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Review Article

Neurovascular Shifts, Sensory Sensitivity, and PMDD in Autistic Women: Exploring Blood Flow Redirection, Mood Dysregulation, and Pain Tolerance during Menstruation

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Abstract

This article examines the relationship between Premenstrual Dysphoric Disorder (PMDD), neurovascular dynamics, and sensory sensitivities in autistic women during menstruation. The redirection of blood flow to the uterus during the menstrual cycle has been found to exacerbate cerebral perfusion deficits in neurodivergent individuals, particularly in the Prefrontal Cortex (PFC), which contributes to the mood dysregulation and emotional instability characteristic of PMDD. Autistic women, who often exhibit heightened sensory sensitivities, experience intensified discomfort during menstruation, as sensory overload and altered pain perception compound the emotional challenges of PMDD. These findings emphasize the need for neurodivergent-friendly menstrual products that mitigate both physical and emotional discomfort. Additionally, innovations using biodegradable materials, smart fabrics, and custom-fit menstrual solutions are discussed as potential breakthroughs to improve the quality of life for autistic women managing PMDD. This research highlights the importance of addressing both neurobiological and sensory aspects when designing interventions for PMDD in neurodivergent populations.

More Information

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Introduction

Recent research on Premenstrual Dysphoric Disorder (PMDD) has illuminated the complex interaction between hormonal fluctuations, neurosteroids, and sensory processing sensitivities. A key area of focus is how PMDD's pathophysiology is tied to neurosteroids like allopregnanolone (ALLO), which modulate GABA-A receptors in the brain. Emerging evidence indicates that individuals with PMDD may have impaired sensitivity to ALLO, leading to poor regulation of the hypothalamic-pituitary-adrenal (HPA) axis and heightened stress sensitivity during the luteal phase (Modzelewski, et al. 2024). This dysregulation is linked to the core emotional symptoms of PMDD, including irritability, anxiety, and mood instability (Hantsoo & Epperson, 2020). Additionally, selective serotonin reuptake inhibitors (SSRIs) are proving to be one of the most effective treatments for managing these symptoms, with intermittent luteal phase administration showing promise as a therapeutic approach (Jespersen, et al. 2024; Steiner & Pearlstein, 2000).

From a sensory processing perspective, PMDD has been associated with increased sensitivity to physical sensations and environmental stimuli. Women affected by the disorder often report heightened discomfort related to sensory issues, such as intensified awareness of sensations like bloating, cramps, and tenderness. These sensory sensitivities exacerbate the emotional and cognitive symptoms of the chronic condition, creating a multifaceted interaction between physical and psychological stressors. New therapeutic strategies, including cognitive-behavioral therapy (CBT) and lifestyle modifications aimed at reducing sensory overload, are being explored to alleviate these symptoms (Rapkin & Lewis, 2013; Roudsari, 2024 Tizabi,). These insights highlight the need for a holistic approach to treatment that addresses both neurobiological factors and sensory sensitivities.

Further research into the neurological aspects of the condition has increasingly focused on how neurosteroid dysregulation contributes to its affective symptoms. ALLO, which plays a key role in modulating GABA-A receptors,

has been found to have diminished efficacy in women with the disorder, particularly during the luteal phase (Miller, et al. 2024; Morgan 2020). This reduced sensitivity leads to impaired regulation of the HPA axis, contributing to increased stress sensitivity and emotional instability. Treatments that address this disrupted ALLO-GABA interaction, such as SSRIs, have shown significant promise in stabilizing mood and emotional responses (Hantsoo & Epperson, 2020).

In addition to neurosteroids, recent neuroimaging studies have identified altered functional connectivity in key brain networks responsible for emotional regulation in women with PMDD. A 2019 fMRI study by Petersen revealed stronger connectivity between the left middle temporal gyrus and the Executive Control Network (ECN) across menstrual phases. This increased connectivity suggests a heightened emotional reactivity tied to the ECN, which is central to regulating emotional responses. Interestingly, Monteiro, et al. (2024) observed these changes were independent of hormonal fluctuations, suggesting that intrinsic brain network differences may underlie the chronic emotional dysregulation observed in the condition.

