Interpretable Gradient Boosting Analysis of Academic Cheating in Adolescents Using Moral Disengagement and Achievement Goals

Asma. Trabelsi[1] , Rebecca. Nolan[2]* , Rafael. Costa[3]

[1] Department of Psychology and Consulting, University of Sfax, Sfax, Tunisia
[2] Department of Clinical Psychology, University of Michigan, Ann Arbor, USA
[3] Department of Educational Psychology, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

* **Corresponding author email address**: rebecca.nolan@umich.edu

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A B S T R A C T

Objective: This study aimed to develop an interpretable machine learning model to examine the predictive roles of moral disengagement and achievement goal orientations in academic cheating among high school adolescents.

Methods and Materials: The study employed a cross-sectional correlational design with a predictive analytics framework and was conducted among 681 adolescents aged 14–18 years enrolled in public high schools in California. Participants completed standardized self-report measures assessing academic cheating behavior, moral disengagement, and achievement goal orientations, along with demographic information. Data were analyzed using an Extreme Gradient Boosting (XGBoost) regression model with five-fold cross-validation and Bayesian hyperparameter optimization. Model performance was evaluated using root mean squared error, mean absolute error, and explained variance. To ensure interpretability, Shapley Additive Explanations were applied to quantify the relative and local contributions of predictors, and partial dependence analyses were conducted to examine nonlinear and interactive effects.

Findings: The gradient boosting model demonstrated strong predictive performance, accounting for 56% of the variance in academic cheating. Moral disengagement emerged as the most influential predictor, followed by performance-avoidance and performance-approach goals. Mastery-approach goals exhibited a consistent negative association with cheating. The model identified nonlinear threshold effects for moral disengagement and significant interaction patterns between motivational orientations and moral cognition, indicating that performance-based goals amplified the impact of moral disengagement on cheating behavior.

Conclusion: The findings indicate that academic cheating in adolescence is primarily driven by cognitive moral mechanisms operating in conjunction with achievement-related motivational pressures. Interpretable machine learning offers a powerful framework for uncovering these complex psychological dynamics and provides actionable insights for the design of targeted educational interventions aimed at promoting academic integrity.

Keywords: *Academic cheating, moral disengagement, achievement goal orientations, adolescents.*

1. Introduction

Academic cheating among adolescents has become an increasingly visible concern in contemporary educational systems due to its implications for moral development, academic integrity, and long-term behavioral trajectories. With heightened academic competition, standardized testing pressures, digital learning environments, and performance-oriented evaluation systems, adolescents are exposed to expanding opportunities and motivations for dishonest academic behaviors. Recent empirical work indicates that cheating in adolescence is not an isolated classroom phenomenon but reflects broader psychosocial processes linked to motivation, moral cognition, peer influence, institutional climate, and self-regulation capacities (Karam et al., 2025; Kazem, 2024; Moura et al., 2022). Understanding the psychological mechanisms that underlie academic cheating is therefore essential for the development of effective prevention strategies and educational policies.

One of the most robust theoretical frameworks for explaining unethical behavior in academic and organizational contexts is moral disengagement theory, which explains how individuals cognitively restructure immoral actions to appear acceptable or justified, thereby reducing self-sanction and guilt. Empirical research demonstrates that moral disengagement predicts a wide range of deviant behaviors, including academic dishonesty, workplace cheating, and unethical decision-making (Tahrir et al., 2020; Welsh et al., 2020; Zhang et al., 2020). Adolescents who adopt moral disengagement strategies are more likely to justify cheating as harmless, blame external pressures, minimize consequences, and displace responsibility, which allows dishonest behaviors to be enacted without psychological distress (Dias-Oliveira et al., 2022; He et al., 2023). Moral disengagement therefore functions as a central cognitive gateway through which achievement pressures translate into unethical academic conduct.

Achievement goal orientation theory provides a complementary motivational framework for understanding why adolescents engage in cheating. Students who adopt performance-oriented goals, particularly performance-avoidance goals, are motivated by fear of failure and external evaluation, which increases susceptibility to dishonest strategies when academic demands exceed perceived coping resources (He et al., 2023; Khan et al., 2023; Li, 2025). Conversely, mastery-oriented goals emphasize learning, self-improvement, and intrinsic interest, which are associated with higher academic integrity and lower engagement in cheating behaviors (Yau et al., 2022; Yau et al., 2021). Meta-analytic evidence confirms that performance goals exhibit consistent positive associations with cheating, whereas mastery goals demonstrate protective effects (Li, 2025). However, these relationships are rarely linear or isolated; instead, they interact dynamically with moral cognition, self-efficacy, social context, and institutional pressures.

