RESEARCH ARTICLE

Graphic Neutralization and Gender Stereotypes in Early Childhood: How Visual Variables Shape Children's Interpretations

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Abstract: This research explores the influence of gendered connotations in children's book illustrations on the perception and assimilation of gender stereotypes among boys and girls aged four to five. Through an empirical study conducted in a context designed to maximize ecological validity, the investigation examined whether graphic neutralization, defined as the reduction of details associated with gendered characteristics, can help decrease the activation of stereotypical schemas in children's behaviors. The study is grounded in theoretical frameworks drawn from research on visual perception, the acquisition of gender stereotypes in preschool age, and visual communication in educational contexts. The experimental design involved 82 participants (M = 41, F = 41; M = 4.73 years, SD = 0.45), structured in two phases: a baseline test, aimed at assessing pre-existing knowledge of gender stereotypes, and a subsequent test, conducted with two groups (control and experimental) to evaluate the effect of graphic neutralization. The illustrations, balanced in content but differentiated by the level of gender connotation, were presented individually. Data were collected through participant observation and structured ordinal quantitative observation sheets, allowing for the analysis of behaviors, preferences, and spontaneous associations between gender and activities. The results revealed a statistically significant reduction in stereotyped choices in the experimental group compared to the control group, along with a lower tendency to automatically assign gender to the depicted activities. Some variables, such as response certainty (CCU), recognition of gender-related elements (RGAA), and awareness of change (CSC), showed significant differences between groups, suggesting a tangible impact of visual neutralization on children's behavior. At a qualitative level, children in the experimental group displayed greater hesitation in their decision-making process, indicative of a suspension of cognitive automatisms linked to stereotypes.

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Implications for practice: The findings suggest that visual design choices in preschool educational materials can play a meaningful role in reducing the activation of gender stereotypes. In practice, illustrators, educators, and publishers should avoid treating visual style as a neutral component of learning resources, since features such as color, hairstyle, clothing, posture, facial detail, body shape, and symbolic objects may guide children's gendered interpretations of activities and roles. Educational materials, particularly those related to science, technology, engineering, and mathematics, should therefore represent tools, experiments, construction tasks, technological devices, and scientific exploration without systematically associating them with masculine or feminine visual markers. Graphic neutralization may be implemented by reducing explicit gender cues, limiting culturally gendered colors and accessories, softening or simplifying character features, and preserving recognizability without reinforcing binary gender associations. In early-childhood settings, where children frequently encounter scientific and technological content through picturebooks, games, and narrative images, such design strategies may help present STEM-related activities as broadly accessible and not implicitly tied to a specific gender.

Keywords: childhood; gender stereotypes; graphic variables; illustration; inclusion

1. Introduction

Gender stereotypes begin to form early in childhood and progressively influence cognitive expectations, preferences, and behavioral choices up to adult age (Grobelny & Michalski, 2015). Research in developmental psychology has shown that children between four and five years of age are already capable of associating activities, objects, and roles with gendered categories, often applying these associations consistently in their everyday decisions (Martin & Ruble, 2004; Serbin et al., 2001; Shutts et al., 2010). These early categorizations are not benign: they contribute to the construction of self-concept and play a role in shaping future educational interests and aspirations, particularly in domains traditionally marked by strong gender segregation such as STEM (Bian et al., 2017).

While the development of gender stereotypes has been widely studied from psychological and educational perspectives, comparatively less empirical attention has been paid to how visual communication may cue, reinforce, or shape children's gendered interpretations. Children's illustrated materials—picture books, educational worksheets, and learning tools—are often treated as neutral supports for content delivery. However, research in visual semiotics and multimodality has consistently shown that images operate as semiotic and informational systems within multimodal ensembles, actively shaping interpretation and contributing to the transmission of cognitive and cultural frameworks rather than merely accompanying verbal content (Cheng et al., 2025; Serafini & Freid, 2024).

Visual attributes such as color, shape, character morphology, and symbolic objects function as informational cues that guide interpretation and categorization processes.

Studies on children's literature have documented the persistence of gender bias in illustrated books, showing systematic imbalances in representation and recurrent associations between gender and activities (Boero & Giuliani, 2019; Brugeilles et al., 2002).

