectively explained 67% of the variance in relationship instability ($R^2 = 0.67$, $p < 0.001$).

Conclusion: The findings suggest that romantic relationship instability among emerging adults is strongly associated with emotional insecurity, maladaptive

jealousy cognitions, impulsive tendencies, and digitally mediated surveillance behaviors. The study further demonstrates that machine learning approaches such as LightGBM provide powerful tools for identifying complex nonlinear interaction patterns underlying romantic dysfunction. These findings highlight the importance of addressing attachment insecurity, emotional dependency, and unhealthy digital relational behaviors in prevention and intervention programs targeting young adults' romantic well-being.

Keywords: *Romantic relationship instability, attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, impulsivity, LightGBM, machine learning, emerging adults.*

1. Introduction

Romantic relationships during emerging adulthood constitute one of the most psychologically significant developmental experiences because they shape emotional regulation capacities, interpersonal functioning, identity formation, and long-term relational expectations. Emerging adulthood, generally spanning the ages of 18 to 29 years, represents a transitional developmental stage characterized by instability, exploration, heightened emotional intensity, and evolving relational commitments. During this period, individuals often experience multiple romantic partnerships, fluctuating levels of commitment, and increased vulnerability to relational dissatisfaction and breakup experiences. Contemporary relational environments have become increasingly complex due to the pervasive integration of digital communication technologies and social networking platforms into intimate interactions. As a result, romantic instability is no longer solely influenced by traditional interpersonal variables but is increasingly shaped by digitally mediated behaviors such as social media surveillance, online jealousy, electronic monitoring, and partner phubbing behaviors (Fernandes et al., 2023; Ni et al., 2025; Stöven & Herzberg, 2020). Relationship instability has consequently emerged as a multidimensional psychological phenomenon involving emotional insecurity, cognitive dysregulation, behavioral impulsivity, relational distrust, and maladaptive communication patterns. Previous studies have demonstrated that unstable romantic relationships are associated with depression, anxiety, diminished psychological well-being, interpersonal aggression, and reduced life satisfaction among young adults (Ghasemi et al., 2024; Haack et al., 2023; Lantagne & Furman, 2020). Despite increasing scholarly attention toward romantic functioning in the digital era, substantial gaps remain regarding the integrated prediction of relationship instability through advanced machine learning approaches capable of modeling nonlinear interactions among multiple psychological and behavioral variables simultaneously.

Attachment theory has remained one of the most influential frameworks for understanding romantic relationship functioning and instability across developmental stages. Attachment orientations formed through early relational experiences influence emotional regulation strategies, perceptions of intimacy, coping mechanisms, and interpersonal expectations within adult romantic relationships. Individuals characterized by attachment anxiety often display heightened fears of abandonment, reassurance-seeking behaviors, emotional dependency, and hypervigilance toward signs of rejection, all of which may contribute to relational instability and conflict escalation (Ferraro & Taylor, 2021; Hapon et al., 2021). Research has consistently shown that anxiously attached individuals are more likely to interpret ambiguous relational situations as threatening and to engage in maladaptive cognitive and behavioral responses when confronted with uncertainty or perceived partner unavailability (Deng et al., 2023; Richter et al., 2022). Similarly, studies examining digital relational behaviors have demonstrated that insecure attachment orientations are strongly associated with online partner monitoring, cyber dating abuse, electronic surveillance, and excessive jealousy in social networking environments (Laforte et al., 2023; Toplu-Demirtaş et al., 2020). The emotional insecurity characteristic of anxious attachment may therefore become amplified within contemporary digital contexts where constant access to partner activities and online interactions intensifies uncertainty and cognitive rumination. Evidence further suggests that anxiously attached individuals experience greater emotional dysregulation and difficulty maintaining ontological security within intimate relationships (Huda & Lestari, 2024; Waffa & Pitigala, 2024). Intergenerational patterns of attachment have also been shown to influence emotional regulation and relational outcomes in adulthood, indicating that attachment-related vulnerabilities may persist across developmental and familial contexts (Ibrahim et al., 2023; Shanoora et al., 2025). These findings collectively highlight attachment

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anxiety as a central psychological vulnerability factor contributing to romantic instability among emerging adults.

Jealousy cognitions represent another prominent mechanism associated with relational dissatisfaction, conflict, and instability. Romantic jealousy encompasses cognitive, emotional, and behavioral reactions triggered by perceived threats to a valued relationship. Cognitive jealousy specifically involves intrusive suspicious thoughts, rumination regarding partner fidelity, preoccupation with relational threats, and exaggerated interpretations of ambiguous interpersonal situations. Recent studies have emphasized that jealousy is not merely an episodic emotional response but rather a stable cognitive-affective pattern that significantly influences relational functioning (Fernández et al., 2025; Wildey, 2026). Individuals exhibiting heightened cognitive jealousy frequently engage in reassurance-seeking behaviors, interpersonal monitoring, emotional overreactivity, and partner control strategies that ultimately undermine relational trust and satisfaction. Research has demonstrated robust associations between insecure attachment and jealousy tendencies, suggesting that fears of abandonment intensify suspicious cognitive processing within romantic relationships (Deng et al., 2023; Richter et al., 2022). Furthermore, jealousy has been linked to relationship obsessive-compulsive symptoms, emotional dysregulation, and maladaptive mate retention strategies (Degiuli et al., 2023; Misirli & Kaynak, 2023). Studies conducted among university students and young adults have similarly shown that elevated jealousy predicts lower relationship satisfaction and greater relational conflict (Çulfa & Izgı, 2023). Digital environments appear to exacerbate these processes because social networking platforms provide constant opportunities for interpersonal comparison, partner surveillance, and perceived relational threat detection. The emergence of social media friendship jealousy and digitally mediated jealousy processes has therefore become an important area of contemporary relational research (Gubler et al., 2023; Vaillancourt et al., 2024). Meta-analytic evidence has further indicated that social media-induced jealousy is associated with distrust, emotional insecurity, relational dissatisfaction, and psychological distress among romantic partners (Tandon et al., 2021). Consequently, jealousy cognitions may function as both a direct predictor of romantic instability and an intermediary mechanism linking attachment insecurity to maladaptive relational behaviors.

