

Algorithmic Differentiation of Parenting Phenotypes: Clustering Parental Burnout, Psychological Flexibility, and Their Effects on Child Effortful Control

Laura. Paredes¹, Andrés. Mejía^{2*}

¹ Department of Educational Psychology, Autonomous University of Santo Domingo, Santo Domingo, Dominican Republic

² Department of Social Psychology, Universidad del Valle, Cali, Colombia

* Corresponding author email address: andres.mejia@correounivalle.edu.co

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ABSTRACT

Objective: This study aimed to differentiate parenting phenotypes via algorithmic clustering of parental burnout and psychological flexibility, and to examine their subsequent impact on child effortful control.

Methods and Materials: A cross-sectional, quantitative study was conducted with 734 primary caregivers of children aged 4 to 9 years in Colombia. Data were collected via a secure online survey utilizing validated instruments: the Parental Burnout Assessment (PBA), the Parental Acceptance and Action Questionnaire (PAAQ; reverse-coded), and the Effortful Control scale from the parent-reported Child Behavior Questionnaire (CBQ). A two-step cluster analysis (hierarchical with Ward's method followed by K-means) was applied to standardized z-scores of the PBA and PAAQ to determine parenting profiles. Group distinctiveness and effects on child effortful control were analyzed using MANOVA and ANCOVA, controlling for parent age and child gender, followed by post-hoc Tukey's HSD tests.

Findings: The clustering algorithm yielded an optimal three-phenotype solution (average silhouette width = .59): Adaptive ($n = 352$, low burnout, high flexibility), Strained ($n = 168$, high burnout, low flexibility), and Vulnerable ($n = 214$, moderate scores). A MANOVA confirmed significant multivariate distinctiveness between the clusters (Wilks' $\Lambda = .21$, $F(4,1460) = 405.62$, $p < .001$, $\eta_p^2 = .54$). ANCOVA revealed a significant main effect of parenting phenotype on child effortful control ($F(2,729) = 68.45$, $p < .001$, $\eta_p^2 = .16$). Children of the Adaptive Phenotype exhibited the highest effortful control ($M = 5.21$), scoring significantly higher than both the Vulnerable ($M = 4.78$) and Strained ($M = 4.15$) phenotypes ($p < .001$ for all pairwise comparisons).

Conclusion: Distinct algorithmic parenting phenotypes significantly predict variations in child effortful control, highlighting the critical influence of parental psychological states on child self-regulation.

Keywords: Parental burnout, psychological flexibility, effortful control, cluster analysis, parenting phenotypes, child development

1. Introduction

The landscape of modern parenting is increasingly characterized by an intersection of systemic pressures, escalating societal expectations, and acute external stressors. Compounded significantly by recent global crises that abruptly shifted the boundaries of work and home life, parents are navigating unprecedented cognitive and emotional demands (Joyce, 2022). When the chronicity of these demands overwhelms a caregiver's available psychosocial resources, the resultant state is recognized clinically as parental burnout. Parental burnout is a complex syndrome characterized by profound physical and emotional exhaustion related to one's parenting role, emotional distancing from one's children, and a stark contrast with one's previous parental self (Brianda et al., 2023). The etiology of this burnout is deeply intertwined with pre-existing parenting styles; caregivers who adopt overly rigid or highly perfectionistic approaches to child-rearing often find themselves at a significantly elevated risk for rapid emotional depletion (Mikkonen et al., 2023).

As parental emotional reserves evaporate into exhaustion, there is a well-documented and deleterious shift in daily parenting behaviors. Burnt-out parents frequently lose the cognitive bandwidth required to engage in patient, autonomy-supportive caregiving. Instead, exhaustion frequently morphs into psychological intrusion and coercive control (Zhou et al., 2025). In an attempt to force compliance and minimize immediate caregiving demands, parents may inadvertently rely on manipulation, guilt-induction, and the withdrawal of affection. Cultivating self-compassion has been identified as a vital mechanism to reduce this burnout, thereby lowering the incidence of such harmful psychological control and increasing parental support (Nguyen et al., 2022). Without targeted intervention, however, parental exhaustion manifests in a variety of maladaptive behaviors. For instance, exhausted caregivers may increasingly engage in parental phubbing—the act of ignoring one's children in favor of digital devices—which has been shown to precipitate academic burnout and severely diminish self-control capacities in adolescents (Jiang et al., 2023).