Information design is not only about legibility and clarity, but about what distinctions are made salient and what categories become cognitively available for decision-making. When illustrations systematically encode gender through color conventions, morphological signals, and symbolic props, they do more than represent; they pre-structure inference. Large-scale analyses of children's books have documented persistent imbalances and gendered patterns in depiction, supporting the claim that children's publishing participates in the reproduction of gender norms (Boero & Giuliani, 2019; Brugeilles et al., 2002). Yet much of this evidence is descriptive: it identifies bias in content but leaves open the causal question central to design research—whether and how specific visual variables modulate children's cognitive and behavioral responses.

Preschool age constitutes a particularly sensitive window for such investigation. At this stage, perceptual cues play a dominant role in meaning-making, and visual information often precedes or even substitutes verbal reasoning (Lewis et al., 2022). Children rely heavily on salient visual markers to structure social categories, making them especially susceptible to implicit cues embedded in graphic artifacts. Consequently, the repeated exposure to gender-connoted visual patterns may contribute to the early naturalization of stereotypes, reinforcing them before critical reflection becomes possible.

In response to this issue, recent design-oriented discussions have advocated for the development of inclusive and stereotype-aware educational materials. Yet these proposals are often normative and lack empirical validation. In particular, there is limited experimental evidence assessing whether modifying specific visual variables can measurably alter children's stereotypical responses. For information design research, this lack of evidence limits the translation of ethical intentions into operational design strategies.

The present study addresses this gap by empirically examining the effects of graphic neutralization in children's illustrations. Graphic neutralization is defined here as the systematic reduction of visual gender markers, including chromatic conventions, explicitly gendered symbols, and strongly connoted character traits, while maintaining narrative coherence and usability. Rather than introducing counter-stereotypical representations, the study investigates whether reducing the salience of gender cues can weaken stereotype-driven decision-making.

Using a pre-post experimental design with a control group and an experimental group, the study compares children's behavioral choices when exposed to gender-connoted versus visually neutralized illustrations. In the experimental condition, visual neutralization was operationalized through a controlled manipulation of specific graphic variables commonly associated with gender coding in children's visual culture. These included (1) the use of pastel and low-saturation color palettes, as well as colors less rigidly associated with gender—such as green (Hurlbert & Ling, 2007)—in place of culturally gendered chromatic schemes, whose early gender associations have been shown to emerge in preschool children and to be reinforced through socialization processes and everyday visual environments (Cherney et al., 2006; Eichstedt et al., 2002; Zemach et al., 2007); (2) the reduction of strongly connoted symbolic objects, which function as culturally shared gender cues in children's visual environments (Shutts et al., 2010); and (3) the attenuation of gendered bodily markers through simplified character features, such as rounded shapes and less explicitly gender-coded facial, hairstyle, clothing, and bodily details, while preserving sufficient visual detail for preschool children to recognize the characters and actions depicted. This choice was informed by developmental evidence showing that, in the absence of external sex-stereotyped cues such as hairstyle and clothing, children's ability to categorize faces by sex depends on internal facial-structure information and varies with age (Wild et al., 2000). Johnson et al. (2010) further showed that preschool children become increasingly able to use body-shape information when categorizing sex, supporting the broader methodological decision to reduce the salience of visible bodily cues that might guide gender attribution.

The use of simplified and pedomorphic character features was intended to reduce the salience of gendered bodily cues, a strategy that has been shown to be developmentally appropriate for preschool-aged children and particularly effective in minimizing externally imposed markers of gender during interaction (Malisiova & Kompoti, 2025).

However, evidence from studies on virtual and real infants suggests that even when visual gender cues are minimal or absent, observers—including children—may still infer and assign gender categories on the basis of sparse visual information, indicating that simplified character design can modulate, but not fully prevent, gender attribution processes (Araujo et al., 2022; Karniol, 2011). For this reason, the experimental stimuli were designed to minimize salient gender cues while preserving recognizability of the character, and children's gender attributions were retained as empirical outcomes in the analysis rather than treated as neutralized by design.

The focus is not on explicit attitudes but on observable responses, decision patterns, and indicators of cognitive engagement. This approach aligns with an information design perspective that conceives visual artifacts as structures that organize action and interpretation, particularly in early and pre-verbal stages of cognition.

