



The semiotic ecology of gender: A critical narrative review of the pink–blue binary across discourses and domains

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Abstract

The pink–blue divide has long been dismissed as a trivial cultural code. However, this study demonstrates that it operates as a powerful discursive system shaping gendered subjectivities across childhood socialisation, consumer culture, education, and neuroscience. Drawing on a critical narrative review of 44 peer-reviewed and institutional sources published between 1975 and 2025, the analysis integrates feminist theory, sociolinguistics, critical discourse analysis, and neurofeminism to interrogate how chromatic coding constructs, reinforces, and contests binary gender identities. Findings reveal a *multimodal discursive feedback loop* in which language, imagery, product design, and institutional practice repeatedly legitimise gender binaries, naturalising them as biological inevitabilities despite their socio-historical contingency. While resistance strategies such as gender-neutral pedagogy and inclusive marketing campaigns show potential, they often remain limited, performative, or co-opted by commercial imperatives. Neuroscience further complicates the picture: while traditional studies reinforced binary essentialism, emerging research on brain mosaics and transgender populations destabilises the male–female dichotomy. However, risks of rebiologising identity persist. This study introduces the concept of a *semiotic ecology* to capture the systemic interdependence of discourses sustaining the pink–blue binary and argues that dismantling these codes requires coordinated discursive and structural reform in education, marketing, and science communication. By situating the pink–blue divide within a global, interdisciplinary framework, the paper challenges its assumed universality and offers a critical agenda for advancing more inclusive understandings of gender.

Keywords: Gender Binaries; Pink–Blue Divide; Semiotic Ecology; Discourse Analysis; Gender Socialisation; Marketing Discourse; Educational Inequality; Neurofeminism; Cultural Semiotics; Feminist Theory

JEL Classifications: I21, J16, Z13, Z19, I29, O35

1. Introduction

The cultural coding of pink and blue as gender markers is more than an aesthetic tradition; it is a socio-semiotic system that regulates the performance and perception of gender. From infancy, chromatic cues structure expectations of identity, shaping how individuals are socialised into norms of masculinity and femininity (Paoletti, 2012). These associations extend across multiple domains, including family practices, retail design, schooling, and even scientific discourse, influencing aspirations, self-concepts, and life opportunities (Bem, 1981; Rippon, 2019). Rather than being natural or inevitable, the pink–blue binary reflects a historically contingent construct whose persistence underscores the ideological endurance of gender essentialism.

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A growing body of scholarship examines how semiotics and discourse reproduce gender binaries. Lakoff (1975) and Cameron (1992) demonstrate how linguistic practices encode gender hierarchies, while Butler (1990) theorises gender as a performative act sustained through repetition of signs, including colour. Paoletti (2012) provides historical evidence that pink and blue have not always signified femininity and masculinity, underscoring their cultural malleability. More recent critiques highlight the economic entrenchment of gender binaries through gendered marketing practices, including the “pink tax” (Gerdeman, 2019; NYC Department of Consumer Affairs, 2015). Simultaneously, neuroscientific claims of innate sex-based brain differences have been challenged by Fine (2010) and Joel et al. (2015), who demonstrate that such assertions often reflect cultural bias rather than biological inevitability. Educational research further shows how gendered discourses embedded in curricula and teacher–student interactions shape aspirations and self-perceptions (Sadker & Sadker, 1994; Shutts et al., 2017).

1.1. Research Gap

Despite extensive research across individual domains, there remains a lack of *integrated, cross-disciplinary analysis* of how the pink–blue binary operates simultaneously across socialisation, consumer culture, education, and neuroscience. Furthermore, much of the existing literature centres on Euro-American contexts, with insufficient attention to postcolonial and non-Western perspectives where gender ideologies may diverge significantly (Hossain, 2017). This paper addresses these gaps by offering a comparative synthesis that foregrounds both global variation and interdisciplinary intersections.

1.2. Research Aim

This study aims to synthesise literature on the pink–blue gender binary critically across the domains of childhood socialisation, marketing discourse, education, and neuroscience. By applying frameworks from feminist theory, sociolinguistics, and critical discourse analysis, the paper seeks to demonstrate how chromatic gender coding is discursively produced, contested, and reshaped across diverse cultural and institutional contexts.