The cascade from parental burnout to psychological control exerts a profoundly destructive impact on the psychological well-being and developmental trajectories of children and adolescents. Excessive parental psychological control is fundamentally antithetical to a child's basic psychological need for autonomy. Consequently, it has been

consistently and directly linked to the exacerbation of internalizing symptoms, such as severe clinical depression and anxiety among adolescent populations (Zhu et al., 2024). This relationship holds true across various developmental stages, significantly increasing broad depressive symptomology among middle school students (Zhang, 2024). Furthermore, the subjective experience of this control is vital; significant discrepancies between how parents and adolescents perceive psychological control and autonomy support can independently predict poor psychological adjustment and relational fractures (Zheng & Chen, 2025). Conversely, environments defined by high levels of parental autonomy support, which represent the behavioral antithesis of psychological control, are foundational for enhancing the subjective well-being and emotional thriving of elementary-aged students (Ding et al., 2025).

Beyond internalizing psychopathology, the spillover effects of exhausted and controlling parenting permeate multiple behavioral and academic domains. High levels of psychological control have been empirically shown to reduce children's learning engagement, dampening their intrinsic motivation and overall life satisfaction (Zhang & Peng, 2025). The core syndrome of parental burnout itself is directly and negatively associated with the academic outcomes of primary school students, creating an environment where cognitive development is inadvertently stunted by the caregiver's distress (An et al., 2021). Behaviorally, controlling and intrusive parenting environments significantly increase the likelihood that adolescents will develop problematic internet use as an escapist coping mechanism (Huang et al., 2026). Similarly, psychological control fosters a heightened fear of missing out (FoMO) among youth, a dynamic that is frequently mediated by the onset of social media addiction (Khan et al., 2025). The overarching stress within the family unit also precipitates parent-adolescent conflict, which further degrades adolescent self-control and serves as a strong longitudinal predictor of externalizing behaviors, such as bullying perpetration (Song, 2025).

Given the severe, multi-domain consequences of parental burnout and harsh parenting paradigms, identifying and cultivating protective psychological mechanisms is of paramount clinical importance. In recent years, psychological flexibility has emerged as a cornerstone of adaptive human functioning and resilience. In the specific context of caregiving, parental psychological flexibility is defined as a parent's ability to remain mindfully present, open, and engaged in values-based parenting behaviors,

even when experiencing distressing thoughts, emotional turmoil, or highly challenging child behaviors. Operating as a critical psychological buffer, greater flexibility predicts significantly lower parental stress, even among mothers navigating the chronic difficulties associated with raising children who exhibit severe behavioral problems (Jannesari, 2025). Furthermore, perceived parenting attitudes and a parent's capacity for effective self-emotion regulation are deeply, structurally intertwined with their baseline level of psychological flexibility (Erkul, 2023).

The protective power of this flexibility extends beyond the parent, directly shaping and safeguarding child outcomes. Higher parental psychological flexibility acts as a robust moderating variable; it significantly dampens the adverse impacts of parental burnout and dysfunctional co-parenting dynamics on a child's subsequent internalizing and externalizing problems (Cao et al., 2024). Flexibility also serves as a critical, active mechanism in mitigating children's generalized behavior problems, often achieving this by organically fostering better emotion regulation capacities within the child themselves (Ren et al., 2022). Conversely, a systemic lack of psychological flexibility is heavily implicated in long-term dysfunctional parenting patterns, eventually contributing to profound emotional dysregulation and substance misuse vulnerabilities in later developmental stages, such as among college-aged students (Arslan, 2023). Recognizing its immense clinical utility, structured therapeutic interventions—ranging from dialectical behavior therapy (Nazari et al., 2025) to filial and attachment-based play therapies (Adili et al., 2024)—have been specifically designed to target these mechanisms, proving effective at reducing parental burnout and fostering adaptive, flexible parenting paradigms. Additionally, the broader cognitive and psychological flexibility of parents is directly correlated with the successful promotion of prosocial behaviors in diverse youth populations (Lan, 2023).