Despite the growing body of research into PMDD and sensory sensitivities, specific neurodivergent conditions like autism have not been thoroughly examined in this context. Autistic individuals experience unique neurobiological and sensory processing differences that may exacerbate the challenges associated with menstruation and the severe condition. Existing literature often overlooks the intersection between autism and menstrual health, particularly in how altered sensory processing and neurovascular dynamics, such as blood flow redirection, impact emotional regulation and pain tolerance during menstruation. This article seeks to address these gaps by exploring the neurological, sensory, and hormonal factors that complicate menstruation for autistic individuals. Through this approach, it will also highlight the necessity for more inclusive menstrual care solutions tailored to the sensory needs of neurodivergent individuals.

Blood flow redistribution during menstruation and its impact on mood

Uterine blood flow and neurovascular shifts: During the luteal phase of the menstrual cycle, the body undergoes significant changes to prepare for potential pregnancy, including an increased demand for blood flow to the uterus. This redirection of blood flow can cause systemic effects, particularly reducing the amount of blood available to other organs, including the brain. Recent research by Huang, et al. [1] has shown that this reduction in Cerebral Blood Flow (CBF) is particularly pronounced in the Prefrontal Cortex (PFC), a region critical for emotional regulation. The menstrual cycle has been linked to fluctuations in CBF, with changes particularly observed during the luteal phase. These fluctuations can lead to impaired emotional regulation, exacerbating mood swings, and other symptoms associated with PMDD [2,3]. In autistic individuals, who already experience reduced PFC blood flow due to neurodevelopmental differences, this redistribution may further amplify emotional dysregulation during menstruation [4,5].

Prefrontal cortex and emotional regulation: The PFC plays a crucial role in higher-order cognitive functions, including decision-making and emotional regulation. In neurotypical individuals, the PFC helps to mitigate emotional reactions, even when hormonal fluctuations occur during the menstrual cycle. However, research indicates that, in individuals with Autism Spectrum Condition (ASC), the PFC often exhibits reduced connectivity and blood flow, which worsens during periods of heightened physiological demands, such as the luteal phase of menstruation [6,7]. This impaired blood flow leads to difficulties in emotional regulation, which can exacerbate the hallmark mood swings, irritability, and emotional dysregulation associated with PMDD. The reduced CBF, combined with the stress of hormonal shifts, makes emotional regulation particularly challenging during menstruation [2,8].

Increased uterine blood flow during menstruation further limits the availability of blood to the brain, particularly in regions like the PFC that are critical for maintaining emotional equilibrium. This phenomenon is more pronounced in individuals who are already vulnerable to emotional dysregulation, such as those with ASC. These individuals are more likely to experience severe emotional and cognitive symptoms during menstruation because their ability to regulate emotions is compromised by both biological and neurological factors [9,10]. The connection between uterine blood flow redistribution and emotional regulation during menstruation is a critical area of concern, particularly for individuals with autism who already face challenges in emotional regulation. Understanding these neurovascular shifts provides important insights into the physiological and neurological factors that exacerbate PMDD symptoms, and underscores the need for targeted interventions that account for both hormonal and neurobiological dynamics.

Pain tolerance and sensory sensitivities in autistic menstruation

Altered pain perception: Research indicates that many autistic individuals exhibit atypical pain perception, often characterized by either heightened or diminished pain sensitivity [11]. This divergence is thought to stem from differences in key brain regions responsible for sensory processing, including the insula and somatosensory cortex, which mediate interoception and the perception of external stimuli [12]. A study by Yasuda, et al. [13] comparing autistic individuals with neurotypical controls revealed significant differences in pain thresholds and tolerance across various sensory modalities, including cold and heat stimuli. Autistic

individuals reported being hypersensitive to affective pain components despite having similar physiological thresholds to pain, suggesting impairments in the perception of pain regarding emotional or cognitive processing aspects. The complex interplay between neurological and sensory abnormalities makes menstruation especially challenging for autistic individuals, as the cyclic redirection of blood flow to the uterus exacerbates their already altered pain sensitivity [14].

Additionally, fluctuations in neurotransmitter levels such as serotonin during the menstrual cycle are known to affect pain perception. In autistic individuals, who often experience irregular serotonin production, hormonal changes during menstruation can further complicate pain regulation. This misalignment in neurotransmitter activity is a contributing factor to heightened discomfort and pain sensitivity during the menstrual cycle, increasing the severity of cramps and other menstrual-related pains [15].