1.3. Research Questions

To guide this inquiry, the following research questions are posed:

- How has the pink–blue binary emerged, shifted, and been contested across different historical and cultural contexts?
- Through what discursive strategies do marketing and consumer culture reinforce, or challenge, binary gender constructions?
- In what ways do educational discourses and practices reproduce or disrupt colour-coded gender expectations?
- How has neuroscientific research both supported and problematised binary conceptions of gender?
- How can a cross-disciplinary, cross-cultural synthesis advance understanding of colour-coded gender binaries as socio-semiotic constructs?

1.4. Contributions

This research makes three key contributions. First, it provides a rare cross-sectoral synthesis that traces the continuity of the pink–blue binary across childhood, consumer culture, education, and neuroscience. Second, it integrates feminist linguistic and semiotic analysis with contemporary neuroscience to show how cultural practices and scientific claims co-construct gender ideologies. Third, it broadens the discussion beyond Euro-American frameworks by incorporating postcolonial and non-Western perspectives, thereby challenging assumptions of universality. Together, these contributions position the study as an interdisciplinary intervention into ongoing debates about the persistence and transformation of gender binaries.

2. Methodology

2.1. Research Design

This study employs a critical narrative review design, combining thematic synthesis with elements of scoping review methodology. Unlike traditional narrative reviews, which risk selective reporting, this approach systematically identified and screened relevant sources before applying critical discourse analysis to synthesise findings. The aim was not to measure effect sizes but to interrogate how the pink–blue binary has been constructed, reinforced, and contested across multiple domains.

2.2. Search Strategy and Data Sources

To ensure breadth and transparency, a comprehensive search was conducted across Scopus, Web of Science, PsycINFO, and JSTOR, supplemented with targeted searches in Google Scholar to capture grey but peer-reviewed or institutionally vetted literature. Boolean search strings combined key terms such as “gender socialisation”, “pink AND blue AND marketing”, “gendered education”, “neurosexism”, and “gender discourse.”

Inclusion criteria were:

- Peer-reviewed journal articles, scholarly books, or official reports by governments/NGOs.
- English-language publications between 1975 and 2025, with priority given to studies published post-2015.
- Works explicitly addressing the construction of gender binaries in language, marketing, education, or neuroscience.

Exclusion criteria were:

- Non-peer-reviewed blogs, editorials, or media commentary without a scholarly foundation.
- Sources with no explicit theoretical engagement with gender binaries.

This process yielded 332 initial records, of which 44 met full inclusion criteria after title, abstract, and full-text screening.