A critical, foundational developmental outcome that is heavily contingent upon this interplay between parental burnout and psychological flexibility is child effortful control. Effortful control is a vital temperamental trait defined as the neurocognitive ability to inhibit a dominant, impulsive response in order to execute a subdominant, adaptive response, to detect behavioral errors, and to engage in long-term planning. It serves as the primary cognitive and emotional substrate upon which children build academic success, peer relationships, and lifelong emotional resilience. When primary caregivers are chronically burnt

out, their capacity to scaffold this complex, energy-intensive skill in their children diminishes rapidly. The exhaustion characteristic of burnout severely limits a parent's ability to model the exact self-regulation they are attempting to instill. Consequently, the child's relational environment becomes unpredictable and reactive rather than proactive and structured, severely stunting the organic, neurological development of effortful control.

Conversely, parents who exhibit high levels of psychological flexibility provide the most optimal environmental matrix for the cultivation of child effortful control. By maintaining a non-judgmental stance toward their own internal parenting stressors and remaining fiercely committed to long-term parenting values, flexible caregivers consistently model high-level emotional regulation. They are able to respond to a child's inevitable dysregulation with steady, coregulating behaviors rather than resorting to the reactive, controlling, or punitive measures associated with burnout. This consistent, autonomy-supportive scaffolding directly nurtures the neural pathways necessary for a child to internalize robust effortful control. Thus, psychological flexibility is not merely a private, internal coping mechanism utilized by the parent; it functions as an active, structural, and indispensable element in the child's developmental ecology.

Therefore, the aim of this study is to utilize algorithmic clustering to differentiate primary caregivers into distinct parenting phenotypes based on their combined profiles of parental burnout and psychological flexibility, and subsequently examine how these distinct algorithmic phenotypes affect the development of child effortful control.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a cross-sectional, quantitative research design to identify distinct parenting phenotypes and examine their relationship with child outcomes. A total of 734 primary caregivers residing in various urban centers across Colombia were recruited for participation. Recruitment was conducted primarily through online channels, including social media parenting groups, collaborations with educational institutions, and digital advertisements targeted at parents. To be eligible for inclusion, participants had to be the primary caregiver of at least one child between the ages of four and nine years, be over 18 years of age, and provide informed digital consent prior to participation. This age range for the child was

selected as it is a critical developmental period for the consolidation of effortful control. Participants with incomplete survey data exceeding 15% on any single psychometric scale were excluded from the final analysis, resulting in a robust final sample for the clustering algorithm.

2.2. Measures

Data were collected using a secure online survey platform. The survey battery included a demographic questionnaire and three validated psychometric instruments translated and culturally adapted for the Colombian Spanish-speaking population. The demographic section collected information on parent age, gender, educational attainment, socioeconomic status, as well as the child's age and gender. Parental burnout was assessed using the Parental Burnout Assessment (PBA). This instrument measures the core dimensions of burnout in the parenting domain, including emotional exhaustion, emotional distancing from one's children, feelings of being fed up, and the contrast between the current and previous parental self. To measure psychological flexibility within the parenting context, the Parental Acceptance and Action Questionnaire (PAAQ) was administered. The PAAQ evaluates the extent to which parents engage in value-driven actions and maintain psychological acceptance and cognitive defusion when faced with challenging child behaviors and internal parenting-related distress. Finally, child effortful control was measured via parent report using the Effortful Control scale from the Child Behavior Questionnaire (CBQ) - Short Form. This widely used scale assesses a child's ability to regulate their attention and behavior, with sub-components including inhibitory control, attentional focusing, and low-intensity pleasure.