Sensory processing and menstrual products: Autistic individuals face unique challenges with sensory processing, which are often amplified during menstruation. The physical sensations associated with cramps, bloating, and menstrual blood can overwhelm the sensory systems, leading to sensory overload. In particular, insertion-based menstrual products like tampons and menstrual cups can exacerbate these sensitivities. Research shows that autistic individuals, who often struggle with habituation to sensory inputs, may experience constant discomfort when using these products, as they are unable to adapt to the sensation of a foreign object within their body [16]. For many neurodivergent individuals, this lack of habituation results in significant discomfort and stress, which can further impair their ability to manage menstruation [17].

The sensory overload experienced during menstruation is not limited to menstrual products but extends to the overall sensory experience. Many autistic individuals report heightened sensitivity to physical sensations such as bloating and the sensation of blood flow, which can trigger additional anxiety and emotional dysregulation. A study by Mosely, et al. [18], for instance, highlighted how autistic women often find menstruation overwhelming due to increased sensory sensitivity, emotional dysregulation, and difficulty managing physical discomfort. These findings underline the need for alternative menstrual products designed with sensory sensitivities in mind, such as biodegradable materials or products that minimize tactile sensations.

Pain sensitivity across the menstrual cycle: Pain perception is known to fluctuate throughout the menstrual cycle, and autistic individuals may experience these fluctuations more intensely due to their altered sensory processing [19]. Studies have shown that during the luteal phase of the menstrual cycle, pain sensitivity increases, particularly in response to pressure and ischemic pain stimuli [20]. Autistic individuals, who already experience heightened sensitivity to certain sensory stimuli, may find these fluctuations in pain tolerance particularly debilitating [19,21]. The combination of menstrual-related pain and heightened sensory sensitivities can significantly impair their quality of life during menstruation.

Coping strategies and therapeutic interventions: Given the challenges that autistic individuals face with pain perception and sensory sensitivities during menstruation, there is a growing interest in developing coping strategies and therapeutic interventions to address these issues. Cognitive-Behavioral Therapy (CBT) has been explored as a potential intervention to help autistic individuals manage their emotional and sensory responses to pain [22]. Additionally, sensory integration therapy, which focuses on helping individuals adapt to sensory stimuli, is being investigated as a possible solution for reducing the discomfort associated with menstrual products and physical sensations [23,24]. These therapies aim to improve both the emotional and sensory processing capabilities of autistic individuals, helping them better manage the sensory and emotional stress of menstruation. The interaction between altered pain perception and sensory sensitivities in autistic individuals highlights the need for more tailored approaches to managing menstruation. Addressing both the neurological and sensory components of pain and discomfort can help alleviate the challenges faced by neurodivergent individuals during this time. Developing sensory-friendly menstrual products and integrating therapeutic interventions are crucial steps toward improving the menstrual experience for autistic individuals.

Gap in the literature on autism and menstruation

Neurovascular dynamics and menstruation in autism: While research on the challenges faced by autistic women during menstruation has grown, there remain critical gaps, particularly concerning neurovascular dynamics. Studies have largely overlooked how blood flow redirection to the uterus during menstruation affects cerebral perfusion, especially in autistic individuals. Autistic women already experience altered cerebral blood flow in key areas such as the PFC, which is responsible for mood regulation. The limited studies addressing this issue indicate that hormonal fluctuations can further compromise blood flow to the PFC, potentially exacerbating mood dysregulation during menstruation [25]. Yet, systematic exploration of these neurovascular shifts in autistic women remains scarce, highlighting a significant gap in the literature.

Pain perception and menstruation in autism: Altered pain perception in autistic individuals is well-documented, but few studies have examined how this specifically affects menstruation. Pain sensitivity in autism is inconsistent, with some individuals reporting heightened sensitivity, while others demonstrate hypo-sensitivity. During menstruation,

these altered pain thresholds could influence the experience of menstrual cramps and discomfort, yet the interaction between hormonal changes and pain perception in autism has not been fully explored. Recent studies emphasize the need for more nuanced investigations into how sensory processing challenges and pain tolerance are affected during the menstrual cycle in autistic individuals [15]. Without understanding this relationship, clinicians and caregivers lack the insights necessary to provide effective pain management strategies.

