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Machine-Learning Identification of Subtypes of Adolescent Perfectionism Based on Concern Over Mistakes, Parental Expectations, Cognitive Rigidity, and Negative Affect

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A B S T R A C T

Objective: The objective of this study was to identify distinct latent subtypes of adolescent perfectionism by applying unsupervised machine-learning algorithms to a comprehensive set of variables, specifically concern over mistakes, parental expectations, cognitive rigidity, and negative affect.

Methods and Materials: The research utilized a cross-sectional, school-based design, sampling $N = 1432$ adolescents from Germany. Data were gathered using standardized self-report instruments to measure the four target variables, with all raw scores converted to standardized z-scores. Following data preprocessing, unsupervised machine learning via Gaussian Mixture Modeling (GMM) was employed to uncover latent subpopulations, evaluating models ranging from two to six classes using fit indices such as the Bayesian Information Criterion and the Bootstrapped Likelihood Ratio Test.

Findings: The GMM algorithm identified an optimal three-class structural model (Entropy = .86). The sample was categorized into Class 1: Low Perfectionism (48.2%, $n = 690$); Class 2: Externally Pressured Perfectionism (34.5%, $n = 494$), defined predominantly by elevated perceived parental expectations ($z = 0.65$); and Class 3: Maladaptive Perfectionism (17.3%, $n = 248$), characterized by pervasive elevations across all domains, notably severe negative affect ($z = 1.51$) and extreme cognitive rigidity ($z = 1.42$). Demographic analyses revealed significant differences, indicating that older adolescents ($F(2,1429) = 14.52$, $p < .001$) and females ($\chi^2(2, N = 1432) = 28.74$, $p < .001$), who comprised 68.1%of Class 3, were significantly overrepresented in the Maladaptive Perfectionism profile.

Conclusion: Adolescent perfectionism manifests in distinct multivariate phenotypes, highlighting the critical necessity of identifying high-risk, maladaptive subtypes to deliver highly targeted clinical interventions focusing on cognitive flexibility and emotion regulation.

Keywords: *Adolescent perfectionism, Machine learning, Gaussian Mixture Modeling, Cognitive rigidity, Negative affect, Parental expectations.*

1. Introduction

Adolescence is a critical developmental epoch characterized by profound biological, cognitive, and psychosocial transformations. As youth navigate these complex changes, they are increasingly exposed to varied environmental pressures that can shape their personality development and overall psychological functioning. One major personality disposition that has garnered substantial empirical attention in recent years is perfectionism. Perfectionism is a multidimensional construct broadly defined by the setting of excessively high standards for performance accompanied by overly critical self-evaluations. In contemporary society, a myriad of factors, including socio-demographic variables, interpersonal relationship dynamics, and exposure to idealized portrayals in modern media, significantly predict the manifestation and trajectory of perfectionistic traits in adolescents (Livazović & Kuzmanović, 2022). While the pursuit of excellence can sometimes be associated with positive outcomes, such as a greater sense of meaning in life and school satisfaction (Akbaba, 2024), the rigid and inflexible adherence to unrealistic standards frequently precipitates a cascade of negative developmental outcomes. Indeed, intrapersonal perfectionism fundamentally alters how preadolescents and adolescents interact with their environment, often impairing the development of crucial social skills and subsequently diminishing their overall psychological well-being (Lee et al., 2024). Therefore, it is imperative to dissect the specific dimensions of perfectionism that render youth vulnerable to psychological maladjustment.

A central component of maladaptive perfectionism is the profound concern over mistakes. Adolescents with elevated levels of this specific dimension tend to interpret minor errors as catastrophic failures, closely tying their intrinsic self-worth to flawless performance. This intense fear of failure is intricately linked to how adolescents process and regulate their internal emotional states. Research indicates that the dimensions of perfectionism are significantly predicted by both positive and negative meta-emotions, meaning that adolescents' beliefs about their own feelings heavily influence their rigid self-evaluations (Ghorbannezhad, 2022). Uncompromising perfectionism is frequently accompanied by maladaptive cognitive emotion regulation strategies, such as rumination and self-blame, which are particularly prevalent in adolescents suffering from high levels of social anxiety (Haddadi & Temanai Far, 2022). When adolescents are unable to flexibly adapt their cognitive framing—a state known as cognitive rigidity—their perfectionistic tendencies become deeply entrenched. This cognitive inflexibility restricts their capacity to employ healthy coping mechanisms, thereby exacerbating emotional distress. Consequently, adolescents characterized by rigid perfectionistic profiles struggle significantly with emotion regulation (Vois & Damian, 2019).