2.3. Data Analysis

All data analyses were conducted using the R programming language, specifically utilizing the stats and cluster packages. The analysis proceeded in three distinct phases. First, preliminary analyses were performed, including the calculation of descriptive statistics (means, standard deviations) and an assessment of the psychometric properties of the scales within our sample. Bivariate Pearson's correlation coefficients, represented as r , were calculated to examine the initial linear relationships between parental burnout, psychological flexibility, and child effortful control. The second phase involved the core

algorithmic differentiation of parenting phenotypes. A two-step cluster analysis was employed using the standardized z-scores of the primary subscales of the Parental Burnout Assessment and the Parental Acceptance and Action Questionnaire as input variables. Initially, a hierarchical agglomerative clustering approach using Ward's minimum variance method with squared Euclidean distance was conducted to explore the data structure and determine the optimal number of clusters. This decision was guided by examining the dendrogram and calculating silhouette scores. Subsequently, a non-hierarchical K-means clustering analysis was performed, prespecifying the optimal number of clusters identified in the hierarchical step, to assign each participant to a final, distinct parenting phenotype. The validity of the resulting clusters was confirmed using a one-way multivariate analysis of variance (MANOVA) to ensure the clusters were statistically distinct on the input variables. The final phase of the analysis aimed to determine the effect of these parenting phenotypes on child outcomes. An analysis of covariance (ANCOVA) was conducted with the parent cluster membership as the independent variable and the child's effortful control score as the dependent variable. Parent's age and the child's gender were included as covariates to control for their potential confounding effects on the results. A significant main effect of cluster membership, evaluated by the F-statistic and its associated p-value, was followed by post-hoc comparisons using Tukey's HSD test to identify specific between-group differences in child effortful control scores across the identified parenting phenotypes.

3. Findings and Results

Preliminary analyses were conducted to examine the distributional properties of the data and to assess the internal consistency of the psychometric instruments utilized within the Colombian sample of primary caregivers ($N = 734$). An evaluation of skewness and kurtosis indicated that the continuous variables approximated a normal distribution, with values falling well within the acceptable range of -2.0 to $+2.0$, thereby justifying the use of parametric statistical tests. The internal consistency of all scales was robust. The Parental Burnout Assessment demonstrated excellent reliability ($\alpha = .92$), as did the Parental Acceptance and Action Questionnaire ($\alpha = .88$) and the Effortful Control scale of the Child Behavior Questionnaire ($\alpha = .85$). For the purpose of these analyses, the Parental Acceptance and Action Questionnaire scores were reverse-

coded such that higher composite scores reflect greater psychological flexibility. Bivariate correlational analyses using Pearson’s *r* revealed significant associations among the primary study variables in the expected directions. Parental burnout was significantly and negatively correlated with both psychological flexibility ($r = -.54, p < .001$) and child effortful control ($r = -.39, p < .001$). Conversely, psychological flexibility exhibited a significant

positive correlation with child effortful control ($r = .42, p < .001$). Additional demographic correlations revealed that neither parent age ($r = .06, p = .104$) nor child gender ($r = .04, p = .278$) were strongly associated with the primary variables, though they were retained as covariates in subsequent analyses to ensure conservative hypothesis testing. The descriptive statistics and bivariate correlations for the primary continuous variables are summarized below.