PMDD and autism: Although there is growing evidence that PMDD is more prevalent in autistic women, research examining how the condition manifests in this population is limited. Studies on neurotypical women indicate that these symptoms are closely tied to hormonal fluctuations and emotional dysregulation, but the interaction between autism-specific factors—such as sensory sensitivity, social isolation, and cognitive inflexibility—and the condition has yet to be thoroughly investigated. There is an urgent need for research focusing on how these factors uniquely exacerbate PMDD in autistic women [18]. This gap limits the development of targeted interventions that could improve the menstrual experience for neurodivergent individuals.

Absence of neurodivergent-friendly menstrual products: While sensory sensitivities during menstruation are well-documented, there is a lack of empirical research evaluating the effectiveness of neurodivergent-friendly menstrual products. Autistic women often report discomfort with insertion-based products like tampons, yet there are few studies assessing alternative options such as cloth pads, period underwear, or moisture-wicking technologies. Most of the literature generalizes sensory discomfort without incorporating feedback from autistic individuals or rigorously testing the effectiveness of various products [26]. This is a significant oversight, as neurodivergent-friendly products could provide much-needed relief for autistic individuals who struggle with sensory overload during menstruation.

Menstruation education for autistic individuals: Another gap in the literature is the lack of research on how menstruation education is delivered to autistic individuals. Anecdotal evidence suggests that traditional education methods are ineffective for this population due to their cognitive and sensory processing differences. However, few studies have explored how to tailor menstrual education to meet the needs of neurodivergent individuals [27]. Without this research, autistic individuals may not receive the appropriate support and information needed to navigate menstruation, exacerbating the physical and emotional challenges they already face.

Identifying neurodivergent-friendly menstrual product design

Dehydrating or disintegrating fabrics for menstrual products: Neurodivergent individuals often face unique challenges during menstruation due to heightened sensory sensitivities. The following outlines several potential considerations and solutions (Table 1). One promising solution is the development of menstrual products that incorporate dehydrating fabrics designed to absorb moisture without expanding or causing discomfort. Super Absorbent Polymers (SAP) embedded in natural fibers like bamboo or organic cotton could offer neurodivergent-friendly solutions that wick moisture away without the bulkiness typically associated with traditional menstrual pads. Recent studies have demonstrated the effectiveness of biodegradable polymers such as sodium carboxymethyl cellulose (NaCMC) blended with starch for creating thin, flexible membranes that maintain high absorbency without compromising comfort or tactile sensitivity [28]. These innovations could significantly improve comfort for neurodivergent individuals who are more sensitive to tactile stimuli.

Smart fabrics and biodegradable solutions: Further innovation in menstrual product design could involve the use of smart fabrics and biodegradable hydrogels that combine comfort with environmental sustainability. Electrospun nanofibers, which absorb liquid and promote rapid evaporation, offer a cutting-edge solution that addresses both moisture control and sensory sensitivities. Biodegradable materials such as hydrogels that trap moisture and transform into a non-expanding gel can enhance the sensory experience for neurodivergent individuals. Studies suggest that these biodegradable solutions not only improve comfort but also contribute to environmental sustainability by reducing waste from non-biodegradable products [29]. Recent advancements in biopolymer technology offer a promising alternative, as biodegradable materials such as bamboo, hemp, and sodium alginate have been developed for use in menstrual pads. These materials not only offer superior absorbency but also reduce the environmental footprint. Bamboo, for example, has a high absorption index and is naturally antibacterial, making it an ideal material for sustainable menstrual products [30]. These biodegradable alternatives address the needs of eco-conscious consumers while providing neurodivergent-friendly solutions due to their soft texture and low sensory impact.

Smart fabrics for sensory relief: For neurodivergent individuals, managing sensory sensitivities during menstruation is paramount. Smart textiles represent a significant step forward in addressing this challenge. Using materials such as electrospun nanofibers, menstrual products can be designed to be highly absorbent while remaining thin and flexible. These nanofibers wick away moisture, preventing the bulkiness that can cause discomfort for individuals with heightened tactile sensitivities. Furthermore, smart fabrics incorporating Phase-Change Materials (PCMs) can adjust their properties—such as thickness and moisture absorption—based on environmental conditions like temperature and

Table 1: Recommended Neurodivergent-Friendly Menstrual Product Solutions.