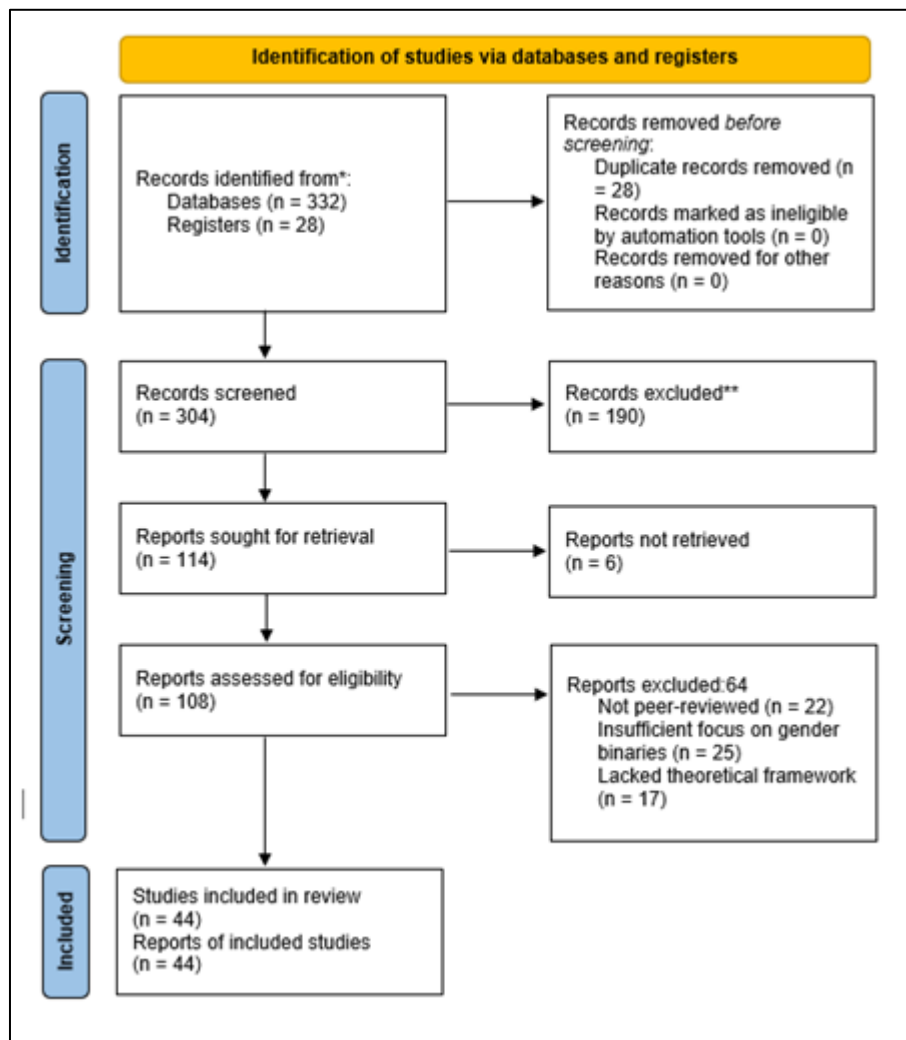


Figure 1 PRISMA 2020 Flow Diagram of Study Selection for Critical Narrative Review

2.3. Analytical Framework

Analysis proceeded in three stages:

2.3.1. Thematic Mapping

Sources were grouped into four domains: socialisation, marketing, education, and neuroscience. Within each domain, recurrent themes and discursive patterns were identified and coded.

2.3.2. Critical Discourse Analysis (CDA)

Guided by Butler's (1990) performativity, Bourdieu's (2001) symbolic power, and Cameron's (1992, 2006) sociolinguistic frameworks, texts were analysed for how gendered colour coding was linguistically and visually constructed. Special attention was given to indexical signs, metaphorical framings, and institutional narratives.

2.3.3. Cross-Domain Synthesis

Themes were then compared across domains to identify intersections and contradictions. This process informed the development of the *multimodal discursive feedback loop* concept introduced in the Discussion.

2.4. Reflexivity and Bias Management

Given the interpretive nature of narrative synthesis, reflexivity was prioritised to mitigate bias. Coding was performed iteratively, with categories refined through constant comparison. Where possible, triangulation with empirical findings (e.g., experimental studies on children's colour preferences or MRI studies of brain mosaics) was used to validate theoretical interpretations. Nonetheless, as this review is limited to English-language sources, there is a risk of Euro-American centrism, which is explicitly acknowledged in the Conclusion.

2.5. Limitations

While this critical narrative review allows for conceptual breadth and interdisciplinary integration, it does not claim statistical generalisability. The reliance on published academic and institutional sources excludes lived experiences that may be captured through ethnographic or participatory methods. Furthermore, non-English scholarship, especially from Global South contexts, may offer insights absent from this synthesis. These limitations reinforce the importance of complementing narrative reviews with corpus-based, ethnographic, and cross-cultural empirical research in future studies.

3. Literature Review

3.1. Gender, Colour, and the Semiotics of Socialisation

The pink-blue binary operates as a semiotic system that naturalises gender categories through repeated visual and linguistic cues. While Paoletti (2012) provides a valuable historical account of how these associations emerged in the twentieth century, her work has often been cited uncritically, obscuring the broader mechanisms by which colour functions as symbolic power. Rather than treating pink and blue as cultural curiosities, it is necessary to situate them within broader discursive frameworks.

Foucault's (1978) analysis of discourse as a vehicle for power highlights how colour codes, once internalised, operate not as arbitrary choices but as technologies of social regulation. Butler's (1990) notion of performativity further suggests that assigning colour to infants is not a benign act; it is an early iteration of gender performance, embedding normative expectations that are policed through everyday repetition. Sociolinguistic studies support this view. Holmes (2006) and Tannen (1990) show how children absorb gendered expectations through both direct linguistic modelling and indirect semiotic cues. Colour becomes one of the first symbolic resources in this schema, priming children to interpret identity through a binary lens.

Crucially, empirical research demonstrates that these associations are socially produced rather than biologically inevitable. LoBue and DeLoache (2011) found that gendered colour preferences intensify only once children begin to internalise linguistic gender categories, suggesting that preference is a learned rather than innate phenomenon. Wong and Hines (2015) confirmed that shifting cultural labels can alter children's colour preferences, undermining claims of

biological determinism. Cross-cultural data further dismantles the universality of the binary: among the Hadza of Tanzania, no systematic colour–gender distinction is observed (Palmer & Schloss, 2010). Such cases illustrate that what is often presented as “natural” is contingent, context-specific, and politically constructed.