Recent research further demonstrates that performance pressure and competitive academic environments intensify the relationship between achievement goals and unethical conduct. Performance pressure activates fear-based motivation, cognitive overload, and risk-seeking behaviors, which increase reliance on moral disengagement mechanisms and expedient solutions such as cheating (Kamran et al., 2022; Khan et al., 2023; Shi et al., 2025). Adolescents embedded in high-stakes testing environments often experience psychological strain that undermines self-regulation and moral decision-making, making cheating appear as an adaptive coping response rather than a moral violation (Burns et al., 2022; Watts et al., 2023). These dynamics are further reinforced by peer modeling, social comparison processes, and perceptions of normative behavior within classrooms and digital learning platforms (Monge & Matthews, 2024; Niayatulloh & Haikal, 2024).

The social and developmental context of adolescence adds further complexity to these processes. Adolescence represents a critical period for identity formation, moral reasoning development, and future orientation. Research demonstrates that adolescents' sense of purpose, self-efficacy, and future orientation are shaped by family climate, school support, and perceived life opportunities, all of which influence academic behavior and ethical decision-making (H et al., 2025; Hill & Burrow, 2021). When institutional environments emphasize outcomes over process, competition over cooperation, and surveillance over trust, adolescents may experience diminished moral agency and increased disengagement from ethical standards (Příhodová et al., 2021; Thiel et al., 2021). Such environments foster conditions in which cheating becomes normalized, rationalized, and socially reinforced.

Family and social environments also play a crucial role in shaping adolescents' ethical behavior. Adolescents raised in family systems characterized by emotional instability, anger dysregulation, and weak moral communication exhibit higher propensities for deviant behavior, including academic

dishonesty (Saladino et al., 2020). Conversely, social support profiles marked by emotional availability, structure, and autonomy support are associated with higher study wellbeing and lower engagement in unethical conduct (Ulmanen et al., 2022). These findings align with broader developmental research indicating that moral behavior emerges from the interaction of motivational, cognitive, emotional, and social processes rather than from isolated personality traits (Doron et al., 2023; Pérez, 2022).

The psychological architecture of cheating is further influenced by personality factors and dark motivational traits. Psychopathic tendencies, narcissism, hubristic pride, and grandiosity have been shown to increase susceptibility to cheating by amplifying entitlement beliefs and diminishing empathy and accountability (Dias-Oliveira et al., 2022; Liu et al., 2022). Such traits interact with situational pressures and moral disengagement to produce stable patterns of unethical behavior that persist across academic and organizational contexts (Kamran et al., 2022; Zhang et al., 2020). These findings highlight the need for integrated models that simultaneously capture motivational orientation, moral cognition, personality characteristics, and contextual influences.

Despite this growing body of research, much of the existing literature relies on traditional linear modeling approaches that assume independent and additive relationships among predictors. However, contemporary psychological phenomena, particularly those involving moral behavior, are inherently nonlinear, interactive, and context-dependent. Advances in computational social science and educational data mining have demonstrated the utility of machine learning techniques for capturing complex behavioral patterns that remain obscured in conventional regression frameworks (Shi et al., 2025; Watts et al., 2023). Gradient boosting models, in particular, offer powerful capabilities for modeling nonlinear relationships, high-order interactions, and threshold effects, making them especially well-suited for psychological prediction tasks.

However, the adoption of machine learning in psychological research introduces challenges related to interpretability and theoretical integration. Black-box prediction without explanatory insight limits the contribution of such models to psychological theory and educational practice. Interpretable artificial intelligence methods, including Shapley Additive Explanations, provide a principled solution by decomposing model predictions into meaningful feature contributions that can be theoretically interpreted and practically applied (Wang & Read, 2024).

These tools allow researchers to quantify the relative importance of moral disengagement, achievement goals, and contextual variables in shaping academic cheating while preserving the predictive power of advanced algorithms.