Solution	Example	Description	Benefit	Citations
Electrospun Nanofibers	FlexTech Alliance and SPINNOVA smart textiles	Ultra-thin, highly absorbent fabrics made from materials like bamboo or cotton; designed to wick moisture away without adding bulk, ideal for reducing sensory discomfort.	Highly absorbent yet lightweight fabrics reduce bulk, providing comfort to individuals with sensory sensitivities.	[30]
Responsive Fabrics (PCMs)	Outlast Technologies phase-change materials	Fabrics that adjust thickness or moisture absorption based on environmental conditions like temperature and humidity, ensuring lightweight, non-intrusive menstrual flow management.	Adaptive properties help manage menstrual flow without adding bulk, reducing discomfort during physical changes.	[31]
Embedded Sensors	Wearable devices with app integration	Tiny sensors embedded in pads or underwear monitor moisture levels and alert the user via a phone app, reducing anxiety for those with difficulty sensing when products are full.	Real-time alerts reduce anxiety about product changes, improving autonomy for those with interoceptive challenges.	[35]
Hydrogel Pads	AlgiKnit's bio-based seaweed textiles	Pads made from organic materials like plant cellulose or seaweed absorb menstrual blood, turning it into a gel without expanding or causing bulk, ideal for sensitive skin.	Organic materials offer an eco-friendly solution while ensuring comfort for sensitive skin without adding bulk.	[36]
Moisture-Dehydrating Fabrics	Nanotechnology-based fabrics from Nanowerk	Nanotechnology-based fabrics that absorb liquid without swelling, maintaining a thin and flexible form, ideal for individuals sensitive to the bulk of traditional pads.	Maintains comfort and prevents sensory overload by remaining thin even after absorbing liquid.	[37]
Natural Sponge Tampons	Biodegradable sea sponges or hemp fibers	Biodegradable, organic sea sponges or hemp fibers that naturally conform to the body and can be rinsed and reused, offering better sensory comfort than traditional tampons.	Natural materials provide a soft, conforming fit, ideal for users sensitive to traditional tampons.	[38]
Chitosan-Based Absorbers	Chitosan-based antibacterial materials from shellfish	Antibacterial, biodegradable inserts made from chitosan (derived from shellfish), offer a soft, lightweight, and hypoallergenic alternative to traditional tampons or pads.	Hypoallergenic and biodegradable materials provide a soft, antibacterial solution for individuals with sensitivities.	[39]
Neurodivergent-Friendly Apps	Custom-built apps for neurodivergent individuals	Apps that provide reminders for product changes and symptom tracking, with interfaces designed to cater to autistic preferences, integrating with wearable devices for menstrual cycle prediction.	Customizable reminders reduce anxiety and improve menstrual management for neurodivergent individuals.	[40]
AI-Based Assistants	AI menstrual assistants learning from personal cycles	AI-based assistants integrated with apps or products, learn from personal menstrual cycles to suggest product changes based on flow patterns and skin sensitivity, reducing sensory overload.	AI-based insights optimize product changes, reducing sensory overload and enhancing comfort during menstruation.	[41]
3D Printed Menstrual Cups or Pads	Formlabs and Carbon 3D custom-fit printed products	Custom-fit menstrual products are developed using 3D printing to match an individual's body shape, minimizing discomfort, and ensuring a tailored experience using organic, flexible, biodegradable materials.	Custom-fit ensures maximum comfort, reducing pressure points and improving the sensory experience.	[42]
Plant-based superabsorbent Polymers (SAP)	Natracare and Rael's organic materials	Superabsorbent polymers made from natural sources like cornstarch or potato starch, absorb up to 30 times their weight in liquid, keeping products thin and comfortable without harmful chemicals.	Organic materials keep products thin and comfortable, addressing concerns about bulkiness and chemical exposure.	[43]

humidity. This adaptive technology ensures that the product remains lightweight and non-intrusive, providing significant relief for those who are sensitive to changes in texture or moisture levels [31].