Table 1

Descriptive Statistics and Bivariate Correlations for Primary Study Variables

Variable	<i>M</i>	<i>SD</i>	Range	1	2	3
1. Parental Burnout	42.31	18.45	0 – 108	–		
2. Psychological Flexibility	76.82	14.12	20 – 105	-.54**	–	
3. Child Effortful Control	4.85	0.92	1.5 – 6.8	-.39**	.42**	–

To identify distinct parenting phenotypes based on algorithmic differentiation, a two-step cluster analysis was performed using the standardized *z*-scores of parental burnout and psychological flexibility. Initially, a hierarchical agglomerative cluster analysis utilizing Ward’s minimum variance method with squared Euclidean distances was conducted. An examination of the resulting dendrogram, coupled with an evaluation of the silhouette coefficients, strongly indicated a three-cluster solution as the most statistically optimal and theoretically meaningful partition of the data (average silhouette width = .59). Following this determination, a non-hierarchical K-means clustering algorithm was executed, specifying $k = 3$, to iteratively partition the participants into final phenotypic groups. To validate the distinctiveness of these algorithmically derived clusters, a one-way multivariate analysis of variance (MANOVA) was conducted with cluster membership as the independent variable and the standardized scores of parental burnout and psychological flexibility as the dependent variables. The MANOVA

revealed a statistically significant multivariate main effect of cluster membership, Wilks’ $\Lambda = .21, F(4,1460) = 405.62, p < .001, \eta_p^2 = .54$. The resulting three clusters were conceptually labeled based on their distinct psychometric profiles. The first cluster ($n = 352$), labeled the “Adaptive Phenotype,” was characterized by significantly low levels of parental burnout and high levels of psychological flexibility. The second cluster ($n = 168$), designated the “Strained Phenotype,” exhibited the most maladaptive profile, marked by critically high levels of parental burnout and severely diminished psychological flexibility. The third cluster ($n = 214$), termed the “Vulnerable Phenotype,” displayed moderate, mid-range scores on both dimensions, representing a transitional or at-risk group. The specific unstandardized means, standard deviations, and univariate analysis of variance (ANOVA) results confirming the differentiation of these phenotypes are detailed in the subsequent table.

Table 2

Cluster Profiles and Univariate ANOVA Results for Parenting Phenotypes

Variable	Adaptive Phenotype ($n = 352$)	Strained Phenotype ($n = 168$)	Vulnerable Phenotype ($n = 214$)	$F(2, 731)$	<i>p</i>	η_p^2
Parental Burnout (<i>M</i>)	28.14 _a	72.58 _b	41.87 _c	524.31	< .001	.59
Parental Burnout (<i>SD</i>)	10.22	12.45	9.81			
Psychological Flexibility (<i>M</i>)	86.51 _a	55.40 _b	77.69 _c	388.15	< .001	.51
Psychological Flexibility (<i>SD</i>)	8.95	11.32	10.04			

To determine the effects of these distinct algorithmic parenting phenotypes on child effortful control, an analysis of covariance (ANCOVA) was executed. Prior to conducting the ANCOVA, the assumption of homogeneity of regression slopes was tested and met, as the interaction terms between the covariates and the independent variable were not statistically significant ($p > .05$). Furthermore, Levene’s test for equality of error variances indicated that the assumption of homoscedasticity was satisfied, $F(2,731) = 1.62, p = .198$. In the primary ANCOVA model, parenting phenotype (Adaptive, Strained, Vulnerable) served as the fixed factor, child effortful control served as the continuous

dependent variable, and parent age and child gender were entered as covariates to isolate the unique variance attributable to the parenting profiles. The analysis revealed that after controlling for the effects of parent age and child gender—neither of which exerted a significant main effect on the dependent variable—there was a highly significant main effect of parenting phenotype on child effortful control, $F(2,729) = 68.45, p < .001, \eta_p^2 = .16$. This moderate-to-large effect size indicates that approximately 16% of the variance in a child’s effortful control can be explained by the specific burnout-flexibility cluster to which their primary caregiver belongs.