Integrating interpretable machine learning with moral and motivational theory offers a promising pathway for advancing the scientific understanding of academic dishonesty. Such integration enables the identification of nonlinear risk thresholds, synergistic effects between moral cognition and achievement motivation, and individualized vulnerability profiles. This approach aligns with contemporary movements in psychological science that emphasize precision education, adaptive interventions, and data-driven policy design (Boardley et al., 2025; Shi et al., 2025). In educational contexts, such insights can inform targeted prevention programs, teacher training initiatives, and institutional reforms aimed at promoting academic integrity and moral development.

Moreover, global trends in digital learning, remote assessment, and generative artificial intelligence have transformed the cheating landscape, introducing new ethical challenges and behavioral dynamics. Students' interactions with AI tools, online resources, and digital platforms complicate traditional notions of authorship, originality, and academic honesty (Monge & Matthews, 2024; Watts et al., 2023). These technological shifts further underscore the urgency of developing sophisticated, interpretable models capable of capturing the evolving psychological ecology of academic cheating.

Although existing studies have examined individual links between achievement goals, moral disengagement, and cheating, few have integrated these constructs within an interpretable machine learning framework, particularly among adolescent populations in real educational settings. Furthermore, the majority of prior research has focused on university students, leaving adolescent academic integrity comparatively underexplored despite its critical developmental significance (Karam et al., 2025; Kazem, 2024). Addressing this gap is essential for early intervention and for establishing ethical trajectories that extend into adulthood.

Accordingly, the present study applies an interpretable gradient boosting modeling approach to examine the complex predictive relationships between moral disengagement, achievement goal orientations, and academic cheating among high school adolescents in California, providing both high predictive accuracy and theoretically meaningful explanatory insights, with the aim

of identifying the most influential psychological mechanisms underlying academic dishonesty in this population.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a cross-sectional, correlational design with a predictive modeling framework to examine the contribution of moral disengagement and achievement goal orientations to academic cheating behavior among adolescents using an interpretable gradient boosting approach. The target population consisted of secondary school students enrolled in public high schools across urban and suburban districts in the state of California. A multistage cluster sampling strategy was used in which school districts were first selected based on geographic distribution and socioeconomic diversity, followed by random selection of schools within each district and then intact classrooms within each school. Participants were adolescents aged 14 to 18 years who were enrolled in grades 9 through 12 during the 2025–2026 academic year. After obtaining approvals from school administrations and institutional review board clearance, written informed consent was secured from parents or legal guardians, and assent was obtained from all student participants. A total of 742 students were invited to participate, of whom 681 provided complete and usable data after data screening procedures, yielding a final analytic sample composed of 347 females and 334 males with a mean age of 16.21 years (SD = 1.12). Inclusion criteria required participants to be currently enrolled in high school and capable of completing the survey instruments in English, while exclusion criteria included diagnosed cognitive impairments or learning disabilities that would compromise questionnaire comprehension. Data were collected during regular school hours in supervised classroom sessions conducted by trained research assistants to ensure standardized administration conditions.

2.2. Measures

Academic cheating behavior was assessed using the Adolescent Academic Dishonesty Scale, a 20-item self-report measure designed to capture the frequency of behaviors such as copying assignments, using unauthorized materials during exams, plagiarism, and collaborative cheating. Items were rated on a five-point Likert continuum ranging from never to very often, with higher scores reflecting greater involvement in cheating behaviors. Moral disengagement was measured using the Moral Disengagement in Academic Contexts Scale, consisting of 24 items assessing mechanisms such as moral justification, euphemistic labeling, diffusion of responsibility, displacement of responsibility, distortion of consequences, dehumanization, and attribution of blame. Responses were recorded on a five-point agreement scale from strongly disagree to strongly agree, with higher scores indicating stronger endorsement of moral disengagement mechanisms. Achievement goal orientations were measured using the Achievement Goal Questionnaire–Revised, which includes subscales for mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance goals, with 12 items rated on a seven-point agreement scale. All instruments demonstrated strong internal consistency in the present sample, with Cronbach's alpha coefficients ranging from 0.83 to 0.91. Prior to main data collection, a pilot study with 60 students was conducted to confirm clarity of wording and estimate completion time, resulting in minor linguistic refinements. Demographic information including age, gender, grade level, parental education, and academic performance (self-reported GPA) was also collected to allow for control of potential confounding variables.