However, the persistence of the pink–blue binary should not be underestimated. Sunderland (2006) observes that ideological systems survive precisely because they are embedded in mundane, everyday acts. Room décor, clothing, and toys are not neutral objects; they are vehicles of social inscription that reinforce the legitimacy of binary gender categories. Thus, to treat pink and blue merely as stylistic preferences, as some earlier literature does, risks overlooking their semiotic role in sustaining normative gender orders.

In short, while Paoletti (2012) establishes the historical trajectory of the pink–blue divide, a critical synthesis requires moving beyond description to interrogate the discursive, semiotic, and psychological processes that reproduce this binary. Colour coding is not a reflection of gender difference but an apparatus through which gendered subjectivities are produced and policed.

3.2. Gender in Marketing and Consumer Discourse

Marketing operates not merely as a reflection of social norms but as a key producer of gendered ideology. Through visual design, packaging, language, and strategic segmentation, consumer culture embeds and amplifies the pink–blue binary in ways that shape identity formation from early childhood to adulthood. Drawing on Bourdieu’s (2001) concept of symbolic power, the gendering of commodities is not neutral but ideological, naturalising consumption as a gendered activity.

Indexicality plays a central role here. As Ochs (1992) and Eckert (2008) argue, colours, shapes, and lexical choices are used not only to signal gender but to construct it through repetition. Pink packaging, rounded forms, diminutives, and emotional appeals are consistently aligned with femininity, while blue, angularity, and assertive slogans signal masculinity. These are not aesthetic coincidences; they are deliberate semiotic tools that link products to socially constructed gender scripts (Lazar, 2006; Cameron, 2005).

Child-focused marketing reveals the full extent of this strategy. Toy aisles divided by chromatic and thematic cues—pastel-coloured domestic sets for girls and dark-toned construction sets for boys—function as early training grounds for gender identity (Auster & Mansbach, 2012). These material cues reinforce a rigid bifurcation in taste, ability, and aspiration long before children are capable of critical reflection. As Butler (1990) would argue, such consumer cues constitute stylised acts of gender performance—repeated, commercialised, and internalised.

Recent marketing campaigns purport to challenge these norms. Initiatives like Dove’s *Real Beauty* or Always’ *Like a Girl* frame themselves as feminist interventions, promoting empowerment and self-esteem. However, these campaigns often fall into what Gill (2008) calls “commodity feminism”: the appropriation of feminist rhetoric to serve capitalist goals. They rebrand femininity as powerful, but rarely dismantle the underlying aesthetic codes or profit models that sustain binary gender segmentation. Empowerment is thus sold as a product, not practised as structural change.

More explicitly, the “pink tax” reveals how gendered marketing is not just symbolic but exploitative. Identical products marketed to women—such as razors, pens, and deodorants—are routinely priced higher (NYC Department of Consumer Affairs, 2015). This practice exposes the economic consequences of binary segmentation and contradicts any claim that gendered branding serves consumer choice. Rather, it constrains choice by penalising deviation from market-assigned gender categories.

Some brands, such as the LEGO Group (2021), have attempted more inclusive approaches, pledging to remove gender labels from products. However, the sincerity and effectiveness of such shifts remain contested. The brand continues to release heavily gender-coded product lines—e.g., LEGO Friends—which undermine their public messaging. The dissonance between declared commitments and product portfolios illustrates the limits of superficial reform. Without structural changes to product design, placement, and pricing, such campaigns risk functioning as performative virtue signalling.

Moreover, global marketing trends show that these binaries are not being dismantled universally. Narayan et al. (2024) argue that Western brands often export binary gender discourses into emerging markets under the guise of modernity, thereby globalising essentialist ideals under the framework of consumer choice. In these contexts, pink–blue segmentation is not being replaced but reinforced, dressed in the language of progress.

In sum, marketing discourse functions less as a mirror of gender norms than as an active participant in their construction, commodification, and global circulation. While isolated campaigns gesture toward inclusivity, they often remain entangled in the same profit logics that require gender segmentation for differentiation and scalability. Understanding this terrain requires more than descriptive catalogue—it demands scrutiny of the discursive contradictions and structural incentives that sustain gender binaries in the marketplace.