The rapid expansion of social networking technologies has transformed the structure and dynamics of romantic relationships, particularly among emerging adults who rely heavily on digital communication for interpersonal interaction. Social media surveillance behaviors, including monitoring a partner's online activities, checking followers and interactions, reviewing online status updates, and investigating digital communication patterns, have become increasingly prevalent within romantic partnerships. Although some individuals perceive these behaviors as normative relational practices, excessive electronic monitoring has been associated with jealousy, distrust, psychological maladjustment, cyber dating abuse, and relationship dissatisfaction (Ashdown et al., 2021; Rodríguez-deArriba et al., 2024). Social media environments may intensify relational insecurity by increasing accessibility to potentially threatening information, facilitating interpersonal comparison, and creating opportunities for ambiguous interpretations of partner behaviors. Studies examining online relational processes have found that individuals with insecure attachment styles are particularly vulnerable to engaging in compulsive digital surveillance behaviors (Stöven & Herzberg, 2020; Sullivan, 2021). Emerging adults characterized by attachment anxiety frequently demonstrate heightened sensitivity toward online communication patterns and may perceive reduced digital responsiveness as evidence of rejection or infidelity. Electronic partner surveillance has also been identified as a significant mediator between attachment anxiety and relationship dissatisfaction within digitally mediated romantic contexts (Métellus et al., 2025). Furthermore, recent investigations into digital violence and online dating aggression have revealed that intrusive online monitoring behaviors are strongly associated with emotional control, coercion, and cyber aggression within romantic relationships (Ergun-Basak, 2025; Toplu-Demirtaş et al., 2020). Research focusing on threatening online alternatives similarly suggests that individuals evaluate partner commitment based on social media behaviors, thereby increasing relational insecurity and cognitive jealousy processes (Black, 2023). These findings indicate that social media surveillance represents a psychologically significant relational behavior capable of destabilizing intimacy and trust among emerging adults.

Emotional dependency and impulsivity have also emerged as critical contributors to dysfunctional romantic functioning and relational instability. Emotional dependency refers to excessive emotional reliance on a romantic partner accompanied by fears of loneliness, diminished relational

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autonomy, and heightened need for validation and reassurance. Emotionally dependent individuals often tolerate unhealthy or abusive relationships due to fears of abandonment and emotional isolation (Ghasemi et al., 2024). Such individuals may prioritize relationship preservation at the expense of personal well-being and frequently experience heightened vulnerability to emotional dysregulation, jealousy, and interpersonal conflict. Studies examining romantic attachment and emotional regulation have consistently demonstrated that poor emotional self-regulation intensifies relational dissatisfaction and maladaptive interpersonal behaviors (Ferraro & Taylor, 2021; Waffa & Pitigala, 2024). Emotional dependency may therefore amplify the impact of attachment anxiety and jealousy on relational instability by increasing emotional reactivity and cognitive preoccupation with relational threats. In parallel, impulsivity has been associated with aggression, poor conflict management, emotional volatility, and reduced behavioral inhibition within romantic contexts. Impulsive individuals may exhibit difficulties regulating emotional responses during interpersonal conflict, leading to hostile communication patterns, retaliatory behaviors, and unstable relational dynamics. Research examining cyber dating abuse and dating violence has indicated that impulsive emotional reactions and cognitive rumination substantially increase the likelihood of relational aggression and boundary violations (Chugh & Guggisberg, 2020; İyiaydın et al., 2020). Additionally, borderline personality traits characterized by impulsivity and emotional instability have been linked to maladaptive romantic beliefs, obsessive relational tendencies, and insecure attachment patterns (Farajİ & BaŞÇElİK, 2023). Studies involving individuals convicted of stalking and interpersonal violence similarly suggest that attachment dysregulation, impaired reflective functioning, and impulsive cognitive-affective processes contribute significantly to relational dysfunction and intrusive behaviors (Civilotti et al., 2020; Iria de la Osa et al., 2024). Collectively, these findings emphasize the importance of considering emotional dependency and impulsivity as central components of contemporary models of romantic instability.