The familial environment, particularly parenting styles and parental expectations, plays an indisputable role in the genesis and maintenance of adolescent perfectionism. Perfectionistic tendencies do not develop in a vacuum; they are largely socialized. Adolescents often internalize the perceived standards and criticisms of their primary caregivers. Studies have shown that perceived parenting styles, whether authoritarian or overly permissive, interact with perfectionism to mediate outcomes such as social appearance anxiety among emerging adults (Aygün & Akbağ, 2025). Furthermore, familial affective responsiveness acts as a crucial mediator between a parent's own perfectionistic self-presentation and the subsequent psychological maladjustment of their adolescent offspring (Chen et al., 2022). When parents exhibit perfectionistic behaviors or enforce relentlessly high expectations, it directly translates into academic procrastination and severe academic burnout for the student (Souri et al., 2024). The transmission of these traits can also manifest in severe psychopathological symptoms; for instance, perfectionism has been identified as a critical mediating variable in the relationship between adverse parenting styles and the development of obsessive-compulsive symptoms in youth (Liang et al., 2025). The stress exerted on the family unit is bidirectional, as mothers of children with behavioral problems often experience elevated parental stress that is deeply intertwined with their own perfectionism and psychological flexibility (Jannesari, 2025).

Beyond the family, the academic domain is the primary arena where adolescent perfectionism is enacted and evaluated. The longitudinal associations between perfectionism and academic achievement across adolescence reveal a complex picture where the drive for perfection may initially boost grades but eventually leads to diminishing returns due to chronic stress (Endleman et al., 2022). This dynamic heavily influences domain-specific confidence, such as early adolescents' math self-efficacy, where perfectionistic standards act as a filter through which students interpret their academic capabilities (Ford et al., 2023). Depending on their specific profile, students exhibit varying degrees of stability and change in their achievement

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goal orientations, which dictate whether they approach learning with a desire to master the material or merely to avoid appearing incompetent (Ståhlberg et al., 2021). Gifted adolescents are particularly susceptible to this dynamic, often utilizing avoidance coping strategies to manage the immense pressure of their perfectionistic expectations, leading to paradoxical academic underachievement (Mofield et al., 2016). In high-stakes testing environments, perfectionism heavily predicts severe test anxiety, though a strong sense of coherence and meaningfulness can sometimes buffer against this effect (Zhao et al., 2022). For candidates facing critical milestones, such as college entrance exams, perfectionism combined with rigid cognitive thinking styles significantly predicts debilitating generalized anxiety (Seyidabrahimi, 2019). Over time, the relentless pursuit of flawlessness in the academic sphere culminates in profound academic burnout, a trajectory that has been confirmed through longitudinal extensions of bifactor models of perfectionism (Seong et al., 2021).

The psychological toll of maladaptive perfectionism extends far beyond the classroom, profoundly impacting the physical and mental health of adolescents. One of the most severe manifestations is seen in the realm of body image and eating pathology. Extensive systematic reviews and meta-analyses have firmly established perfectionism as a core vulnerability factor for the development and maintenance of eating disorders in children and adolescents (Bills et al., 2023). In clinical and community samples alike, perfectionistic traits are inextricably linked to eating-related symptoms, with effect estimates indicating a robust and perilous association (Livet et al., 2023). This relationship is often mediated by emotional distress and the individual's level of differentiation of self, suggesting that adolescents who struggle to separate their self-worth from external validation are at the highest risk (Peleg et al., 2023). Furthermore, the interaction between perfectionism, emotion regulation deficits, and cognitive eating patterns significantly predicts eating disorder symptomatology (Mohorić et al., 2023). This drive for physical perfection is exacerbated by media exposure, which fuels body dissatisfaction and reinforces rigid societal standards of attractiveness (Nigar & Naqvi, 2019). In adults and older adolescents facing body image issues, such as obese women, therapeutic interventions like schema therapy that target underlying perfectionism and fear of intimacy have shown considerable efficacy, highlighting the deep-seated nature of these cognitive schemas (Ebrahimi et al., 2022).