In particular, such knowledge may inform the design of visual materials aimed at introducing STEM-related concepts in early childhood, a domain in which girls' lower participation and performance have been shown to emerge despite the absence of cognitive differences, pointing instead to cultural and environmental factors as key contributors (Bian et al., 2017; Lindberg & al., 2010). Yet much of the existing evidence remains descriptive: it identifies bias in content but leaves open the causal question central to design research—whether and how specific visual variables modulate children's cognitive and behavioral responses.

This research aims to contribute empirical evidence on how visual design can actively shape cognitive processes related to gender. The findings are intended to inform both theoretical discussions on the role of visual communication in early learning and practical design decisions in educational publishing.

2. Method

2.1. Hypotheses

Drawing on the reviewed literature, this study addresses the following research question: In children aged 4–5 years, does exposure to stereotyped-content illustrations incorporating gender-neutralizing graphic variables, compared with exposure to the same illustrations without these variables, lead to a reduction in the perception of gender stereotypes, as measured using a pre-post experimental design with repeated measures?

The study seeks to determine whether visual neutralization constitutes an effective strategy for reducing adherence to gender stereotypes in early childhood, with potential implications for the design of inclusive educational materials.

2.2. Experimental Design and Procedure

The study adopts a pre-post experimental design with repeated measures, involving a single experimental condition and two comparison groups, a control and an experimental group. This structure makes it possible to isolate the effect of graphic variables, control for external variables and reduce biases such as social conformity (Haun & Tomasello, 2011; Pedon, 2011), ensuring that the observed variations can be attributed to the visual manipulation of the stimuli.

The experiment was organized in two consecutive phases. The first phase, called Baseline Test, aimed to identify the spontaneous preferences of children for illustrations containing gender-symbolic elements. This phase provided an initial measure of pre-existing gender stereotypes (Bian et al., 2017; Lewis et al., 2022). For this, a pair of illustrations containing gender-symbolic elements such as ballet shoes opposite

football boots was presented. The Experimental Test presented the same activities in two graphic versions. This phase investigated the impact of graphic neutralization of the illustrations. It assessed whether reducing gender-related details could change children's perceptions and choices. Participants were randomly assigned to two groups. This procedure allows for comparison of responses and the assessment of the impact of graphic neutralization (Bikhchandani et al., 1992; Haun & Tomasello, 2011; Piaget, 1932). The control group received stereotyped illustrations with explicit gender details, while the experimental group received illustrations analogous in content but graphically neutral, lacking distinctive features attributable to a specific gender. The order of administration was kept the same for all participants to prevent carryover effects (Bordens & Abbott, 2011). In other words, this avoided the first test influencing behavior in the second test.

2.3. Participants

The sample consisted of 82 children aged 4–5 years, equally distributed by gender (41 males; 41 females), attending the final and penultimate years of preschool. Twenty-two children were four years old (14 females; 8 males) and sixty were five years old (27 females; 33 males). The overall mean age was 4.73 years (SD = 0.45). Gender distribution was balanced and the internal variability ensured a sufficiently heterogeneous sample. Participant selection was based on convenience, according to age and gender; geographical origin was not considered. The experiment was conducted in four public and private preschools located in central and northern Italy: Scuola dell'Infanzia Tavernelle "Bruno Munari" (Tavernelle di Colli al Metauro), Scuola dell'Infanzia di Sterpeti, Istituto Comprensivo D. Bramante – Scuola dell'Infanzia Fermignano, and European School of Venice (Mestre). Data collection took place within the school environment, in quiet classroom areas prepared by the teachers and adapted for individual administration of the tasks. Each child completed the task individually, separated from peers, in order to minimize potential social influence and conformity effects on attribution and choice responses (Haun & Tomasello, 2011). Session duration was not standardized and no quantitative measure of testing time was collected. Participation was authorized through informed consent obtained from parents or legal guardians.

2.4. Independent Variables

The independent variables consisted of specific graphic characteristics of the illustrations, systematically manipulated to modulate the degree of gender connotation of the visual stimuli. In particular, the manipulation concerned three dimensions: color, pedomorphic traits, and symbolic gender connotations.