2.3. Data Analysis

Data analysis was conducted using Python and R statistical environments. Preliminary analyses included missing data inspection, outlier detection using the interquartile range method, and assessment of normality, multicollinearity, and homoscedasticity. Missing values, which comprised less than 3% of the dataset, were handled using multiple imputation via chained equations. To model academic cheating, an Extreme Gradient Boosting (XGBoost) regression framework was implemented due to its capacity to capture complex nonlinear relationships and high-order interactions among psychological variables. Model training used an 80/20 train-test split with five-fold cross-validation for hyperparameter tuning via Bayesian optimization. Model performance was evaluated using root mean squared error, mean absolute error, and coefficient of determination on the holdout dataset. To ensure interpretability of the machine learning model, Shapley Additive Explanations were computed to estimate the relative and local contribution of each predictor to cheating behavior. Feature importance rankings, partial dependence

plots, and interaction effects were examined to interpret how different forms of moral disengagement and achievement goals jointly influenced cheating tendencies. Additional robustness checks included comparison of gradient boosting performance with linear regression and random forest models. All analyses were conducted at a significance threshold of $p < .05$ for complementary inferential procedures, and findings were reported in accordance with contemporary best practices for interpretable machine learning in psychological research.

3. Findings and Results

Table 1 presents the descriptive statistics and Pearson correlation coefficients among academic cheating, moral disengagement, and achievement goal orientations. These results provide an initial understanding of the central tendency, variability, and direction of associations among the core variables prior to predictive modeling.

Table 1

Descriptive Statistics and Correlations Among Study Variables (N = 681)

Variable	Mean	SD	1	2	3	4	5	6
1. Academic Cheating	2.41	0.71	—					
2. Moral Disengagement	2.89	0.65	.54**	—				
3. Mastery-Approach Goals	4.98	0.92	−.18**	−.22**	—			
4. Mastery-Avoidance Goals	4.21	0.88	.12**	.19**	.36**	—		
5. Performance-Approach Goals	4.45	1.01	.29**	.33**	.21**	.27**	—	
6. Performance-Avoidance Goals	4.67	0.96	.41**	.46**	−.09*	.31**	.39**	—

As shown in Table 1, academic cheating demonstrated a strong positive correlation with moral disengagement, indicating that adolescents who more frequently endorsed moral disengagement mechanisms reported higher engagement in cheating behaviors. Cheating was moderately and positively associated with performance-approach and performance-avoidance goals, suggesting that competitive and failure-avoidant motivational orientations were linked to greater academic dishonesty. In contrast, mastery-approach goals showed a negative association with cheating, implying a protective role of intrinsic learning-oriented motivation.

Mastery-avoidance goals exhibited a small but significant positive relationship with cheating. Moral disengagement was negatively associated with mastery-approach goals and positively associated with all avoidance- and performance-based goal orientations, highlighting its central role in maladaptive academic behaviors.

Table 2 summarizes the predictive performance of the gradient boosting model in estimating academic cheating, along with comparative performance indices for baseline linear regression and random forest models.

Table 2

Predictive Performance of Models for Academic Cheating

Model	RMSE	MAE	R²
Linear Regression	0.58	0.46	0.31
Random Forest	0.49	0.38	0.47
Gradient Boosting (XGBoost)	0.44	0.34	0.56

The results presented in Table 2 indicate that the gradient boosting model outperformed both linear regression and random forest approaches across all performance metrics. The gradient boosting model accounted for 56% of the variance in academic cheating, demonstrating substantial predictive accuracy and supporting the presence of nonlinear and interactive effects among moral disengagement and achievement goal variables. The improvement over linear regression underscores the limitations of purely linear assumptions in modeling adolescent cheating behavior.

Table 3 presents the global feature importance rankings derived from the gradient boosting model based on mean absolute Shapley values, reflecting the relative contribution of each predictor to model predictions.