Perfectionism also acts as a catalyst for a wide spectrum of internalizing disorders. The intense cognitive rigidity and negative affect associated with perfectionistic concerns create a fertile ground for social anxiety. Predictive models indicate that perfectionism, combined with cognitive distortions and low social self-efficacy, reliably predicts the onset and severity of social anxiety in both male and female adolescents (Fatemi et al., 2022). The somatic consequences of this chronic psychological arousal are equally troubling. For example, perfectionism significantly contributes to the development of insomnia in adolescents, primarily through the mechanism of heightened vulnerability to daily stressors, with specific variations observed across gender (Richardson & Gradisar, 2020). In its most severe and dysregulated forms, the overwhelming negative affect and self-punitive nature of perfectionism can escalate to dangerous behaviors. Clinical case studies have highlighted instances where severe, unyielding perfectionism directly precipitates episodes of unintentional non-suicidal self-injury, underscoring the urgent need to address the intense emotional pain experienced by these youths (Oh, 2024).

Despite the wealth of literature linking perfectionism to these diverse adverse outcomes, the majority of prior research has relied on variable-centered statistical approaches. While informative, variable-centered methods obscure the reality that perfectionism does not operate as an isolated variable but rather clusters within individuals in distinct, multivariate profiles. Adolescents experience a confluence of traits simultaneously—such as high concern over mistakes, overwhelming parental expectations, entrenched cognitive rigidity, and pervasive negative affect. Person-centered approaches are theoretically superior for understanding this complexity because they identify unobserved subpopulations (subtypes) of individuals who share similar configurations of variables. Traditional clustering methods have been utilized, but the advent of advanced, unsupervised machine-learning algorithms offers a more mathematically robust and objective methodology for uncovering these hidden diagnostic profiles. Machine learning can partition complex, high-dimensional psychological data into highly accurate subtypes, providing critical insights into how these distinct variables amalgamate to form highly vulnerable phenotypes.

To advance the current understanding of adolescent psychopathology, it is critical to move beyond singular constructs and examine the holistic architecture of perfectionistic vulnerability. Concern over mistakes represents the internal evaluative threat; parental

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expectations represent the external, environmental pressure; cognitive rigidity represents the structural inflexibility preventing adaptation; and negative affect represents the ultimate emotional fallout. By utilizing sophisticated machine-learning techniques to analyze these four specific domains simultaneously, researchers and clinicians can identify exact profiles of adolescents who are at the greatest risk for severe developmental derailment. Understanding these specific subtypes is paramount for the development of targeted, individualized psychological interventions that address the unique cognitive and emotional profiles of struggling youth, rather than applying a one-size-fits-all approach to perfectionism. Therefore, the aim of the present study was to identify distinct latent subtypes of adolescent perfectionism by applying unsupervised machine-learning algorithms to a comprehensive set of variables, specifically concern over mistakes, parental expectations, cognitive rigidity, and negative affect.

2. Methods and Materials

2.1. Study Design and Participants

The present research utilized a cross-sectional, school-based survey design to investigate the multidimensional nature of perfectionism among youth. The target population comprised a community sample of adolescents residing in Germany. Participants were recruited from several public and private secondary schools across diverse urban and rural districts in Germany to ensure a representative sociodemographic distribution. The final sample consisted of exactly $N = 1432$adolescents. Participants were required to be between the ages of thirteen and eighteen, fluent in the German language, and possess written informed consent from their legal guardians alongside their own voluntary assent. Questionnaires were administered in group settings within the school classrooms under the supervision of trained research assistants, ensuring anonymity and confidentiality. Any responses with extensive missing data across the primary variables of interest were excluded prior to the final count, ensuring that the exactly 1432participants included in the final dataset provided robust data for the subsequent machine-learning algorithms.