Color was treated as a key variable in gender coding in early childhood (Cherney et al., 2006; Eichstedt et al., 2002; Zemach et al., 2007). In the control condition, the illustra-

tions employed culturally gendered color palettes, commonly associated with male and female categories (Figure 1; Table 1). The color palette used was informed by previous studies documenting gender-related color associations in childhood (Passig & Levin, 1999; Cherney et al., 2006; Eichstedt et al., 2002; Zemach et al., 2007). In particular, the selection of hues and their manipulation were based on the framework proposed by Xue et al. (2024), who identified seven colors (blue, orange, green, yellow, red, violet, and magenta) showing different degrees of gender association. In the experimental condition, the same base hues were visually neutralized through a systematic reduction of saturation and brightness using the HSB model, to reduce their recognizability as

Figure 1. Control condition stereotyped palette.

Figure 2. Experimental condition neutralized palette.

Table 1. Stereotyped color palette in CMYK values.

Hue	Cyan (%)	Magenta	Yellow	Black
Blue	92.4	74.6	0	0
Orange	0	62.9	91.3	0
Green	61.4	0	100	0
Yellow	0	0	100	0
Red	0	96.1	94.7	0
Purple	75.8	79.7	0	0
Magenta	0	100	0	0

Table 2. Neutralized color palette with HSB and CMYK values.

Hue	Hue	Sat. (%)	Bright.	Cyan (%)	Magenta	Yellow	Black
Blue	210°	15	70	24	23	23	4
Orange	30°	50	45	14	39	61	3
Green	118°	10	85	29	5	29	0
Yellow	50°	40	95	8	8	53	0
Red	10°	30	75	22	45	40	10
Purple	272°	10	50	53	48	34	19
Magenta	330°	15	65	36	44	27	9

gender markers (Figure 2; Table 2) (Hurlbert & Ling, 2007) while preserving overall chromatic variety.

The illustrated characters differed in the degree of pedomorphism and bodily differentiation. In the control condition, clearly gendered bodily and facial markers were present (e.g., hairstyles, proportions, posture) (Figure 3). In the experimental condition, these markers were attenuated through a simplified graphic style characterized by reduced sexual dimorphism, and ambiguous facial and bodily traits (Figure 4). For example, the larger hair shape in Figure 4 was used to increase the perceived size and roundness of the head within a simplified pedomorphic character design, rather than as a gendered hairstyle cue. To this end, the hair was rendered as a non-specific shape, avoiding a haircut that could be readily identified as masculine or feminine. Likewise, the simplification of the mouth and other facial details was intended to reduce expressive and stylistic specificity, not because these features are inherently gendered in isolation.

The comparison between Figures 3 and 4 should therefore not be understood as the isolation of a single visual variable, but as a controlled reduction of multiple gender-coded cues that operate in combination. For example, facial details such as the presence, shape, or emphasis of the mouth were not treated as inherently gendered in themselves; rather, they were considered part of a broader visual configuration through which expression, softness, maturity, and character identity may be culturally interpreted. Similarly, differences in eye size, body/head proportion, hairstyle, skin tone, and color palette were controlled as elements contributing to the overall gender coding of the character, rather than as independent indicators of gender. Given the multivariate nature of illustration, the aim was not to attribute gendered meaning to any single graphic feature in isolation, but to reduce the cumulative salience of visual

Figure 3. Control condition. Characters with distinct gendered pedomorphic features.

Figure 4. Experimental condition. Characters with reduced gender cues and ambiguous pedomorphic traits.

cues that, within familiar conventions of children's illustration, may support gender attribution.

This approach is grounded in picturebook and multimodal literacy scholarship, which shows that meaning in illustrated materials emerges through the interaction of verbal and visual resources rather than through narrative content alone (Nikolajeva & Scott, 2001). From a social semiotic perspective, children's interpretation of picturebooks is also situated within broader social, historical, and cultural contexts (Serafini, 2023). Accordingly, the gendered meaning of visual features such as hairstyle, clothing, posture, and bodily details was treated as culturally situated (center and north Italy, 2025) rather than universal.

Accordingly, the neutralization strategy was not intended to remove gender attribution altogether, but to reduce the salience of culturally recognizable gender cues within the specific visual conventions available to the participating children. Consistently, evidence on gender attribution suggests that observers may still assign gender categories even when explicit gender cues are reduced; therefore, simplified character design was treated as a strategy for modulating, rather than eliminating, gender attribution processes (Karniol, 2011).