Table 3

Global Feature Importance Based on Shapley Values

Predictor	Mean Absolute SHAP Value	Rank
Moral Disengagement	0.182	1
Performance-Avoidance Goals	0.113	2
Performance-Approach Goals	0.096	3
Mastery-Avoidance Goals	0.071	4
Mastery-Approach Goals	0.058	5
Self-Reported GPA	0.041	6
Parental Education	0.026	7
Gender	0.019	8
Age	0.014	9

As shown in Table 3, moral disengagement emerged as the most influential predictor of academic cheating, with a substantially larger contribution than any other variable. Performance-avoidance and performance-approach goals ranked second and third, respectively, indicating that fear of failure and competitive achievement motives play prominent roles in cheating behavior. Mastery-approach goals had the lowest importance among motivational variables, reinforcing their comparatively weaker but protective influence. Demographic variables showed relatively minor contributions, suggesting that psychological constructs were more salient determinants of cheating behavior than background characteristics.

Table 4 reports the direction and magnitude of marginal effects for key predictors based on partial dependence estimates from the gradient boosting model.

Table 4

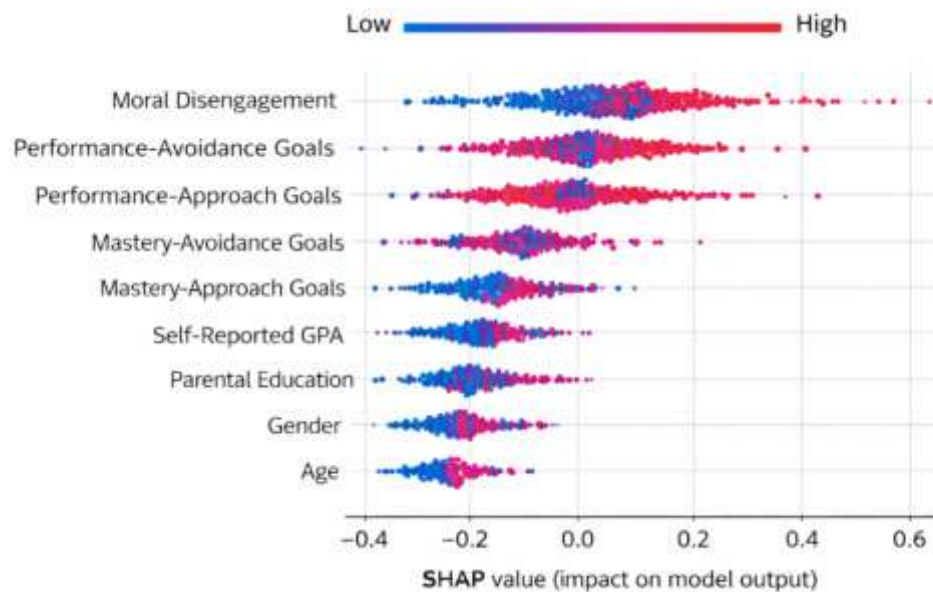*Partial Dependence Effects of Key Predictors on Academic Cheating*

Predictor	Direction of Effect	Pattern of Association
Moral Disengagement	Positive	Strongly nonlinear, accelerating at higher levels
Performance-Avoidance Goals	Positive	Linear to moderately nonlinear
Performance-Approach Goals	Positive	Curvilinear, plateauing at high levels
Mastery-Avoidance Goals	Positive	Weak linear
Mastery-Approach Goals	Negative	Linear protective effect

The partial dependence results indicate that increases in moral disengagement were associated with a steep rise in predicted cheating, particularly beyond moderate levels, highlighting a threshold effect. Performance-avoidance goals showed a consistent positive association with cheating across their range, whereas performance-approach goals demonstrated diminishing marginal effects at higher levels. Mastery-approach goals were associated with a steady decrease in predicted cheating, supporting their role as a protective motivational factor.

Figure 1

SHAP summary plot illustrating the distribution and direction of feature effects on academic cheating predictions

The SHAP summary visualization further demonstrated that higher values of moral disengagement and performance-based goals consistently shifted model predictions toward higher cheating scores, whereas higher mastery-approach goal scores shifted predictions downward. Collectively, the findings indicate that moral disengagement mechanisms constitute the central psychological driver of academic cheating in adolescents, with achievement goal orientations exerting meaningful but secondary influences through complex, nonlinear pathways.