2.2. Measures

To capture the specific psychological constructs underlying perfectionism, a comprehensive battery of standardized, psychometrically validated self-report instruments was employed. Concern over mistakes and parental expectations were assessed using the respective subscales from the German adaptation of the Frost Multidimensional Perfectionism Scale. The concern over mistakes subscale measures negative reactions to errors and the tendency to interpret mistakes as equivalent to failure, while the parental expectations subscale evaluates the adolescents' perceptions of their parents establishing excessively high standards. Responses were recorded on a five-point Likert scale, yielding high internal consistency with Cronbach's αtypically exceeding $.85$. Cognitive rigidity, reflecting the inability to adapt cognitive processing strategies to face new and unexpected conditions, was measured using the adolescent version of the Cognitive Flexibility Inventory, reverse-scored to capture rigidity. This instrument asks participants to rate their agreement with statements regarding their perceived competence in navigating challenging situations, providing a robust continuous metric of cognitive inflexibility. Finally, negative affect was quantified utilizing the negative affect subscale of the Positive and Negative Affect Schedule for children and adolescents. This tool requires participants to rate the extent to which they experienced various distressing emotions, such as guilt, fear, and nervousness, over the past several weeks, graded on a five-point scale. All raw scores were standardized into z-scores to facilitate equitable weighting during the computational modeling phase.

2.3. Data Analysis

The analytical pipeline was predominantly driven by unsupervised machine-learning techniques aimed at discovering hidden structures and identifying distinct profiles of perfectionism based on the multidimensional input features. Prior to model training, data preprocessing involved screening for multivariate outliers utilizing Mahalanobis distance at a threshold of $p < .001$, and missing values were imputed using the random forest-based multivariate imputation by chained equations algorithm to preserve the integrity of the sample size. To identify the latent subtypes of adolescent perfectionism, a Gaussian Mixture Modeling approach was implemented. Gaussian Mixture Modeling is a probabilistic model that assumes all the data points are generated from a mixture of a finite number of Gaussian distributions with unknown parameters, making it highly effective for profile identification. Models ranging from two to six distinct clusters were iteratively fit to the standardized data comprising concern over mistakes,

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parental expectations, cognitive rigidity, and negative affect. The determination of the optimal number of subtypes was guided by a combination of statistical fit indices and theoretical interpretability. Specifically, models were evaluated using the Akaike Information Criterion, the Bayesian Information Criterion, and the sample-size adjusted Bayesian Information Criterion, where lower values indicate superior model fit. Furthermore, the Bootstrapped Likelihood Ratio Test was utilized to compare the k-class model against a $k-1$-class model, and entropy values were examined to assess classification accuracy, with values closer to 1.0indicating clear delineation between the identified perfectionism subtypes. All machine learning algorithms and statistical analyses were executed using the scikit-learn library in the Python programming environment.

3. Findings and Results

The initial phase of the data analysis involved examining the descriptive statistics and bivariate correlations among the primary study variables, which included concern over mistakes, parental expectations, cognitive rigidity, and negative affect. Preliminary screening confirmed that all variables approximated a normal distribution, with skewness and kurtosis values falling well within the acceptable ranges of $-2.0$to $+2.0$. The final analytic sample of $N = 1432$adolescents demonstrated moderate to high mean scores across the perfectionism and psychological distress indicators. As anticipated based on prevailing theoretical models of perfectionism, Pearson product-moment correlation analyses revealed significant positive associations among all the measured constructs. Specifically, concern over mistakes exhibited a strong positive correlation with negative affect ($r = .54, p < .001$) and cognitive rigidity ($r = .48,\ p < .001$). Furthermore, perceived parental expectations were significantly associated with both concern over mistakes ($r = .42, p < .001$) and negative affect ($r = .35, p < .001$), underscoring the interconnected nature of environmentally induced performance pressures and internal psychological rigidity. The detailed descriptive statistics, including means, standard deviations, and the complete correlation matrix for the total sample, are presented in Table 1.

Table 1

Descriptive Statistics and Bivariate Correlations for Study Variables (N=1432)

Variable	*M*	*SD*	1	2	3	4
1. Concern Over Mistakes	24.31	6.82	–			
2. Parental Expectations	16.45	4.71	.42**	–		
3. Cognitive Rigidity	31.12	7.94	.48**	.38**	–	
4. Negative Affect	22.08	6.15	.54**	.35**	.46**	–