3.3. Gender in Educational Discourse

Education is one of the most significant sites where the pink–blue binary is both reproduced and resisted. Early studies, notably Sadker and Sadker’s (1994) work on gender inequity in U.S. classrooms, remain foundational, but relying on such dated research risks overstating their contemporary relevance. Since then, a large body of empirical work has demonstrated that gendered discourses in education continue to shape student identities, subject choices, and achievement outcomes (Hargreaves et al., 2008).

Critically, gender differentiation in schooling is not merely the residue of outdated pedagogies; it is discursively produced through everyday practices. As Butler’s (1990) theory of performativity suggests, students are not simply recipients of gendered norms but active performers within institutional scripts. Teacher–student interactions, feedback styles, and classroom organisation function as mechanisms of gender regulation. For example, boys are often encouraged to dominate STEM subjects and classroom discussions, while girls receive praise for compliance and neatness, reinforcing divergent academic identities (Jones & Myhill, 2011). These practices are rarely explicit, but their cumulative effect constructs what Hargreaves et al. (2008) describe as gendered pathways into subject specialisation.

Beyond interactional patterns, the visual and institutional landscape of schools contributes to binary reinforcement. Restroom labelling, uniform policies, and gendered extracurricular activities embody what Eckert and McConnell-Ginet (2013) call the “linguistic landscape” of education, where gender is made visible, policed, and normalised. Such semiotic environments implicitly instruct students on what it means to be a boy or a girl, thereby embedding chromatic and symbolic binaries into the everyday life of schooling.

Some contexts, however, illustrate the potential for disruption. In Sweden, gender-neutral preschools have replaced binary pronouns, redesigned curricula, and removed “boys versus girls” divisions, resulting in measurable changes in children’s peer interactions and flexibility in gender beliefs (Shutts et al., 2017). Yet, as Viarengo (2021) cautions, policy texts that aim for inclusivity often reproduce the very binaries they claim to dismantle, suggesting that institutional reform requires more profound discursive shifts rather than surface-level changes.

The persistence of gender gaps in subject selection further underscores the inadequacy of existing interventions. Despite decades of reform, boys remain overrepresented in physics and computing, while girls continue to dominate in humanities and caregiving fields (Hargreaves et al., 2008). Claims that these differences reflect innate ability echo neurosexist interpretations (Fine, 2010), ignoring how discursive framings—such as portraying reading as a “feminine” activity—shape students’ self-perceptions and choices.

In sum, contemporary research indicates that education is not simply a site where gender binaries linger; it is a domain where discourses actively construct and enforce them. While some initiatives challenge these norms, most remain partial or contradictory, highlighting the resilience of the pink–blue binary in shaping not only what students learn but how they imagine their future selves.

3.4. Gender and Neuroscientific Discourse

Neuroscientific discourse has long played a central role in legitimising binary understandings of gender. Popular accounts have often overstated biological determinism, framing differences in brain structure or function as evidence of “male” and “female” brains (Eliot, 2009). Such claims, widely circulated in media headlines, provide what Bourdieu (2001) terms *symbolic violence*—the imposition of arbitrary social hierarchies under the guise of scientific objectivity.

Critical neurofeminist scholarship has been instrumental in dismantling this narrative. Fine (2010) exposed how methodological flaws and cultural biases contributed to neurosexist claims, while Rippon (2019) demonstrated that neural plasticity undermines the notion of stable sex-differentiated brains. Joel et al. (2015) further advanced this challenge with the “brain mosaic” model, showing that individual brains exhibit unique blends of traits, rather than conforming to binary categories. Together, these works provide compelling evidence that brain differences are not fixed biological truths but contingent reflections of social experience.

However, while Fine and Rippon's critiques have been groundbreaking, they are not without limitations. Their focus largely centres on Euro-American contexts, leaving underexplored the ways cultural variation may intersect with neural development. Moreover, their work often frames the debate in terms of correcting flawed science, rather than interrogating how neuroscientific discourse itself becomes entangled in cultural and political projects. As Bluhm (2013) argues, even critical neuroscience risks reinforcing essentialism if it positions biology as the ultimate arbiter of gender identity.

Developments in trans and nonbinary neuroscience further complicate the debate. Studies of transgender and gender-diverse participants suggest that certain brain features may align more closely with gender identity than with assigned sex at birth (Guillamon et al., 2016). While such findings challenge simplistic male–female dichotomies, they raise new concerns: do they risk re-biologising identity by suggesting legitimacy requires neural evidence? As Cameron (2008) warns, reliance on brain scans to validate lived gender experiences risks pathologising those whose neural profiles do not “conform.”