Although previous studies have identified significant associations among attachment insecurity, jealousy, digital surveillance behaviors, emotional dependency, and relational dysfunction, much of the existing literature has relied on traditional linear statistical approaches that may inadequately capture the complexity of romantic relationship processes. Romantic instability is inherently multidimensional and likely emerges through nonlinear interactions among emotional, cognitive, behavioral, and technological variables. Machine learning methods offer substantial advantages for psychological prediction because they can identify complex interaction patterns, nonlinear associations, and hidden predictive structures that are often overlooked in conventional regression analyses. Among these methods, Light Gradient Boosting Machine (LightGBM) algorithms provide high predictive accuracy, computational efficiency, and advanced handling of multidimensional psychological datasets. Despite the growing application of machine learning in mental health and behavioral sciences, relatively limited research has utilized explainable machine learning approaches to predict romantic relationship instability in emerging adults. Existing studies have often focused on isolated predictors such as jealousy, attachment, or digital behaviors independently rather than examining their cumulative and interactive effects within integrated predictive frameworks (Métellus et al., 2025; Ventura-León et al., 2025). Moreover, contemporary relational environments characterized by social media integration, electronic surveillance, online jealousy, and digital communication demand more sophisticated analytical frameworks capable of modeling dynamic interpersonal processes. Understanding the relative contribution and interaction of attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, and impulsivity may therefore provide important theoretical and clinical insights into the mechanisms underlying romantic instability among emerging adults.

The aim of the present study was to predict romantic relationship instability in emerging adults through LightGBM machine learning models based on attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, and impulsivity.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a cross-sectional predictive correlational design using machine learning methodology to examine the extent to which attachment anxiety, jealousy cognitions, social media surveillance behaviors, emotional dependency, and impulsivity could predict romantic relationship instability among emerging adults. The study was conducted in Canada between September 2025 and January 2026 and focused on individuals currently involved

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in romantic relationships or those who had experienced a romantic relationship within the previous twelve months. Given the developmental sensitivity of emerging adulthood and the increasing integration of digital communication into intimate relationships, this age group was considered particularly suitable for investigating the psychological and behavioral predictors of relational instability.

The statistical population consisted of emerging adults aged 18 to 29 years residing in major Canadian urban centers including Toronto, Vancouver, Montreal, Ottawa, Calgary, and Edmonton. Participants were recruited through a combination of online and university-based sampling procedures. Recruitment advertisements were distributed through university mailing lists, student psychological research platforms, Instagram advertisements, Reddit relationship forums, and mental health community groups. Individuals were eligible to participate if they were between 18 and 29 years of age, fluent in English, had internet access for questionnaire completion, and reported at least one romantic relationship lasting longer than three months. Participants with severe self-reported psychiatric disorders that could interfere with accurate self-reporting or those who completed questionnaires with excessive missing data were excluded from the final analyses.

A total of 1,284 individuals initially accessed the survey link. After removing incomplete responses, duplicate entries, patterned responses, and cases with substantial missing values, the final sample consisted of 1,137 emerging adults. Of these participants, 612 were female, 503 were male, and 22 identified as nonbinary or preferred not to disclose gender identity. The mean age of the participants was 23.84 years with a standard deviation of 3.12 years. Approximately 58% of participants reported being in an ongoing romantic relationship at the time of the study, whereas 42% indicated that they had experienced a breakup within the preceding year. Relationship duration ranged from four months to seven years. The sample represented diverse educational, socioeconomic, and ethnic backgrounds, reflecting the multicultural composition of Canadian urban populations.

Data collection was conducted entirely online using a secure encrypted survey platform. Prior to participation, all respondents were presented with an electronic informed consent form outlining the purpose of the study, confidentiality procedures, voluntary participation, and the right to withdraw at any stage without penalty. Participants who agreed to participate proceeded to complete the battery of psychological questionnaires. The average completion time for the survey package was approximately 32 minutes.

2.2. Measures

Romantic relationship instability was assessed using the Relationship Stability Scale developed by Booth, Johnson, and Edwards (1983). This instrument is designed to evaluate uncertainty, breakup proneness, relational dissatisfaction, and perceived instability within romantic partnerships. The scale consists of 15 items rated on a five-point Likert continuum ranging from strongly disagree to strongly agree. Higher scores indicate greater instability and vulnerability within romantic relationships. Sample items include statements related to doubts about relationship continuity, consideration of separation, and emotional uncertainty regarding the partner. Previous studies have demonstrated satisfactory construct validity and internal consistency coefficients above 0.85 across emerging adult populations. In the present study, Cronbach's alpha for the total scale was 0.89.

Attachment anxiety was measured using the Experiences in Close Relationships-Revised questionnaire developed by Fraley, Waller, and Brennan (2000). The attachment anxiety subscale contains 18 items evaluating fears of abandonment, excessive reassurance seeking, emotional insecurity, and hypersensitivity to relational rejection. Participants responded on a seven-point Likert scale ranging from strongly disagree to strongly agree. Higher scores reflect higher levels of anxious attachment orientation in intimate relationships. The scale has demonstrated strong psychometric properties in previous Canadian and international studies involving young adults and romantic relationships. In the current sample, the attachment anxiety subscale yielded a Cronbach's alpha coefficient of 0.91.

Jealousy cognitions were assessed using the Multidimensional Jealousy Scale developed by Pfeiffer and Wong (1989), specifically the cognitive jealousy dimension. This subscale evaluates obsessive suspicion, preoccupation with partner fidelity, intrusive jealous thoughts, and cognitive monitoring of potential romantic threats. The instrument includes 8 items scored on a seven-point Likert scale. Higher scores represent greater maladaptive jealous thinking patterns. The scale has shown excellent convergent validity with measures of insecurity, attachment anxiety, and relationship conflict in prior research. Internal reliability in the present study was found to be 0.87.