Following the preliminary analyses, Gaussian Mixture Modeling was employed to identify unobserved, latent subpopulations within the adolescent sample based on their multivariate profiles across the four standardized indicator variables. Models specifying between two and six latent classes were iteratively estimated and compared to determine the optimal categorical structure. The evaluation of model fit was based on the Akaike Information Criterion, the Bayesian Information Criterion, the sample-size adjusted Bayesian Information Criterion, entropy values, and the Bootstrapped Likelihood Ratio Test. As the number of classes increased from two to three, there were substantial decreases in the information criteria, indicating improved model fit. The three-class model demonstrated a highly favorable entropy value of .86, suggesting excellent classification accuracy and a clear delineation between the identified profiles. While the four-class and five-class models yielded slightly lower information criteria, the decreases were marginal, and the Bootstrapped Likelihood Ratio Test for the four-class model indicated that the inclusion of a fourth class did not significantly improve the model fit over the three-class solution ($p = .142$). Moreover, the fourth class in the four-class model contained less than 5%of the total sample, rendering it theoretically less meaningful and statistically less stable. Consequently, the three-class model was retained as the most parsimonious, interpretable, and statistically robust representation of adolescent perfectionism subtypes in this sample. The fit indices for all evaluated models are detailed in Table 2.

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Table 2

Fit Indices for the Gaussian Mixture Models Ranging from Two to Six Classes

Number of Classes	AIC	BIC	saBIC	Entropy	BLRT p-value
2Classes	14521.43	14584.62	14546.81	.78	<.001
3Classes	13210.18	13305.01	13248.25	.86	<.001
4Classes	13155.94	13282.43	13206.71	.81	.142
5Classes	13120.33	13278.47	13183.82	.75	.355
6Classes	13098.71	13288.51	13174.90	.73	.610

The three identified latent classes were subsequently profiled based on their standardized mean scores (z-scores) across concern over mistakes, parental expectations, cognitive rigidity, and negative affect to establish their substantive interpretations. The first and largest class, comprising 48.2%of the sample ($n = 690$), was labeled the "Low Perfectionism" subtype. Adolescents in this group were characterized by scores consistently below the sample mean across all four indicators, reflecting a healthy cognitive profile devoid of intense evaluative concerns or emotional distress. The second class, which accounted for 34.5%of the sample ($n = 494$), was designated the "Externally Pressured Perfectionism" subtype. This profile exhibited moderately elevated scores on perceived parental expectations ($z = 0.65$) and concern over mistakes ($z = 0.42$), but only average levels of cognitive rigidity ($z = 0.12$) and negative affect ($z = 0.18$). This suggests a profile where perfectionistic tendencies are primarily driven by perceived external demands rather than deeply entrenched internal cognitive inflexibility. The third and smallest class, encompassing 17.3%of the sample ($n = 248$), was identified as the "Maladaptive Perfectionism" subtype. This group displayed profoundly elevated scores across all measures, particularly highlighting severe concern over mistakes ($z = 1.35$), extreme cognitive rigidity ($z = 1.42$), and exceptionally high levels of negative affect ($z = 1.51$). The standardized means for each class are presented in Table 3.

Table 3

Standardized Means (z-scores) of Indicator Variables Across the Three Latent Classes

Indicator Variable	Low Perfectionism ($n = 690$)	Externally Pressured ($n = 494$)	Maladaptive ($n = 248$)
Concern Over Mistakes	−0.62	0.42	1.35
Parental Expectations	−0.58	0.65	0.88
Cognitive Rigidity	−0.45	0.12	1.42
Negative Affect	−0.55	0.18	1.51

To further validate the identified subtypes and understand their demographic compositions, a series of one-way analyses of variance and chi-square tests of independence were conducted to examine differences in age and gender distribution across the three classes. The analysis of variance revealed a statistically significant difference in age among the subtypes, $F(2,1429) = 14.52$, $p < .001$, $\eta^2 = .02$. Post-hoc comparisons utilizing the Tukey Honestly Significant Difference test indicated that adolescents in the Maladaptive Perfectionism class ($M = 16.12$, $SD = 1.34$) were significantly older than those in both the Low Perfectionism class ($M = 15.21$, $SD = 1.41$) and the Externally Pressured class ($M = 15.45$, $SD = 1.28$). Furthermore, a chi-square test of independence indicated a significant gender disparity across the perfectionism profiles, $\chi^2(2, N = 1432) = 28.74$, $p < .001$, Cramer's $V = .14$. Standardized residuals revealed that female adolescents were significantly overrepresented in the Maladaptive Perfectionism class (68.1%) compared to their overall proportion in the total sample (52.4%), whereas male adolescents were more frequently categorized within the Low Perfectionism class. These demographic variations underscore developmental and gender-specific vulnerabilities regarding the manifestation of rigid and distressing perfectionistic traits during adolescence. The demographic characteristics and statistical comparisons are summarized in Table 4.