Hydrogel pads and moisture-dehydrating fabrics: Hydrogels made from organic materials, such as plant cellulose or seaweed, offer another innovative solution for menstrual products. These hydrogels absorb menstrual blood and transform it into a gel, providing a non-bulky and highly absorbent alternative to traditional pads. Unlike conventional materials, hydrogels do not expand, making them ideal for individuals who are sensitive to the feeling of a pad becoming fuller throughout the day. Additionally, moisture-dehydrating fabrics, developed using advanced nanotechnology, could absorb liquid without swelling, keeping the product thin and comfortable. These materials disintegrate the moisture as it is absorbed, offering a solution that minimizes the sensation of wetness, which can be particularly bothersome for neurodivergent users [32].

Personalized menstrual products: Personalization is key when it comes to addressing the diverse needs of neurodivergent individuals. Advances in 3D printing technology have made it possible to create custom-fit menstrual products that conform perfectly to an individual's body shape, reducing discomfort. These personalized products, made from biodegradable and organic materials, offer a tailored solution that minimizes sensory discomfort while ensuring effective menstrual management. Custom-fit menstrual cups or pads made using 3D printing could significantly improve the menstrual experience for neurodivergent individuals by providing a fit that eliminates unnecessary bulk or pressure and has been demonstrated successful in other use cases [33]. Additionally, technological innovations, such as wearable devices and personalized menstrual management apps, are transforming how individuals manage their menstrual cycles. For neurodivergent individuals who may struggle with interoception—awareness of bodily signals—apps that track menstrual flow and provide reminders for product changes can alleviate anxiety. These apps could be integrated with sensors embedded in menstrual products, allowing users to receive real-time notifications when a pad or tampon needs changing [34]. This technology not only reduces the need for constant bodily monitoring but also helps prevent sensory overload associated with prolonged use of full menstrual products.

Discussion

Limitations

While this study explores critical gaps in menstrual product design for neurodivergent individuals, several

limitations must be acknowledged [44]. First, the study largely draws on existing literature, which is itself limited in scope regarding neurodivergent-friendly menstrual products. The absence of extensive empirical research, particularly clinical trials testing sensory-adaptive materials and personalized solutions for autistic individuals, restricts the strength of the conclusions. The reliance on anecdotal and secondary sources for certain neurodivergent experiences, such as interoception and sensory overload during menstruation, highlights the need for more rigorous, firsthand data.

Second, the diversity of the neurodivergent population was not fully addressed. Autism, while central to this analysis, is part of a broader spectrum of neurodivergent conditions, and the experiences of individuals with ADHD, sensory processing disorder, or other neurodivergent identities were not comprehensively considered. This limits the generalizability of the findings across the neurodivergent community, leaving open questions regarding how these solutions may apply to other neurotypes.

Third, while product design and recommendations were informed by innovative technologies like biodegradable hydrogels and smart fabrics, these technologies remain largely in experimental or early-stage development. Therefore, the practicality of these products for mass production and market adoption remains speculative. Lastly, the focus on Western contexts in product design and menstrual health services may not fully account for cultural and economic variations in access to neurodivergent-friendly products globally, limiting the broader applicability of the conclusions of the study. To address these limitations, future studies should prioritize empirical research, including user-based testing with diverse neurodivergent populations, and evaluate the feasibility of large-scale production and distribution of the proposed solutions.

Conclusion

Neurodivergent individuals, particularly those on the autism spectrum, face unique challenges during menstruation, including heightened sensory sensitivities, interoception difficulties, and emotional dysregulation. Current menstrual products often fail to meet their specific needs. This article proposes innovative solutions, such as smart fabrics with sensory adaptive properties, biodegradable hydrogels, and personalized menstrual management apps, which offer comfort, sustainability, and customization. Custom-fit products using 3D printing further address sensory discomfort. These solutions not only enhance comfort and autonomy but also promote eco-friendly practices. Future research should prioritize empirical studies to test these products in real-world settings, explore neurovascular dynamics during menstruation, and investigate the intersection of autism and Premenstrual Dysphoric Disorder (PMDD). By advancing product innovation, the menstrual care industry can significantly improve the menstrual experience for neurodivergent individuals.

Data availability: Data is available upon request.

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Although AI-generated tools were used to generate this eBook/ Article, the concepts and central ideas it contains were entirely original and devised by a human writer. The AI merely assisted in the writing process, but the creative vision and intellectual property belong to the human author.

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