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Social media surveillance behaviors were measured using the Social Media Surveillance Scale adapted from Tokunaga (2011) and subsequent digital relationship monitoring studies. The instrument assesses behaviors such as checking a partner's online activity, monitoring followers and interactions, reviewing online status updates, examining digital communication patterns, and engaging in indirect online tracking behaviors. The scale contains 16 items rated on a five-point Likert scale from never to very frequently. Higher scores indicate more frequent social media surveillance of romantic partners. Previous studies have confirmed acceptable factorial validity and strong reliability among emerging adults and university student populations. Cronbach's alpha in the current study was 0.90.

Emotional dependency was evaluated using the Emotional Dependency Questionnaire developed by Lemos and Londoño (2006). This instrument measures excessive emotional reliance on romantic partners, fear of loneliness, submissive relational tendencies, emotional neediness, and difficulty maintaining autonomy within intimate relationships. The questionnaire includes 23 items scored on a six-point Likert scale. Higher scores indicate stronger emotional dependency patterns. Prior psychometric investigations have reported adequate content validity and reliability coefficients above 0.80 in both clinical and nonclinical populations. In the present study, the overall reliability coefficient was 0.92.

Impulsivity was measured using the Barratt Impulsiveness Scale-Version 11 developed by Patton, Stanford, and Barratt (1995). This widely used instrument assesses attentional impulsivity, motor impulsivity, and nonplanning impulsivity through 30 self-report items scored on a four-point Likert scale ranging from rarely/never to almost always/always. Higher scores indicate elevated impulsive personality tendencies. The scale has been extensively validated across different cultural contexts and has demonstrated strong predictive utility in behavioral and emotional regulation research. In the present sample, Cronbach's alpha for the total impulsivity score was 0.88.

Demographic information including age, gender, educational status, relationship duration, cohabitation status, breakup history, and average daily social media usage was also collected through a researcher-developed demographic questionnaire. These variables were included to improve the contextual interpretation of the predictive models and to evaluate potential confounding influences.

2.3. Data Analysis

Data analysis was performed using Python programming language version 3.11 and several machine learning libraries including Scikit-learn, LightGBM, Pandas, NumPy, and SHAP. Preliminary analyses included missing data screening, outlier detection, descriptive statistics, skewness and kurtosis assessment, and examination of intercorrelations among variables. Cases with more than 10% missing data were removed, while minor missing values were handled through multiple imputation procedures. Continuous variables were standardized prior to machine learning implementation to improve model stability and interpretability.

The primary analytical approach involved the development of a Light Gradient Boosting Machine (LightGBM) predictive model to classify and predict romantic relationship instability among emerging adults. LightGBM was selected because of its computational efficiency, high predictive performance, capability to handle nonlinear relationships, and suitability for large multidimensional psychological datasets. The dependent variable consisted of relationship instability scores, while attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, impulsivity, and demographic variables served as predictive features.

The dataset was randomly divided into training and testing subsets using an 80/20 split procedure. Hyperparameter optimization was conducted through grid search and five-fold cross-validation to identify the optimal combination of learning rate, maximum tree depth, feature fraction, boosting rounds, and minimum child samples. Model performance was evaluated using multiple indices including accuracy, precision, recall, F1-score, area under the receiver operating characteristic curve (AUC), and log-loss values. To minimize overfitting, early stopping techniques and regularization parameters were incorporated into the model training process.

Feature importance analysis was conducted using SHapley Additive exPlanations (SHAP) values to identify the relative contribution of each predictor variable to relationship instability outcomes. This explainable artificial intelligence approach enabled the interpretation of complex nonlinear relationships within the LightGBM framework and provided detailed insight into the psychological variables exerting the strongest predictive influence. In addition, partial dependence plots were generated to

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visualize the directional effects of major predictors across different probability levels of relationship instability.

To complement the machine learning analyses, traditional statistical procedures including Pearson correlation coefficients and hierarchical multiple regression analyses were also conducted using SPSS version 27. These supplementary analyses were used to compare conventional statistical findings with machine learning prediction outcomes and to enhance the interpretability of the overall results. Statistical significance for conventional analyses was considered at $p < 0.05$.

3. Findings and Results

The final dataset consisted of 1,137 emerging adults from different urban regions of Canada. The mean age of the participants was 23.84 years (SD = 3.12), with ages ranging from 18 to 29 years. Among the participants, 53.83% were female, 44.24% were male, and 1.93% identified as nonbinary or preferred not to disclose gender identity. In terms of educational status, 61.39% were undergraduate university students, 21.72% were graduate students, 9.85% had completed college diplomas, and 7.04% were employed full-time without current enrollment in academic programs. Regarding relationship status, 58.14% reported being in an ongoing romantic relationship, while 41.86% indicated having experienced at least one romantic breakup within the previous year. The average relationship duration was 2.71 years (SD = 1.94). Participants reported an average daily social media use of 4.86 hours (SD = 2.03), with Instagram, TikTok, Snapchat, and WhatsApp representing the most frequently used platforms for interpersonal and romantic communication. Preliminary screening analyses demonstrated acceptable levels of normality for all study variables, with skewness and kurtosis values falling within recommended ranges. Multicollinearity diagnostics further indicated that tolerance values exceeded 0.20 and variance inflation factor values remained below 5.00, confirming the absence of problematic multicollinearity among predictor variables.