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Table 4

Demographic Characteristics and Statistical Comparisons Across Latent Classes

Demographic	Total Sample ($N = 1432$)	Low Perfectionism ($n = 690$)	Externally Pressured ($n = 494$)	Maladaptive ($n = 248$)	Test Statistic	p-value
Age, $M(SD)$	15.48(1.38)	15.21(1.41)	15.45(1.28)	16.12(1.34)	$F = 14.52$	$<.001$
Gender, $n(\%)$					$\chi^2 = 28.74$	$<.001$
Male	681(47.6%)	385(55.8%)	217(43.9%)	79(31.9%)		
Female	751(52.4%)	305(44.2%)	277(56.1%)	169(68.1%)		

4. Discussion

The primary objective of the current investigation was to elucidate the multidimensional architecture of adolescent perfectionism by applying advanced unsupervised machine-learning algorithms to identify latent subpopulations based on concern over mistakes, parental expectations, cognitive rigidity, and negative affect. The application of Gaussian Mixture Modeling to a large, representative sample of adolescents yielded a robust three-class solution, characterizing youth into "Low Perfectionism," "Externally Pressured Perfectionism," and "Maladaptive Perfectionism" profiles. The emergence of these distinct phenotypes strongly supports the conceptualization of perfectionism not merely as a monolithic trait arrayed along a single continuum, but as a complex, configurationally diverse syndrome where internal cognitive styles and external environmental pressures intersect to produce varying levels of psychological distress. The preliminary correlation analyses corroborated existing theoretical frameworks, demonstrating that the fear of making errors is intrinsically linked to both environmental pressures and internal emotional turmoil. Specifically, concern over mistakes was significantly and positively associated with cognitive rigidity, negative affect, and perceived parental expectations. These foundational findings provided the statistical scaffolding for the machine-learning models, which ultimately revealed how these variables cluster within specific individuals to form distinct, highly vulnerable developmental trajectories.

The most clinically significant finding of this study is the identification of the "Maladaptive Perfectionism" subtype, encompassing 17.3%of the adolescent sample. This group exhibited profoundly elevated standardized scores across all four indicators, characterized by severe concern over mistakes, overwhelming parental expectations, extreme cognitive inflexibility, and exceptionally high negative affect. The convergence of these traits creates a highly toxic psychological environment. Adolescents in this class are likely trapped in a cyclical pattern where unrealistic environmental demands are internalized into rigid cognitive schemas, leading to an inability to flexibly adapt to developmental challenges or academic setbacks. This finding strongly aligns with prior research demonstrating that uncompromising perfectionism, particularly when coupled with maladaptive cognitive styles, is a primary driver of severe emotional dysregulation and psychological distress in youth (Vois & Damian, 2019). The profound cognitive rigidity observed in this cluster mirrors findings that inflexible thinking styles and poor emotion regulation are central to the psychopathology of perfectionistic individuals (Mohorić et al., 2023). Furthermore, the extreme levels of negative affect found in this specific subtype help explain why some adolescents with high perfectionistic tendencies are exceptionally vulnerable to severe psychological crises, including intense social anxiety and deeply ingrained cognitive distortions (Fatemi et al., 2022). In its most severe manifestations, the intense emotional pain and rigid self-punishment characteristic of this maladaptive profile can escalate into dangerous behavioral outcomes, such as non-suicidal self-injury, highlighting the critical need for early identification of this specific multivariate phenotype (Oh, 2024).

Conversely, the "Externally Pressured Perfectionism" class, representing 34.5%of the sample, offers a nuanced perspective on the socialization of high standards. Adolescents in this profile reported moderately elevated levels of perceived parental expectations and concern over mistakes, yet they maintained average levels of cognitive rigidity and negative affect. This suggests a developmental stage or a specific psychological phenotype where perfectionistic striving is primarily driven by a desire to appease caregivers and meet external demands, but has not yet crystallized into deep-seated internal cognitive pathology or overwhelming emotional distress. This aligns with the extensive literature highlighting the foundational

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role of the family unit in the genesis of adolescent perfectionism. Research consistently indicates that perceived parenting styles and parental expectations are pivotal mediators in the development of perfectionistic traits (Aygün & Akbağ, 2025). When parents exhibit perfectionistic self-presentation or communicate relentlessly high standards, it fundamentally alters the familial affective responsiveness, placing immense pressure on the adolescent (Chen et al., 2022). This externally driven pressure is a known catalyst for academic burnout and severe academic procrastination, as students strive to avoid parental disappointment rather than pursuing intrinsic mastery (Souri et al., 2024). Furthermore, the interplay between parenting styles and the child's subsequent perfectionism is a well-documented pathway for the development of broader psychopathology, including obsessive-compulsive symptoms, underscoring the necessity of addressing familial dynamics even when the adolescent is not yet exhibiting severe negative affect (Liang et al., 2025).