Table 3

Analysis of Covariance (ANCOVA) for Child Effortful Control by Parenting Phenotype

Source	Type III Sum of Squares	df	Mean Square	F	p	η_p^2
Corrected Model	102.45	4	25.61	35.13	< .001	.16
Intercept	215.30	1	215.30	295.34	< .001	.29
Parent Age (Covariate)	1.12	1	1.12	1.54	.215	.00
Child Gender (Covariate)	2.35	1	2.35	3.22	.073	.00
Parenting Phenotype	99.80	2	49.90	68.45	< .001	.16
Error	531.43	729	0.73			
Total	17950.00	734				

To elucidate the specific nature of this main effect, pairwise post-hoc comparisons were conducted utilizing Tukey’s Honestly Significant Difference (HSD) test, adjusting for multiple comparisons. These post-hoc tests revealed significant differences across all three phenotypic pairings. Children raised by caregivers classified within the Adaptive Phenotype demonstrated the highest levels of effortful control ($M = 5.21, SE = 0.05$). Their scores were significantly higher than those of children raised by caregivers in both the Vulnerable Phenotype ($M = 4.78, SE = 0.06$; mean difference = 0.43, $p < .001$, Cohen’s $d = 0.48$) and the Strained Phenotype ($M = 4.15, SE = 0.07$; mean difference = 1.06, $p < .001$, Cohen’s $d = 1.25$). Furthermore, children associated with the Vulnerable Phenotype exhibited significantly higher effortful control scores compared to those in the Strained Phenotype (mean difference = 0.63, $p < .001$, Cohen’s $d = 0.72$). These findings unequivocally demonstrate a gradient effect, wherein optimal child self-regulation is associated with the presence of high psychological flexibility and low burnout, while the compound algorithmic phenotype of high parental burnout and psychological inflexibility is associated with profound deficits in child effortful control.

4. Discussion

The primary objective of this investigation was to utilize an algorithmic clustering approach to identify distinct parenting phenotypes based on the intersection of parental burnout and psychological flexibility, and to subsequently evaluate the impact of these compound profiles on child effortful control. The algorithmic differentiation yielded three highly distinct parenting phenotypes: the Adaptive Phenotype, characterized by low burnout and high flexibility; the Strained Phenotype, defined by severe burnout and profound psychological inflexibility; and the Vulnerable Phenotype, representing a moderate, transitional profile. Furthermore, the analysis of covariance revealed a highly significant gradient effect of these phenotypes on child outcomes. Children raised by caregivers belonging to the Adaptive Phenotype exhibited the highest levels of effortful control, whereas those associated with the Strained Phenotype demonstrated severe and pervasive deficits in their self-regulatory capacities.

The emergence of these mathematically distinct profiles aligns robustly with recent conceptualizations of the caregiving experience as a dynamic, multidimensional construct rather than a series of isolated variables. The

profound inverse relationship observed between burnout and flexibility within our clusters supports the premise that a parent's emotional reserves are heavily contingent upon their capacity for mindful, values-based action. Caregivers situated within the Strained Phenotype appear trapped in a self-perpetuating cycle where the chronic emotional exhaustion and distancing characteristic of parental burnout (Brianda et al., 2023) systematically erode their cognitive capacity to remain psychologically flexible. This aligns with findings suggesting that overwhelming systemic and environmental stress inevitably compromises a parent's ability to regulate their own emotions, leading to rigid, reactive, and ultimately dysfunctional parenting attitudes (Erkul, 2023; Joyce, 2022). Conversely, the profile of the Adaptive Phenotype demonstrates that high psychological flexibility serves as a vital structural buffer against the depleting cognitive demands of parenting, effectively fostering resilience and maintaining caregiving efficacy even in the face of normative child-rearing stressors (Mikkonen et al., 2023). When caregivers maintain this psychological flexibility, it actively predicts significantly lower levels of overall parental stress, providing a more stable psychological foundation for the entire family unit (Jannesari, 2025).