Table 1

Descriptive Statistics and Correlations Among Study Variables

Variables	Mean	SD	1	2	3	4	5	6
1. Relationship Instability	47.82	11.43	1					
2. Attachment Anxiety	63.47	14.91	0.71**	1				
3. Jealousy Cognitions	29.56	8.72	0.64**	0.67**	1			
4. Social Media Surveillance	52.31	12.08	0.58**	0.62**	0.69**	1		
5. Emotional Dependency	71.84	15.26	0.74**	0.78**	0.61**	0.57**	1	
6. Impulsivity	68.29	10.97	0.55**	0.49**	0.46**	0.42**	0.53**	1

The results presented in Table 1 demonstrated substantial positive associations among all study variables. Romantic relationship instability showed the strongest correlation with emotional dependency ($r = 0.74$, $p < 0.01$), followed closely by attachment anxiety ($r = 0.71$, $p < 0.01$). These findings indicate that individuals characterized by excessive emotional reliance on romantic partners and heightened fears of abandonment experienced considerably higher levels of relational instability. Jealousy cognitions also exhibited a strong positive relationship with relationship instability ($r = 0.64$, $p < 0.01$), suggesting that intrusive suspicious thinking and cognitive preoccupation with partner fidelity were associated with greater relational uncertainty and breakup proneness. Social media surveillance behaviors demonstrated a moderate-to-strong association with relationship instability ($r = 0.58$, $p < 0.01$), indicating that frequent digital monitoring of romantic partners may contribute to emotional insecurity and conflict escalation within intimate relationships. Impulsivity was positively associated with relationship instability as well ($r = 0.55$, $p < 0.01$), supporting the notion that deficits in behavioral inhibition and emotional self-regulation may undermine relational stability among emerging adults. Furthermore, strong intercorrelations were observed among the predictor variables themselves, particularly between attachment anxiety and emotional dependency ($r = 0.78$, $p < 0.01$), as well as between jealousy cognitions and social media surveillance ($r = 0.69$, $p < 0.01$). Despite these associations, multicollinearity diagnostics remained within acceptable thresholds, supporting the suitability of the variables for subsequent predictive modeling analyses.

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Table 2

Performance Indices of the LightGBM Predictive Model for Romantic Relationship Instability

Performance Metric	Training Set	Testing Set
Accuracy	0.91	0.88
Precision	0.89	0.86
Recall	0.90	0.87
F1-Score	0.89	0.86
AUC	0.94	0.91
Log Loss	0.21	0.27

The findings presented in Table 2 indicated that the Light Gradient Boosting Machine model demonstrated strong predictive capability in identifying romantic relationship instability among emerging adults. The training model achieved an accuracy rate of 91%, while the testing model retained a high accuracy level of 88%, suggesting excellent generalizability and minimal overfitting. Precision and recall values were similarly high across both datasets, indicating that the model effectively distinguished individuals at elevated risk for relational instability from those exhibiting relatively stable romantic functioning. The F1-score values further confirmed balanced classification performance between false positive and false negative predictions. Importantly, the area under the receiver operating characteristic curve reached 0.91 in the testing dataset, reflecting excellent discriminative ability and robust predictive performance of the model across diverse participant profiles. The relatively low log-loss values additionally suggested high probabilistic calibration and stable prediction confidence. Collectively, these findings demonstrated that machine learning approaches, particularly LightGBM algorithms, may offer considerable utility in modeling complex interpersonal and psychological processes associated with romantic instability during emerging adulthood. The results further indicated that the integration of emotional, cognitive, behavioral, and digitally mediated relational variables significantly enhanced prediction accuracy beyond what is typically achieved through conventional linear statistical approaches.

Table 3

Hierarchical Multiple Regression Analysis Predicting Romantic Relationship Instability

Predictor Variables	B	SE	β	t	p
Attachment Anxiety	0.42	0.04	0.36	10.58	<0.001
Jealousy Cognitions	0.31	0.05	0.24	7.14	<0.001
Social Media Surveillance	0.27	0.04	0.19	6.52	<0.001
Emotional Dependency	0.48	0.05	0.41	11.37	<0.001
Impulsivity	0.22	0.03	0.16	5.84	<0.001

The SHAP analysis revealed substantial variability in the relative contribution of predictor variables to the probability of romantic relationship instability. Emotional dependency emerged as the most influential predictor within the LightGBM model, followed by attachment anxiety, jealousy cognitions, social media surveillance behaviors, and impulsivity. Higher values of emotional dependency and attachment anxiety consistently increased the probability of relationship instability across participants, indicating that fears of abandonment, emotional overreliance, and reassurance-seeking tendencies exerted particularly strong effects on relational outcomes. Jealousy cognitions and social media surveillance behaviors also demonstrated notable nonlinear contributions to the predictive model. Specifically, individuals exhibiting elevated levels of obsessive relational suspicion and frequent digital monitoring behaviors showed disproportionately greater probabilities of relational instability once certain psychological thresholds were exceeded. The SHAP summary patterns further suggested interactive effects among variables, whereby combinations of high attachment anxiety and elevated social media surveillance intensified instability predictions more strongly than either factor alone. Impulsivity displayed a comparatively moderate but still meaningful contribution, particularly among participants with shorter relationship durations and higher levels of