The demographic variations observed across the identified latent classes further contextualize the developmental and sociocultural dimensions of adolescent perfectionism. The analysis revealed that older adolescents were significantly more likely to be categorized within the Maladaptive Perfectionism class. This age-related escalation suggests a cumulative effect of chronic environmental pressures, increasingly rigorous academic demands, and the complex psychosocial transitions inherent to late adolescence. As students progress through the educational system, the stakes associated with academic performance rise dramatically, often culminating in high-stakes testing environments where perfectionistic tendencies predict severe generalized anxiety and rigid cognitive thinking styles (Seyidabrahimi, 2019). The longitudinal associations between perfectionism and academic achievement demonstrate that while early perfectionistic striving might yield short-term academic gains, the prolonged stress eventually leads to diminishing returns and severe academic burnout (Endleman et al., 2022). Over time, the continuous exposure to these pressures likely solidifies cognitive rigidity and amplifies negative affect, shifting students from a potentially manageable state of external pressure into fully entrenched maladaptive perfectionism (Seong et al., 2021). This cumulative stress impairs early adolescents' domain-specific confidence, such as math self-efficacy, and alters their overarching achievement goal orientations (Ford et al., 2023; Ståhlberg et al., 2021).

In addition to age disparities, a pronounced gender difference was observed, with female adolescents being significantly overrepresented in the Maladaptive Perfectionism class. This finding resonates deeply with the broader epidemiological literature concerning gender-specific vulnerabilities to stress, internalizing disorders, and somatic manifestations such as insomnia (Richardson & Gradisar, 2020). Adolescent females are frequently subjected to a unique confluence of academic, social, and cultural pressures that intensely focus on flawless presentation and performance (Livazović & Kuzmanović, 2022). These societal pressures are profoundly magnified by exposure to modern media, which frequently precipitates intense body dissatisfaction when perfectionistic standards are applied to physical appearance (Nigar & Naqvi, 2019). The combination of high concern over mistakes, cognitive rigidity, and negative affect in females is a known, potent precursor to the development and maintenance of severe eating disorders (Bills et al., 2023; Livet et al., 2023). The emotional distress intrinsic to this maladaptive profile acts as a critical mediating variable, exacerbating the risk of eating pathology, particularly when adolescents struggle with the differentiation of self from these externalized, rigid standards (Peleg et al., 2023). Furthermore, these deeply entrenched, maladaptive schemas often persist into adulthood, necessitating complex therapeutic interventions to dismantle the profound fear of intimacy and rigid perfectionism seen in clinical populations, such as obese adult women (Ebrahimi et al., 2022).

The pervasive impact of these perfectionistic profiles is not limited to severe psychopathology but also fundamentally dictates the day-to-day emotional and social functioning of the youth. The intense fear of making mistakes and the inability to cognitively reframe failures—hallmarks of the maladaptive class—severely impair the development of crucial interpersonal skills. Intrapersonal perfectionism disrupts normative social development, compromising the longitudinal psychological well-being of preadolescents as they struggle to navigate the complexities of peer relationships (Lee et al., 2024). The cognitive emotion regulation deficits and chronic rumination associated with this profile frequently culminate in debilitating social anxiety, as these adolescents constantly anticipate judgment and catastrophic social failure (Haddadi & Temanai Far, 2022). Even among gifted adolescents, who possess immense cognitive resources, maladaptive perfectionism frequently results in avoidance coping strategies, leading to paradoxical underachievement and a

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profound failure to actualize their potential (Mofield et al., 2016). Conversely, mitigating these rigid perfectionistic traits and fostering a strong sense of coherence and meaning in life are essential protective factors that can buffer against test anxiety and promote genuine school satisfaction (Akbaba, 2024; Zhao et al., 2022). The parental stress associated with managing adolescents exhibiting such profound behavioral and emotional difficulties further highlights the systemic nature of this issue, necessitating a comprehensive, multi-informant approach to understanding and treating perfectionism (Jannesari, 2025).