Objects, clothing, and visual contexts were treated as additional gender markers, as they function as culturally shared cues for gender categorization (Shutts et al., 2010). In the control condition, gender-connoted iconic elements were present (Figure 5). In

Figure 5. Control condition with female stereotypes.

Figure 6. Experimental condition with neutralized female stereotypes.

the experimental condition, these elements were maintained at the level of content but represented in a visually neutral manner (Figure 6). For each content, two versions were produced: a stereotyped version (control condition) and a graphically neutralized version (experimental condition).

2.5. The Illustration

The illustrations were created specifically for the study by the first author, who also conducted the experimental sessions. The use of a single illustrator ensured consistency across the stimulus set and allowed the three graphic parameters—color, character morphology, and symbolic gender cues—to be manipulated within a coherent visual language. The adopted style was deliberately simplified and hand-drawn, in line with visual registers commonly found in early-childhood educational materials in Italy. However, the style was not treated as neutral: it was considered a meaningful graphic variable that could influence interpretation. For this reason, the findings should be understood as applying to simplified preschool-oriented illustrations, and not automatically extended to other modes of children's science communication.

In line with empirical evidence on visual recognition processes in preschool children, the stimuli used in both the Baseline Test and the Experimental Test were designed employing a simplified visual language (Eng et al., 2020), characterized by essential geometric forms, soft contours, pedomorphic proportions, and a high level of detail. This was intended to facilitate rapid and unambiguous processing of images by children (Hochberg, 1962; Elkind, 1970; Stone & Church, 1968).

For the Baseline Test, highly symbolic and culturally connoted stimuli were employed, namely a football boot (Zeng & He, 2024; Grabow & Kühl, 2019) and a dance shoe (Oreamuno, 2018), selected insofar as they embody visual and cultural signs that convey gendered behavioral norms and aesthetic ideals (Biemmi, 2017). Both images were rendered using a yellow chromatic palette, chosen as it is generally regarded as perceptually neutral in relation to stereotypical pink/blue gender associations (Cherney et al., 2006; Xue et al., 2024).

In the Experimental Test, the illustrations were differentiated between control and experimental conditions across three principal dimensions: color, pedomorphic features, and symbolic gender connotations. Specifically, the control condition preserves recognizable stereotypical coding, whereas the experimental condition implements a progressive process of visual neutralization through the adoption of non-polarized color palettes (Xue et al., 2024), the removal of identifying elements (Martin & Ruble, 2004), and the use of pedomorphic (Stroessner et al., 2020) and deliberately ambiguous forms.

2.6. Dependent Variables

The dependent variables were children's choices and observable behaviors in response to the illustrations. These measures allowed us to examine whether changes in color, character design, and symbolic objects affected the way children associated the images with gender. This approach builds on developmental studies showing that children's interpretation of images depends on visual detail, salience, and recognizability (Elkind, 1970; Gollin, 1960; Hochberg, 1962; Stone & Church, 1968).

Table 3. Dependent variables (behaviors measured).

Abbrev.	Name
CS	Children satisfaction
CE	Children engagement
CCU	Children confidence/uncertainty
CDE	Children difficulty during the experiment
RGAA	Recognition of gender-associated activities
SC	Stereotyped choices
CSC	Changing of stereotyped choices

Both stereotyped choices (SC) and a set of behavioral and cognitive variables were analyzed to describe children's behavior during the task and their degree of adherence to gender stereotypes in both parts of the experiment (Table 3).

Children's behaviors and choices were recorded using observation sheets, which allowed qualitative information to be transformed into numerical ratings on a 7-point scale. Data were collected through participant observation, fostering a natural and non-invasive interaction to ensure the authenticity of children's responses.

Data collection was conducted consistently across the Baseline Test and the Experimental Test, ensuring methodological continuity between the two phases. The same set of variables was analyzed in both conditions, except for CSC (changing of stereotyped choices), which was introduced exclusively in the experimental test to capture potential changes in children's choices and behaviors resulting from the graphic manipulation of the stimuli.

2.7. Baseline Test

The Baseline Test was designed to examine the presence of automatic gender-stereotypical behaviors and to assess children's knowledge of gender stereotypes, by verifying whether their choices between illustrations containing gender-symbolic elements reflected preferences based on pre-existing stereotypes (Martin & Ruble, 2004; Serbin et al., 2001), thus providing a reference framework for the subsequent experimental test.