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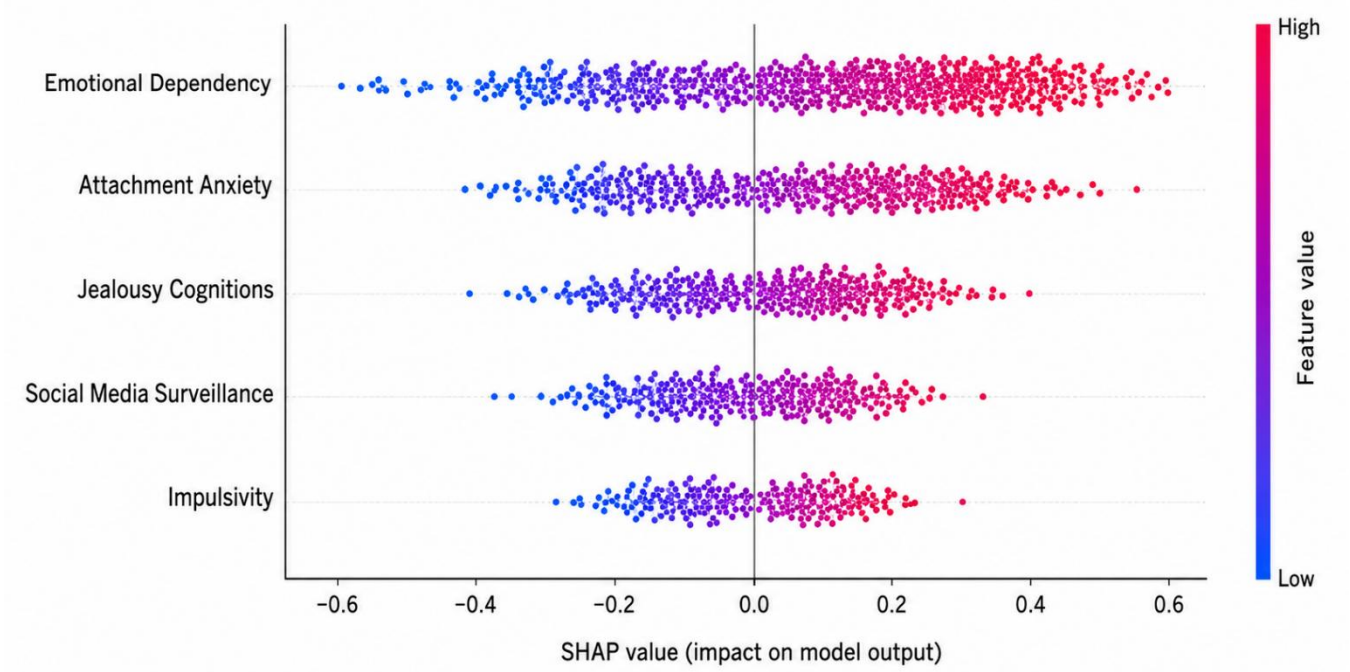
online relational engagement. Overall, the explainable artificial intelligence analyses demonstrated that relationship instability in emerging adults is not attributable to isolated psychological variables, but rather emerges through the cumulative and interactive influence of emotional insecurity, maladaptive cognitive processing, digital monitoring behaviors, and deficits in emotional self-regulation.

Figure 1

SHAP Summary Plot of Predictor Importance in the LightGBM Model of Romantic Relationship Instability



The hierarchical multiple regression analysis demonstrated that the combined predictor variables explained 67% of the variance in romantic relationship instability among emerging adults, indicating a highly substantial explanatory effect. Emotional dependency emerged as the strongest individual predictor ($\beta = 0.41$, $p < 0.001$), reinforcing the central role of excessive relational reliance and emotional insecurity in destabilizing intimate relationships. Attachment anxiety also showed a strong predictive effect ($\beta = 0.36$, $p < 0.001$), suggesting that fears of rejection, abandonment sensitivity, and chronic reassurance-seeking significantly contribute to relational uncertainty and instability. Jealousy cognitions retained significant predictive value ($\beta = 0.24$, $p < 0.001$), indicating that intrusive suspicious thinking patterns and heightened sensitivity to perceived threats undermine relationship functioning. Social media surveillance behaviors emerged as a meaningful behavioral predictor ($\beta = 0.19$, $p < 0.001$), further emphasizing the role of digitally mediated monitoring and online relational hypervigilance in contemporary romantic dynamics. Impulsivity also contributed significantly to the model ($\beta = 0.16$, $p < 0.001$), supporting the assumption that behavioral disinhibition and emotional reactivity increase vulnerability to unstable relational patterns. The overall regression model was statistically significant, $F(5, 1131) = 458.91$, $p < 0.001$, and demonstrated strong explanatory capacity. Comparison of these regression findings with the LightGBM analyses indicated substantial convergence between conventional statistical modeling and machine learning approaches, although the machine learning framework captured more complex nonlinear interactions and achieved superior predictive accuracy.

4. Discussion

The present study aimed to predict romantic relationship instability in emerging adults through LightGBM machine learning models based on attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, and impulsivity. The findings demonstrated that all predictor variables were positively and significantly associated with romantic relationship instability and that the LightGBM model achieved high predictive accuracy in

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identifying individuals vulnerable to unstable romantic functioning. Emotional dependency emerged as the strongest predictor, followed by attachment anxiety, jealousy cognitions, social media surveillance behaviors, and impulsivity. The findings further indicated that the machine learning framework captured complex nonlinear interactions among psychological and behavioral variables and demonstrated stronger predictive performance than conventional statistical approaches. These results highlight the multidimensional nature of romantic instability in contemporary emerging adulthood and emphasize the importance of integrating emotional, cognitive, behavioral, and digitally mediated relational processes into predictive models of romantic functioning.