The severe deficits in effortful control observed among children of the Strained Phenotype can be understood through the destructive behavioral cascade that is invariably triggered by parental exhaustion and inflexibility. As parents become severely burnt out, their depleted cognitive bandwidth frequently translates into harsh, intrusive, and psychologically controlling behaviors, as exhaustion morphs directly into a need for immediate behavioral compliance (Zhou et al., 2025). This algorithmic phenotype's reliance on coercive psychological control fundamentally disrupts the child's relational environment. Previous research consistently demonstrates that environments dominated by such parental psychological control precipitate severe emotional dysregulation in youth, drastically increasing their vulnerability to internalizing symptoms, including clinical depression and severe anxiety, across various developmental stages (Zhang, 2024; Zhu et al., 2024). Furthermore, discrepancies in how this control and a lack of autonomy support are perceived between the parent and the child can independently fracture the relational bond, exacerbating the child's psychological maladjustment (Zheng & Chen, 2025). In the specific context of the Strained Phenotype, the parent's fundamental inability to model emotional regulation or provide steady, patient scaffolding deprives the

child of the necessary environmental matrix to neurologically internalize effortful control. This emotional starvation directly undermines the child's academic engagement, intrinsic motivation, and overall life satisfaction (Zhang & Peng, 2025), echoing broader literature which indicates that parental burnout directly and negatively diminishes the cognitive and academic outcomes of primary school students (An et al., 2021).

The psychological inflexibility inherent in the Strained Phenotype also manifests in subtle but deeply damaging withdrawal behaviors that further stunt child self-regulation. For instance, exhausted and inflexible caregivers are highly prone to engaging in parental phubbing, a withdrawal behavior that has been empirically shown to compromise adolescent self-control and precipitate early academic burnout (Jiang et al., 2023). The chronic stress and emotional reactivity embedded within these inflexible family units frequently escalate into pervasive parent-adolescent conflict, which serves as a potent longitudinal predictor of diminished self-control and subsequent externalizing behaviors, such as bullying perpetration (Song, 2025). Moreover, the intrusive psychological control that characterizes this exhausted parenting paradigm actively drives youth toward escapist, dysregulated coping mechanisms. This significantly increases the risk of developing problematic internet use (Huang et al., 2026) and fosters social media addiction that is heavily mediated by a chronic fear of missing out (Khan et al., 2025).

In stark contrast to the deleterious effects of the Strained Phenotype, the Adaptive Phenotype actively optimizes child self-regulation and effortful control. Parents exhibiting high psychological flexibility are capable of maintaining vital autonomy-supportive parenting behaviors even during moments of acute distress, a practice known to fundamentally enhance a child's subjective well-being and emotional thriving (Ding et al., 2025). This flexibility has been empirically shown to act as a powerful moderating variable, actively shielding children from the toxic spillover effects of burnout and mitigating the development of severe internalizing and externalizing behavioral problems (Cao et al., 2024). By remaining mindfully present, flexible parents actively foster better organic emotion regulation within their children (Ren et al., 2022) and promote the robust development of prosocial behaviors across diverse populations (Lan, 2023). By maintaining a compassionate and flexible stance, these parents drastically reduce their reliance on harsh psychological control (Nguyen et al., 2022), thereby preventing the entrenchment of long-term

dysfunctional patterns that frequently lead to emotional instability and substance misuse vulnerabilities in later developmental stages (Arslan, 2023). The proven efficacy of this flexible, adaptive approach strongly underscores the necessity of targeted clinical interventions. Modalities such as dialectical behavior therapy (Nazari et al., 2025) and specialized attachment-based play therapies (Adili et al., 2024) have demonstrated significant success in reducing parental burnout precisely by aiming to cultivate these essential adaptive psychological mechanisms in struggling caregivers.