The independent variable was the type of illustration shown to the children: one version included objects with culturally gendered associations, while the other reduced or removed these symbolic cues (Figures 7 and 8). The dependent variables were the children's choices, preferences, and observable behaviors during the task.

Figure 7. Baseline test stimulus. Female gender stereotypes in content (ballet shoes) (Bem, 1981; Piluso, 2019; Priulla, 2013; Zeng & He, 2024).

Figure 8. Baseline test stimulus. Male gender stereotypes in content (football shoes).

Yellow was used because it is minimally associated with gender stereotypes (Cherney et al., 2006; Xue et al., 2024). To ensure visibility and contrast against the white background, the hue was darkened by adding black (K=50%).

Stimuli were presented individually to each child (Haun & Tomasello, 2011). Children were asked to indicate an illustration and were asked the following questions: "Which scene do you like most?," "Which activity would you like to do?," "Which character is most like you?," "Which scene makes you think of a friend?"

2.8. Experimental Test

The Experimental Test aims to verify whether graphic variables, specifically the graphic neutralization of illustrations can influence the perception of gender stereotypes in illustrations and adherence to them, compared to detailed and strongly stereotyped stimuli (Cherney et al., 2006; Martin & Ruble, 2004; Serbin et al., 2001; Xue et al., 2024).

The content of the activities remained unchanged, allowing the effect of graphic characteristics to be isolated. The control group received stereotyped illustrations with explicit graphic elements clearly indicating gender through objects and contexts, according to traditional gender roles (Figures 9 and 10). The experimental group received illustrations analogous in content, but graphically neutral, in which gender-indicative details were reduced to a minimum (Figures 11 and 12). Participants were tested individually, and the two stimuli were presented simultaneously. The questions administered were the same as those used in the Baseline Test. This procedure ensured spontaneity of responses and ecological validity of the collected data.

2.9. Ethics

The study was approved by the institutional Ethics Committee of the Iuav University of Venice. The Committee reviewed the submitted documentation and confirmed that the processing of participants' personal data complies with the General Data Protection Regulation (EU 2016/679, GDPR) and that a Data Protection Impact Assessment (DPIA) was not required. Accordingly, the Committee issued a favorable opinion for the conduct of the research, ensuring that all procedures met ethical standards for research with young children.

3. Results

3.1. Baseline Test

The study involved 82 children aged 4–5 years (M age = 4.73, SD = 0.45), equally distributed by gender (41 males, 41 females), recruited from preschools. Variables were analyzed to describe children's behavior during the task. The majority of children displayed

Figure 9. Experimental test stimulus. Control group illustration (girls playing with dolls).

Figure 10. Experimental test stimulus. Control group illustration (boys playing with toy cars).

Figure 11. Experimental test stimulus. Experimental group illustration (female scene, neutralized).

Figure 12. Experimental test stimulus. Experimental group illustration (male scene, neutralized).

Table 4. Baseline Test Contingency Tables. Stereotyped choices divided by participant gender.

SC	Male Participant	Female Participant
MM	40	0
FF	0	37
FM	0	4
MF	1	0
Total	41	41

Table 5. Baseline test—Chi-square test.

	Value	df	*p*
X^2	82.0	3	<.001
N	82		

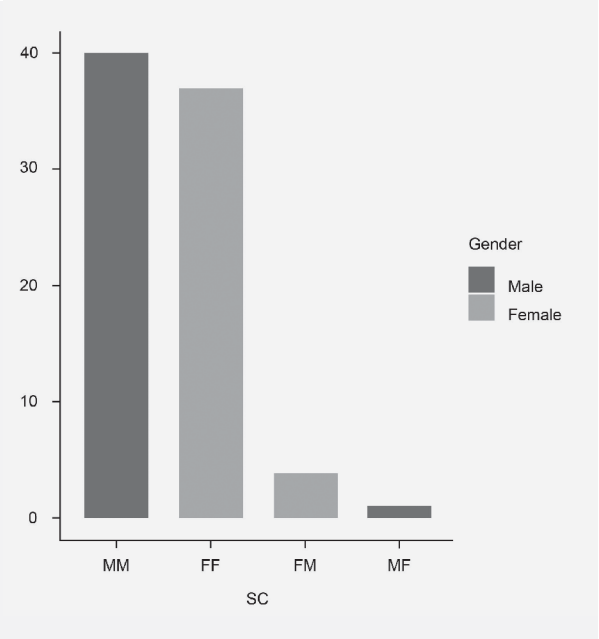


Figure 13. Baseline Test Contingency Chart. Stereotyped choices divided by participant gender.

choices consistent with the gender stereotypes associated with the represented activities (Table 4). The overall percentage of stereotyped choices (SC) was high, indicating a strong early internalization of gender-activity and symbol associations.