One of the most important findings of the present study was the strong predictive role of emotional dependency in romantic relationship instability. Participants who exhibited excessive emotional reliance on romantic partners, heightened fears of abandonment, and reduced relational autonomy were more likely to experience unstable and conflict-ridden romantic relationships. This finding aligns with previous studies indicating that emotionally dependent individuals often remain psychologically vulnerable to relational dissatisfaction, insecurity, and maladaptive interpersonal dynamics (Ghasemi et al., 2024). Emotional dependency may intensify relational instability because dependent individuals frequently interpret minor interpersonal fluctuations as threatening and become excessively preoccupied with maintaining emotional closeness. Such patterns can create cycles of reassurance-seeking, hypersensitivity, emotional exhaustion, and interpersonal conflict that gradually undermine relationship stability. Moreover, emotionally dependent individuals often experience diminished self-regulatory capacities and increased fear of loneliness, which may prevent healthy boundary formation within romantic relationships. The present findings are also consistent with research emphasizing the role of emotional regulation difficulties in maladaptive romantic functioning (Ferraro & Taylor, 2021; Waffa & Pitigala, 2024). Emerging adults characterized by emotional dependency may therefore struggle to maintain emotional equilibrium during relational uncertainty and conflict, increasing vulnerability to breakup proneness and relational dissatisfaction.

Attachment anxiety also emerged as a highly influential predictor of romantic instability. Participants with elevated attachment anxiety demonstrated greater vulnerability to relational uncertainty, emotional insecurity, and unstable romantic functioning. This result strongly supports attachment theory perspectives suggesting that anxiously attached individuals possess hyperactivated attachment systems characterized by fears of rejection, abandonment sensitivity, and excessive reassurance-seeking behaviors (Hapon et al., 2021; Shanoora et al., 2025). Individuals with anxious attachment orientations often interpret ambiguous partner behaviors as indicators of rejection and consequently engage in heightened emotional monitoring and cognitive rumination. Such responses may intensify interpersonal conflict, emotional volatility, and relationship dissatisfaction over time. The findings are highly consistent with studies demonstrating significant associations between insecure attachment and jealousy, emotional dysregulation, cyber dating abuse, and maladaptive relational behaviors (Deng et al., 2023; Haack et al., 2023; Laforte et al., 2023). Furthermore, attachment anxiety may be particularly detrimental within digitally mediated romantic environments because social media and online communication platforms amplify opportunities for reassurance-seeking and relational monitoring. Research has shown that anxiously attached individuals are more likely to engage in electronic partner surveillance and to experience distress in response to perceived online relational threats (Stöven & Herzberg, 2020; Sullivan, 2021). The present findings therefore suggest that attachment insecurity remains a foundational vulnerability factor influencing romantic instability among emerging adults, particularly in contemporary digital contexts.

The findings also demonstrated that jealousy cognitions significantly predicted romantic relationship instability. Participants characterized by intrusive suspicious thoughts, heightened concerns regarding partner fidelity, and obsessive relational rumination exhibited substantially higher levels of relational instability. This finding is congruent with prior studies indicating that jealousy undermines trust, communication quality, and emotional security within romantic relationships (Çulfa & Izgı, 2023; Fernández et al., 2025). Cognitive jealousy may destabilize relationships because persistent suspicious thinking increases emotional hypervigilance and encourages maladaptive interpretive biases regarding partner behavior. Individuals experiencing elevated jealousy may misinterpret ambiguous social interactions as evidence of infidelity or rejection, leading to emotional overreactivity, conflict escalation, and partner monitoring behaviors. The current results also support previous evidence linking insecure attachment to heightened jealousy tendencies (Deng et al.,

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2023; Richter et al., 2022). Attachment-anxious individuals often demonstrate heightened sensitivity toward relational threats, which may intensify suspicious cognitions and relational insecurity. Moreover, recent literature has emphasized that jealousy in modern romantic relationships is increasingly shaped by digital communication environments and social media interactions (Gubler et al., 2023; Vaillancourt et al., 2024). The visibility of online interactions, followers, and digital engagement may create fertile conditions for cognitive jealousy and relational uncertainty. Meta-analytic evidence has similarly shown that social media-induced jealousy is associated with lower relationship satisfaction and greater emotional distress (Tandon et al., 2021). The present findings therefore reinforce the view that jealousy cognitions represent a central cognitive mechanism contributing to romantic instability among emerging adults.

Another important finding involved the significant contribution of social media surveillance behaviors to romantic relationship instability. Participants who frequently monitored their partner's online activities, checked social media interactions, and engaged in electronic surveillance behaviors exhibited higher probabilities of relational instability. This result aligns closely with studies demonstrating that excessive online partner monitoring is associated with distrust, cyber dating aggression, emotional insecurity, and psychological maladjustment (Ashdown et al., 2021; Rodríguez-deArriba et al., 2024). Social media surveillance may damage relationship stability by reinforcing suspicious cognitive patterns and perpetuating cycles of reassurance-seeking and emotional hypervigilance. Constant exposure to a partner's digital activities can intensify interpersonal comparison processes and increase opportunities for ambiguous interpretations of online behavior. Furthermore, individuals engaging in surveillance behaviors may gradually erode mutual trust and relational autonomy, thereby contributing to conflict escalation and emotional distancing. The findings are also consistent with research indicating that electronic partner surveillance mediates the association between attachment anxiety and relationship dissatisfaction (Métellus et al., 2025). Emerging adults characterized by attachment insecurity may use social media monitoring as an attempt to reduce uncertainty and regain emotional control; however, such behaviors often produce the opposite effect by amplifying jealousy and relational insecurity. The present results further correspond with contemporary research on digital violence and cyber dating abuse, which emphasizes that intrusive digital monitoring behaviors represent significant relational risk factors (Ergun-Basak, 2025; Toplu-Demirtaş et al., 2020). In modern romantic contexts where online communication constitutes a central component of interpersonal interaction, social media surveillance may therefore function as a powerful destabilizing mechanism.