4.   Discussion

The present study employed an interpretable gradient boosting framework to investigate the psychological predictors of academic cheating among adolescents, focusing on the roles of moral disengagement and achievement goal orientations. The findings revealed that moral disengagement emerged as the strongest predictor of cheating behavior, followed by performance-avoidance and performance-approach goals, while mastery-approach goals demonstrated a consistent protective effect. These results provide robust empirical support for theoretical models that conceptualize academic dishonesty as a cognitively mediated and motivationally driven behavior shaped by both internal psychological processes and external performance demands.

The dominant influence of moral disengagement observed in this study is consistent with extensive prior research identifying moral disengagement as a central mechanism facilitating unethical conduct across academic and organizational domains. Moral disengagement allows individuals to neutralize moral self-sanctions by cognitively reframing unethical actions as acceptable, justified, or inconsequential, thereby enabling cheating without the experience of guilt or self-reproach (Tahrir et al., 2020; Welsh et al., 2020). The strong nonlinear effect detected in the present analysis indicates that moral disengagement does not simply increase cheating in a proportional manner but instead exerts accelerating influence once a certain cognitive threshold is crossed. This pattern aligns with experimental and field studies showing that once individuals begin to adopt moral disengagement rationalizations, subsequent unethical actions become increasingly easy and psychologically cost-free (Dias-Oliveira et al., 2022; He et al., 2023). The prominence of moral disengagement in the current findings thus reinforces its role as a primary cognitive gateway through which achievement pressure and situational stress translate into dishonest academic behavior.

The second most influential predictors, performance-avoidance and performance-approach goals, further illuminate the motivational architecture underlying cheating. Performance-avoidance goals, characterized by fear of failure and concern about negative evaluation, were strongly

associated with increased cheating, consistent with previous findings that such goals promote anxiety, self-protective behavior, and expedient coping strategies under pressure (He et al., 2023; Li, 2025). Adolescents driven by performance-avoidance are particularly vulnerable to cheating because failure threatens their self-worth and social standing, making dishonest behavior appear as a necessary survival strategy within competitive academic environments (Khan et al., 2023; Shi et al., 2025). Performance-approach goals, although oriented toward success rather than avoidance, also predicted higher cheating, suggesting that excessive emphasis on outperforming peers can similarly undermine ethical standards when success becomes the overriding objective (Boardley et al., 2025; Karam et al., 2025).

In contrast, mastery-approach goals exhibited a consistent negative association with cheating, supporting the protective role of intrinsic learning motivation and self-improvement orientation. Adolescents who pursue mastery goals view academic challenges as opportunities for growth rather than threats to self-worth, which reduces reliance on dishonest coping strategies (Yau et al., 2022; Yau et al., 2021). The current findings corroborate meta-analytic evidence demonstrating that mastery-oriented students are less likely to engage in cheating because their motivation is anchored in personal competence development rather than social comparison or external validation (Li, 2025). Importantly, the interpretable machine learning results showed that the protective effect of mastery-approach goals operates in a stable and linear manner, suggesting that even moderate increases in mastery orientation may yield meaningful reductions in cheating risk.

The interactive patterns uncovered by the gradient boosting model further clarify how motivational and cognitive processes converge to produce academic dishonesty. The results indicate that high levels of performance-based goals amplify the effect of moral disengagement on cheating, creating a synergistic risk configuration. This finding is consistent with organizational and educational studies demonstrating that performance pressure magnifies the ethical consequences of goal commitment, particularly when individuals employ moral disengagement to justify unethical actions in pursuit of desired outcomes (Kamran et al., 2022; Welsh et al., 2020; Zhang et al., 2020). Adolescents experiencing intense performance demands are therefore more likely to activate moral disengagement strategies as psychological tools for navigating conflicting goals of success and integrity.

The developmental context of adolescence provides critical insight into why these dynamics are particularly pronounced during this life stage. Adolescence is characterized by heightened sensitivity to peer evaluation, evolving identity formation, and ongoing development of moral reasoning and self-regulatory capacities. Research indicates that adolescents' sense of purpose, future orientation, and self-efficacy are strongly shaped by family climate and school support structures, which in turn influence ethical decision-making and academic conduct (H et al., 2025; Hill & Burrow, 2021). When adolescents operate within educational systems that prioritize competition, surveillance, and high-stakes evaluation, they may experience diminished moral agency and increased psychological strain, making moral disengagement and cheating more likely responses (Příhodová et al., 2021; Thiel et al., 2021).