Media discourse exacerbates the problem. Headlines such as “Men hardwired for maths” or “Women wired for empathy” translate complex, nuanced findings into essentialist slogans, feeding public narratives that naturalise inequality (Bluhm, 2013). This selective reporting not only distorts science but also perpetuates stereotypes in education, policy, and parenting.

The challenge, therefore, is not only to critique flawed claims but to situate neuroscience within broader socio-discursive frameworks. Butler's (1990) notion of performativity provides a lens through which neural data can be read not as biological destiny but as part of the repeated acts through which gender is constituted. Incorporating trans and nonbinary perspectives further destabilises the assumption that brains, like genders, come in only two categories.

In sum, contemporary neuroscience offers both risks and opportunities for rethinking the pink–blue divide. While the field has moved away from crude binary models, its entanglement with cultural narratives means that scientific discourse can either dismantle or reinscribe gender essentialism, depending on how findings are framed and communicated. A critical, interdisciplinary approach is therefore essential to prevent the neuroscientific study of gender from becoming yet another vehicle for normative binaries.

4. Analysis

The findings across socialisation, marketing, education, and neuroscience confirm that the pink–blue binary functions less as a reflection of innate difference than as a discursive system sustained through repetition and institutional reinforcement. However, to simply restate this conclusion risks underestimating both the ideological resilience of the binary and the uneven success of efforts to dismantle it. This section, therefore, advances three arguments: (1) the pink–blue divide persists through what can be termed a *multimodal discursive feedback loop*, (2) resistance strategies often generate contradictions and unintended consequences, and (3) effective dismantling requires interventions at the intersection of language, policy, and commercial design.

4.1. The Multimodal Discursive Feedback Loop

Existing theories of gender performativity (Butler, 1990) and symbolic power (Bourdieu, 2001) explain the persistence of gender binaries, yet neither fully captures how chromatic gendering operates across multiple semiotic modes simultaneously. The evidence presented here suggests a feedback mechanism where language, imagery, product design, and institutional policies continually reinforce one another. For example, a girl praised for liking pink (socialisation) encounters pink-coded toys (marketing), is represented in textbooks through gendered imagery (education), and later hears claims of female “empathy wiring” in neuroscience (Rippon, 2019). Each context draws legitimacy from the others, creating a circular system that naturalises gendered difference as inevitable. I term this dynamic a *multimodal discursive feedback loop*, which underscores the need to analyse not only individual domains but their systemic interdependence.

4.2. The Contradictions of Resistance

Resistance movements frequently challenge binary discourses but often reproduce elements of the system they seek to dismantle. Gender-neutral preschools in Sweden, for instance, have shown promise in broadening children's social interactions (Shutts et al., 2017). However, their impact remains confined mainly to progressive contexts and has faced accusations of social engineering, limiting scalability in more conservative regions. Similarly, corporate campaigns such as Dove's *Real Beauty* promote empowerment while simultaneously reinforcing beauty norms through carefully curated images (Gill, 2008). LEGO's pledge to drop gender labels was undermined by its continued production of gender-coded

lines like *LEGO Friends*, illustrating how commercial imperatives dilute inclusive rhetoric. These contradictions highlight the risk of what Gill (2008) calls *commodity feminism*—where feminist language is appropriated for profit without destabilising underlying structures.

4.3. Implications for Policy and Practice

The endurance of the pink-blue binary demands more than cosmetic change. Policies that focus solely on surface-level inclusivity—such as renaming restrooms or banning overtly gendered marketing—risk being symbolic gestures if underlying discourses remain intact. Effective interventions must target both semiotic and structural dimensions. In education, this means embedding gender-neutral practices into curricula, teacher training, and assessment methods, not simply altering pronouns in textbooks. In marketing, regulators could address gender-based price discrimination, moving beyond consumer awareness campaigns to enforce legal accountability for the “pink tax.” Neuroscience, meanwhile, must resist media simplification and actively include diverse populations, including transgender and nonbinary participants, to avoid reinscribing biological determinism (Guillamon et al., 2016).