Impulsivity also demonstrated a significant predictive role in romantic relationship instability. Individuals with elevated impulsive tendencies reported greater relational instability, suggesting that emotional and behavioral dysregulation contribute substantially to maladaptive romantic functioning. Impulsivity may undermine relationship stability because impulsive individuals often struggle to regulate emotional reactions during interpersonal conflict and may respond to relational stressors with hostility, emotional outbursts, or reactive decision-making. Such patterns can reduce constructive communication and intensify relational volatility over time. These findings are consistent with prior research linking impulsive emotional responses and cognitive rumination to dating aggression and cyber abuse behaviors (Chugh & Guggisberg, 2020; İyiaydın et al., 2020). Additionally, impulsivity is often associated with borderline personality features, emotional instability, and obsessive relational tendencies, all of which contribute to interpersonal dysfunction (Farajİ & BaŞÇElİK, 2023). The present findings also correspond with studies involving stalking and intrusive relational behaviors, which emphasize the importance of impaired emotional regulation and dysfunctional attachment processes in maladaptive interpersonal conduct (Civilotti et al., 2020). Impulsivity may therefore interact with attachment anxiety, jealousy, and emotional dependency to create particularly unstable relational environments characterized by emotional unpredictability and reduced conflict resolution capacity.

5. Conclusion

An important contribution of the present study lies in the successful application of LightGBM machine learning models to the prediction of romantic relationship instability. The model demonstrated high levels of accuracy, precision, recall, and discriminative ability, indicating that machine learning approaches can effectively identify complex psychological risk profiles associated with relational dysfunction. Traditional linear statistical methods often assume uniform relationships among variables and may fail to capture nonlinear interactions between emotional, cognitive, and behavioral factors. In contrast, the LightGBM

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framework was capable of identifying dynamic interaction patterns among attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, and impulsivity. The SHAP analysis further revealed that these variables exerted cumulative and interactive influences on relational instability rather than functioning as isolated predictors. Such findings support growing calls for the integration of explainable artificial intelligence approaches into psychological and relational research. The use of machine learning may be particularly valuable for understanding contemporary romantic relationships because digital communication environments involve rapidly evolving and highly interactive behavioral processes. Previous studies have highlighted the increasing complexity of romantic functioning in the digital era due to social media jealousy, online surveillance, partner phubbing, and cyber aggression (Black, 2023; Ni et al., 2025). The present findings therefore suggest that advanced predictive analytics may provide a more comprehensive understanding of romantic instability than traditional analytical frameworks alone.

6. Limitations & Suggestions

The findings of the present study should be interpreted in light of several limitations. First, the cross-sectional design prevents causal conclusions regarding the relationships among attachment anxiety, jealousy cognitions, social media surveillance, emotional dependency, impulsivity, and romantic instability. Longitudinal research is necessary to determine temporal and developmental pathways underlying these associations. Second, the study relied exclusively on self-report measures, which may have been influenced by social desirability biases, memory inaccuracies, or subjective interpretations of relational experiences. Third, although the sample was relatively large and diverse, participants were recruited primarily from urban Canadian populations and online platforms, which may limit the generalizability of the findings to other cultural or demographic contexts. Additionally, the study focused mainly on individual-level psychological variables and did not incorporate dyadic partner data, observational assessments, or biological indicators that may contribute to romantic functioning.

Future research should employ longitudinal and dyadic methodologies to examine how attachment insecurity, jealousy, impulsivity, and digital surveillance behaviors evolve across different stages of romantic relationships. Investigations involving couples rather than individual participants may provide more comprehensive insight into reciprocal relational dynamics and interaction patterns. Future studies may also benefit from incorporating ecological momentary assessment methods, behavioral tracking technologies, and digital communication analyses to capture real-time fluctuations in relational experiences. In addition, cross-cultural comparisons could help clarify the extent to which technological norms, cultural expectations, and social values influence the association between digital behaviors and romantic instability. Researchers should further explore protective variables such as emotional intelligence, communication skills, trust development, and adaptive coping mechanisms that may buffer the negative effects of attachment anxiety and jealousy in romantic relationships.

The findings of the present study have several practical implications for clinicians, counselors, educators, and mental health professionals working with emerging adults. Relationship counseling interventions may benefit from targeting attachment-related insecurities, emotional dependency, and maladaptive jealousy processes through emotion regulation training, cognitive restructuring, and interpersonal communication enhancement. Psychoeducational programs focusing on healthy digital boundaries and responsible social media use may also reduce excessive surveillance behaviors and relational distrust among young adults. Mental health practitioners should pay particular attention to the role of impulsivity and emotional dysregulation in romantic conflict and incorporate self-regulation strategies into therapeutic interventions. Furthermore, machine learning models such as LightGBM may eventually assist clinicians in identifying individuals at heightened risk for relational instability and tailoring prevention programs accordingly. Universities and community mental health services may also develop workshops addressing digital relationship behaviors, emotional security, and healthy attachment development to promote more stable and satisfying romantic relationships during emerging adulthood.

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Declaration of Interest

The authors of this article declared no conflict of interest.

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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 to this article.

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