The role of social and familial influences is also evident in the broader literature linking family structure, emotional regulation, and deviance propensity. Adolescents from environments marked by emotional instability, anger dysregulation, and weak moral communication exhibit elevated risk for engaging in dishonest behaviors, including academic cheating (Saladino et al., 2020). Conversely, adolescents embedded in supportive social networks with high levels of emotional availability and autonomy support demonstrate stronger study wellbeing and lower engagement in unethical conduct (Ulmanen et al., 2022). These findings suggest that moral disengagement and achievement goal orientations develop within complex ecological systems rather than in isolation.

Personality traits and dispositional factors further compound these processes. Studies show that psychopathic traits, narcissism, and hubristic pride increase vulnerability to cheating by weakening empathy, inflating entitlement beliefs, and diminishing internal moral restraints (Dias-Oliveira et al., 2022; Liu et al., 2022). These traits interact with achievement pressures and moral disengagement to form stable behavioral patterns that persist across academic and professional contexts (Kamran et al., 2022; Zhang et al., 2020). The present findings align with this integrative perspective by demonstrating that psychological risk for cheating is multidimensional, nonlinear, and dynamically structured.

Importantly, the present study extends the existing literature by demonstrating the utility of interpretable machine learning for advancing psychological theory. Traditional regression models assume linear, additive effects

that fail to capture the complex interactions observed in the present analysis. The gradient boosting approach revealed threshold effects, nonlinear accelerations, and synergistic interactions that offer a more accurate representation of the psychological mechanisms underlying academic dishonesty. By integrating Shapley-based explanations, the study preserved theoretical interpretability while achieving superior predictive performance, addressing longstanding concerns regarding the opacity of machine learning models in psychological research (Shi et al., 2025; Wang & Read, 2024).

The implications of these findings are particularly salient in the contemporary educational landscape, where digital technologies, online assessments, and generative artificial intelligence tools have transformed the nature of academic work and ethical decision-making. Students' interactions with AI systems and digital platforms introduce novel forms of academic misconduct and challenge traditional definitions of originality and authorship (Monge & Matthews, 2024; Watts et al., 2023). The strong predictive role of moral disengagement identified in this study suggests that technological controls alone are insufficient for curbing cheating; instead, interventions must directly address the cognitive and motivational foundations of ethical behavior.

5. Conclusion

Taken together, the results provide compelling evidence that academic cheating among adolescents is best understood as the product of intertwined moral, motivational, and contextual processes. Moral disengagement functions as the central cognitive mechanism enabling cheating, while achievement goal orientations shape the motivational conditions under which disengagement becomes activated. The application of interpretable machine learning offers a powerful framework for uncovering these dynamics and for guiding evidence-based educational interventions.

6. Limitations & Suggestions

Several limitations should be acknowledged. First, the cross-sectional design precludes causal inference regarding the directionality of relationships among moral disengagement, achievement goals, and cheating behavior. Second, reliance on self-report measures may introduce social desirability bias despite assurances of anonymity. Third, the sample was drawn from high schools in California, which may limit generalizability to other cultural

or educational contexts. Fourth, although the model captured complex nonlinear relationships, unmeasured variables such as peer norms, teacher behavior, and school climate were not directly included.

Future studies should employ longitudinal and experimental designs to examine the developmental trajectories of moral disengagement and achievement goals across adolescence and their causal effects on cheating behavior. Incorporating multi-informant assessments, behavioral measures, and ecological momentary sampling could further strengthen validity. Expanding the model to include contextual variables such as classroom climate, teacher practices, and digital learning environments would provide a more comprehensive understanding of the systemic factors shaping academic integrity.

Educational interventions should prioritize the development of students' moral reasoning skills, promote mastery-oriented learning environments, and reduce excessive performance pressure. Teacher training programs should emphasize ethical modeling, supportive feedback, and autonomy-supportive instructional practices. Schools should implement preventive programs that directly address moral disengagement strategies and foster students' intrinsic motivation for learning while integrating ethical literacy into curricula.

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 to this article.

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