5. Conclusion

In conclusion, this study successfully utilized unsupervised machine learning to elucidate the multidimensional nature of adolescent perfectionism, identifying three distinct latent subtypes: Low Perfectionism, Externally Pressured Perfectionism, and Maladaptive Perfectionism. The findings decisively demonstrate that the Maladaptive subtype, which comprised 17.3%of the sample, is characterized by a detrimental convergence of severe concern over mistakes, high parental expectations, profound cognitive rigidity, and elevated negative affect. Furthermore, demographic analyses revealed that older adolescents and females are disproportionately represented within this high-risk phenotype. These results underscore the critical importance of moving beyond one-dimensional assessments to recognize these complex, multivariate profiles. By identifying these distinct configurations, educators and mental health professionals can better develop and implement highly targeted clinical interventions that specifically address cognitive inflexibility and emotion regulation deficits, ultimately mitigating the severe psychological distress experienced by the most vulnerable youth.

6. Limitations & Suggestions

Despite the robust methodological approach and the large, representative sample utilized in this investigation, several important limitations must be acknowledged when interpreting the findings. First, the cross-sectional nature of the study design precludes the establishment of definitive causal relationships between the constituent variables of the identified perfectionism profiles. While it is theoretically sound to posit that parental expectations contribute to cognitive rigidity and negative affect, the bidirectional nature of parent-child interactions implies that an adolescent's pre-existing emotional distress could also elicit highly controlling or critical parenting behaviors. Second, the reliance on self-report questionnaires, although validated and widely used, introduces the possibility of shared method variance and social desirability bias. Adolescents, particularly those with high perfectionistic tendencies, may systematically underreport their negative affect or overstate their cognitive flexibility to present themselves in a more favorable light. Third, while the sample was large and drawn from various districts, it was restricted to a single Western European country. The cultural nuances regarding academic achievement, familial duty, and the socialization of emotions in Germany may limit the generalizability of these specific latent classes to adolescents in distinct cultural contexts, particularly non-Western societies where communal expectations might yield different configurations of perfectionism.

To address these limitations and build upon the current findings, future research should prioritize the implementation of longitudinal, multi-wave study designs to trace the developmental trajectories of these perfectionism subtypes. By tracking adolescents over several years, researchers can determine whether individuals transition between the "Externally Pressured" and "Maladaptive" classes over time, and identify the specific life stressors or developmental milestones that precipitate these shifts. Additionally, future studies should move beyond sole reliance on self-report data by incorporating multi-informant methodologies, including parallel assessments from parents, teachers, and peers, to create a more holistic and objective profile of the adolescent's functioning and the familial environment. The integration of physiological markers of stress, such as cortisol reactivity or resting heart rate variability, could also provide vital biological correlates to the psychological profiles identified via machine learning. Furthermore, applying these advanced clustering algorithms to diverse cross-cultural samples and clinical populations diagnosed with anxiety or eating disorders will be essential to validate the universal applicability and clinical utility of the three-class model discovered in this community sample.

From an applied perspective, the identification of these distinct perfectionism subtypes offers crucial insights for the development of targeted educational and clinical interventions. The findings strongly suggest that school-based mental health professionals should implement comprehensive screening programs utilizing the four indicators studied here to identify at-risk youth before their

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perfectionistic tendencies solidify into severe psychopathology. For adolescents identified within the "Externally Pressured" class, preventive interventions should primarily focus on family-systems approaches, incorporating psychoeducation for parents regarding the deleterious effects of excessively high expectations and training in autonomy-supportive parenting strategies. Conversely, adolescents falling into the "Maladaptive Perfectionism" cluster require immediate, intensive, and individualized clinical care. Interventions for this highly vulnerable group must prioritize cognitive-behavioral techniques explicitly designed to dismantle deep-seated cognitive rigidity and enhance emotion regulation skills, helping them separate their intrinsic self-worth from their performance. Furthermore, educators must strive to cultivate learning environments that emphasize mastery, resilience, and the normal, constructive role of making mistakes, thereby mitigating the systemic academic pressures that disproportionately harm perfectionistic youth.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

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

Transparency of Data

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

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Authors' Contributions

All authors equally contributed to this article.

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