4.4. A Cross-Disciplinary Framework: Gender as Semiotic Ecology

This study proposes a cross-disciplinary framework conceptualising gender binaries as a *semiotic ecology*. In this model, gender is not treated as a fixed category but as a distributed, discursively constructed identity produced through interactions among four interlinked domains:

- Childhood Socialisation (family discourse, toys, clothing norms)
- Marketing Discourse (branding, segmentation, price differentiation)
- Educational Institutions (curricula, teacher feedback, symbolic environments)
- Neuroscientific Research and Communication (labelling, media interpretations, medical norms)

These domains are connected through what this paper terms multimodal discursive feedback loops: recursive, mutually reinforcing circuits of language, image, institutional policy, and symbolic representation. For example, gendered toys (marketing) reinforce behavioural expectations (socialisation), which are reflected in school interactions (education) and later rationalised through scientific discourse (neuroscience).

Framing gender as a semiotic ecology allows for an analysis of how discourses not only operate within individual sectors but circulate across them, stabilising binaries under the appearance of scientific or market neutrality. Crucially, this framework enables both critique and intervention, providing a lens through which scholars and policymakers can identify the most entrenched nodes of binary reinforcement and target them with coordinated reforms.

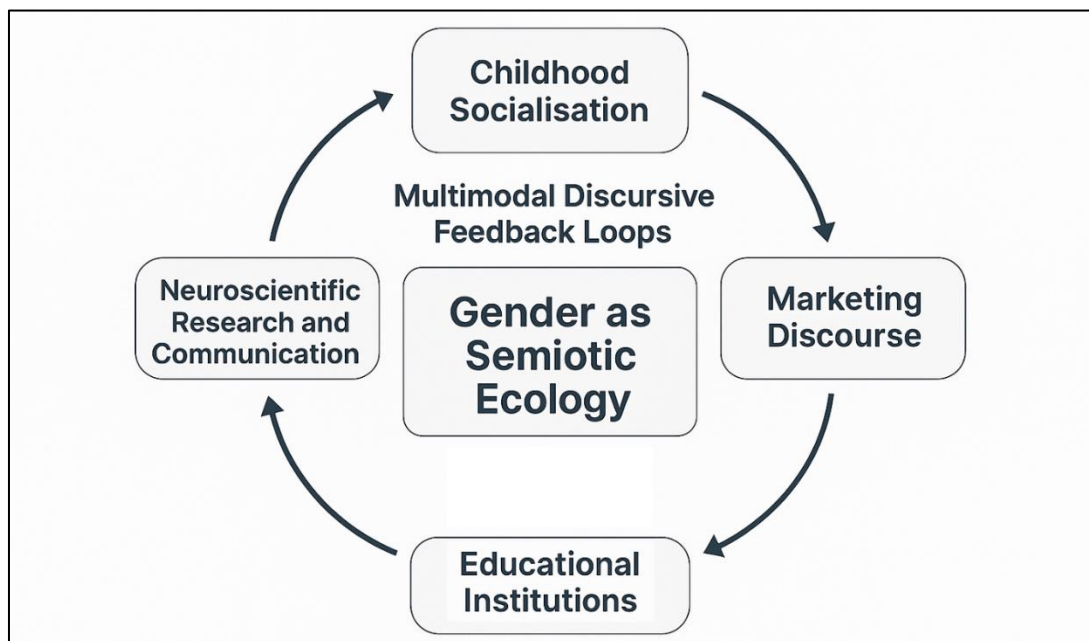


Figure 2 Gender as Semiotic Ecology: A Cross-Disciplinary Framework of Multimodal Discursive Feedback Loops

4.5. Revisiting the Research Questions

4.5.1. RQ1: Historical and Cultural Evolution of the Pink-Blue Divide

The evidence suggests that the pink-blue binary is not a universal phenomenon but a modern Western construction, with Paoletti (2012) tracing its entrenchment only in the twentieth century. Earlier and non-Western contexts reveal far more fluid or absent gender-colour associations (Palmer & Schloss, 2010). Yet the role of globalised marketing has increasingly exported Western binaries into new cultural contexts, a process critics view as cultural homogenisation under the guise of modernity (Narayan et al., 2024). This finding underscores the need to treat gender binaries not as natural inevitabilities but as historically contingent imports with tangible sociocultural effects.

4.5.2. RQ2: Marketing and the Reinforcement of Gender Binaries

Marketing continues to operate as a key enforcer of binary ideology. Through colour-coded packaging, indexical language, and price differentials such as the “pink tax” (Gerdeman, 2019), consumer culture embeds gender distinctions into everyday life. While campaigns such as Dove’s *Real Beauty* attempt to challenge these discourses, they often exemplify Gill’s (2008) critique of “commodity feminism,” appropriating feminist ideals while leaving underlying segmentation intact. This suggests that commercial interventions often substitute rhetorical inclusivity for structural transformation, a contradiction that undermines their long-term efficacy.