5. Conclusion

In conclusion, the application of algorithmic differentiation in this study provides a highly nuanced, ecologically valid framework for understanding the profound complexities of the modern caregiving experience. By moving beyond traditional, isolated variable analyses and instead mathematically grouping caregivers based on their compound psychometric profiles, this research highlights that parental burnout and psychological flexibility are deeply intertwined constructs that collectively dictate the quality of the caregiving environment. The identification of the Adaptive, Vulnerable, and Strained phenotypes reveals a stark gradient effect on developmental outcomes, unequivocally demonstrating that a child's capacity for effortful control is fundamentally reliant upon the psychological bandwidth of their primary caregiver. When caregivers are trapped in a profile of high exhaustion and psychological rigidity, the child's self-regulatory neurocognitive development is severely stunted. Conversely, when the family system is anchored by a caregiver possessing high psychological flexibility and low burnout, the child is provided with the optimal environmental scaffolding necessary to develop robust, lifelong self-regulation.

6. Suggestions and Limitations

Despite the robust algorithmic methodology and large sample size employed in this investigation, several methodological limitations must be carefully acknowledged when interpreting the findings. Primarily, the cross-sectional nature of the research design precludes the establishment of definitive causal pathways. While the theoretical framework strongly suggests that the parental phenotype shapes the child's effortful control, it is mathematically plausible that raising a child with severe, pre-existing deficits in effortful

control bidirectionally accelerates parental burnout and diminishes caregiver flexibility. Furthermore, the reliance on single-informant self-report measures for both the independent parental variables and the dependent child outcomes introduces the risk of shared method variance and social desirability bias. Caregivers within the Strained Phenotype, experiencing profound exhaustion and potential feelings of inadequacy, may have systematically underreported their child's self-regulatory abilities due to a generalized negative perceptual bias regarding their family life. Finally, the sample was restricted to urban populations within Colombia, which may limit the generalizability of these specific algorithmically derived cluster proportions to rural populations or fundamentally different cultural contexts where the structural supports and societal expectations surrounding the parenting role differ significantly.

Future research endeavors should seek to build upon these foundational findings by addressing these methodological limitations and expanding the scope of inquiry. Longitudinal research designs are critically needed to track the stability of these algorithmic phenotypes over time. Understanding the specific environmental or developmental catalysts that cause a caregiver to transition from the Vulnerable Phenotype into the Strained Phenotype, or conversely, what organic factors promote a shift toward the Adaptive Phenotype, would provide invaluable clinical data. Furthermore, future studies must prioritize multi-informant assessment strategies to corroborate the findings related to child outcomes. Integrating objective, laboratory-based neurocognitive assessments of a child's inhibitory control, alongside standardized behavioral reports from educators or secondary caregivers, would eliminate the confounding effects of parental perceptual bias. Additionally, executing identical clustering algorithms across diverse, cross-cultural samples is necessary to determine if the specific $k = 3$ phenotypic structure identified in this study represents a universal psychological phenomenon or if cultural variations in community support and caregiving philosophies alter the mathematical manifestation of these parental profiles.

From a clinical and practical standpoint, the findings of this study offer critical, actionable directives for psychological intervention and public health policy. Traditional parenting interventions that focus exclusively on teaching behavioral management techniques to caregivers are likely to be entirely ineffective for individuals situated within the Strained Phenotype, as these parents currently

lack the cognitive bandwidth and psychological flexibility required to implement new strategies. Instead, primary interventions must focus on the parent's internal psychological architecture. Therapeutic frameworks such as Acceptance and Commitment Therapy, which are explicitly designed to increase psychological flexibility and foster self-compassion, should be positioned as the first line of defense for burnt-out caregivers. By teaching parents how to engage in cognitive defusion and maintain values-based actions despite experiencing overwhelming emotional exhaustion, clinicians can help dismantle the reactive, controlling behaviors that stunt child development. On a systemic level, public health initiatives must aggressively work to destigmatize parental burnout, shifting the societal narrative from one of individual parental failure to one that recognizes burnout as a systemic issue requiring robust community support, equitable labor distribution, and accessible mental health resources.

Authors' Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

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

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report 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.

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