The vast majority of children selected images consistent with stereotypes associated with their own gender. Specifically, 97.6% of boys chose the male-stereotyped image, while 90.2% of girls selected the female-stereotyped one. Only 6.1% of the total made a non-stereotyped choice relative to their gender.

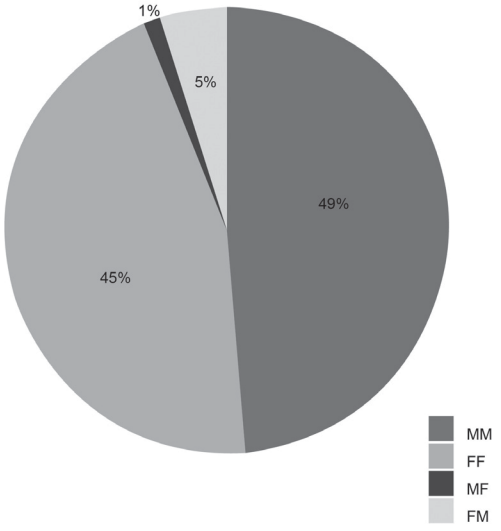
The chi-square test revealed statistically significant association between gender and stereotyped choice, $\chi^2(3) = 82.00$, $p < .001$, indicating that children's choices were strongly influenced by their gender (Table 5). The contingency analysis of SC × gender did not reveal statistically significant differences between boys and girls, suggesting that adherence to gender stereotypes is relatively homogeneous across the two groups (Figures 13–16).

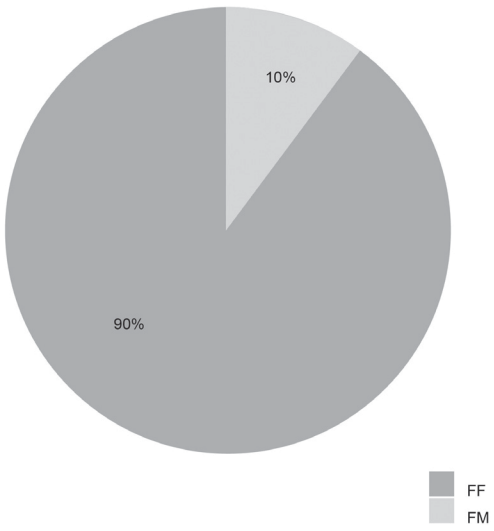
Overall, these results show that by the age of 4–5, children already display a robust adherence to gender stereotypes when choosing images associated with activities or roles, supporting evidence that gender schemas are well established in preschool

age and guide children's interpretations of the world (Martin & Ruble, 2004; Shutts et al., 2010).

The mean scores for Satisfaction (CS) and Engagement (CE) were medium-high (median = 5.00 for both genders), indicating that the baseline activity was generally experienced as enjoyable and engaging, without signs of refusal or disinterest. Safety/Uncertainty (CCU) showed medium-high values (girls: 7.00; boys: 5.00), suggesting that stereotypical choices were not random but accompanied by decisional confidence (Table 6).

Significant positive correlations emerged among recognition of gender-activity associations (RGAA), conformity to gender stereotypes (BCS), and stereotypical choices (SC) (Table 7). Specifically, RGAA–BCS: $\rho = 0.836$, $p < .001$; BCS–SC: $\rho = 0.293$, $p = .008$; RGAA–





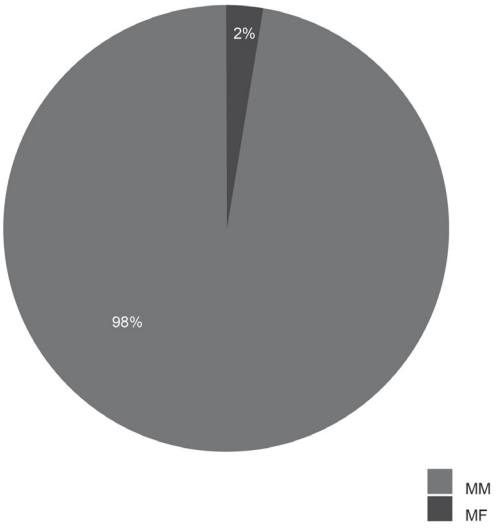


Figure 14 (top left). Participant choices chart in Baseline Test.