4.5.3. RQ3: Education and the Reproduction of Gender Norms

Educational systems remain central to the persistence of gender binaries. While foundational studies highlighted inequalities in teacher-student interactions (Sadker & Sadker, 1994), more recent evidence demonstrates how curriculum design, feedback styles, and institutional structures continue to reproduce divergent academic identities (Jones & Myhill, 2011; Hargreaves et al., 2008). Attempts at disruption, such as Sweden’s gender-neutral preschools (Shutts et al., 2017), show measurable success but remain geographically and politically limited. This suggests that without systemic discursive reform, interventions risk being confined to experimental or progressive niches.

4.5.4. RQ4: Neuroscience and the Binary Paradigm

Traditional neuroscience often reinforced essentialist narratives, framing observed brain differences as evidence of innate gender dichotomies. However, critical scholarship now challenges these claims, emphasising neuroplasticity and the mosaic model of brain organisation (Fine, 2010; Joel et al., 2015; Rippon, 2019). Emerging studies on transgender and nonbinary populations complicate this picture, suggesting that neural patterns correlate more with identity than with assigned sex (Guillamon et al., 2016). However, as Bluhm (2013) warns, reliance on neuroscientific validation risks pathologising diversity by reducing legitimacy to neural conformity.

4.5.5. RQ5: The Value of a Cross-Disciplinary, Cross-Cultural Approach

The integration of feminist theory, sociolinguistics, cultural studies, and neuroscience reveals gender not as a biological fact but as a socio-semiotic construct embedded in a broader *semiotic ecology*. This approach highlights both the interconnectedness of discourses and their global variability. Comparative analyses destabilise the assumed universality of the pink-blue divide, foregrounding postcolonial and non-Western perspectives that resist Western binary impositions (Hossain, 2017). The interdisciplinary synthesis presented here thus advances the field by demonstrating how seemingly benign cultural codes operate as powerful mechanisms of social control.

5. Conclusion

This paper has argued that the pink-blue divide is not a trivial aesthetic code but a multimodal discursive system that shapes gendered subjectivities across socialisation, marketing, education, and neuroscience. By introducing the concept of a *semiotic ecology*, the study moves beyond existing accounts of gender performativity (Butler, 1990) and symbolic power (Bourdieu, 2001), demonstrating how chromatic coding interacts with linguistic, institutional, and commercial practices to sustain binary gender ideologies.

5.1. Implications for Theory and Practice

For theory, this synthesis highlights the necessity of analysing gender binaries not as isolated phenomena within single domains but as feedback systems embedded in overlapping semiotic fields. For practice, it underscores that cosmetic shifts—such as removing overt gender labels in marketing or adopting inclusive pronouns in classrooms—will remain insufficient without structural change. Effective interventions must combine discursive reform with institutional

redesign: regulating discriminatory pricing practices, embedding gender-neutral pedagogies into curricula and teacher training, and framing neuroscientific findings responsibly to avoid media-driven essentialism.

5.2. Limitations and Reflexivity

As a narrative review, this study is interpretive rather than exhaustive. Selection bias and subjective thematic synthesis remain potential limitations, especially given the reliance on English-language sources. While these constraints allowed for conceptual breadth, they also highlight the need for caution in generalising findings across all contexts. Recognising this limitation is critical, as the very critique advanced here—that binaries are sustained through selective discourse—applies equally to the construction of academic narratives.

5.3. Directions for Future Research

Future work should pursue three focused avenues. First, corpus-based linguistic analyses could trace how chromatic gender discourses circulate across media, education, and policy texts, offering quantitative depth to complement interpretive synthesis. Second, cross-cultural ethnographies, particularly from postcolonial and non-Western contexts, are needed to disrupt Euro-American-centric assumptions about gender binaries. Third, interdisciplinary collaborations with neuroscientists studying transgender and nonbinary populations could extend the *semiotic ecology* framework to examine how scientific findings both challenge and risk re-inscribing binary logics.

Ultimately, the persistence of the pink–blue divide demonstrates how profoundly symbolic systems infiltrate material life. However, its contingency also offers grounds for optimism: what has been discursively constructed can be discursively dismantled. The challenge lies not in proving that binaries are artificial, but in enacting the structural, institutional, and cultural changes necessary to render gender diversity visible, legitimate, and unremarkable.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest while doing this review

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