Figure 15 (top right). Female participant choices chart in Baseline Test.

Figure 16 (bottom left). Male participant choices chart in Baseline Test.

Table 6. Baseline test values—dependent variables. M–W: Mann–Whitney.

Variable	M–W U Test	*p*-value	Effect (r)	Female Median	Male Median
CS	765	.452	−0.0898	5.00	5.00
CE	752	.376	−0.1053	5.00	5.00
CCU	647	.055	−0.2302	7.00	5.00
BCS	688	.136	−0.1814	5.00	5.00
CDE	688	.127	−0.1820	5.00	5.00
RGAA	666	.082	−0.2082	7.00	5.00

Table 7. Correlation Matrix between dependent variables in Baseline test.

		CS	CE	CCU	BCS	CDE	RGAA	SC
CS	Spearman's rho	–						
	df	–						
	p-value	–						
CE	Spearman's rho	0.944	–					
	df	80	–					
	p-value	<.001	–					
CCU	Spearman's rho	0.747	0.785	–				
	df	80	80	–				
	p-value	<.001	<.001	–				
BCS	Spearman's rho	0.432	0.412	0.541	–			
	df	80	80	80	–			
	p-value	<.001	<.001	<.001	–			
CDE	Spearman's rho	0.644	0.645	0.579	0.352	–		
	df	80	80	80	80	–		
	p-value	<.001	<.001	<.001	0.001	–		
RGAA	Spearman's rho	0.436	0.467	0.606	0.836	0.320	–	
	df	80	80	80	80	80	–	
	p-value	<.001	<.001	<.001	<.001	0.003	–	
CSC	Spearman's rho	0.084	0.100	0.206	0.293	0.092	0.325	–
	df	80	80	80	80	80	80	–
	p-value	0.454	0.370	0.064	0.008	0.412	0.003	–

SC: ρ = 0.325, p = .003. These findings show that children who more often recognized gender–activity associations also tended to produce more stereotype-congruent responses. Because these correlations are calculated among outcome measures, they do not establish whether recognition of gender–activity associations leads to stereotypical choices, or whether children more inclined to make stereotypical choices are also more likely to identify gender–activity associations. The causal claim is therefore restricted to the experimental manipulation: differences between the control and neutralized conditions suggest that changes in visual cues affected children's responses, while the correlations among RGAA, BCS, and SC are interpreted as associations within those responses rather than as causal pathways.

3.2. Experimental Test

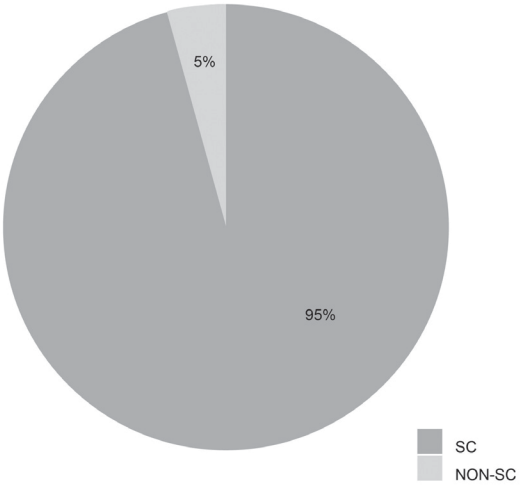
In the control group, the percentages of SC are comparable to those observed in the Baseline Test, confirming the stability of stereotypical automatic responses in the presence of visually connoted stimuli. On the other hand, a significant reduction in the percentage of stereotypical choices is observed, in the experimental group, accompanied by an increase in non-stereotypical choices compared to the control group (Table 8).

In the control group, the vast majority of children made stereotypical choices. Specifically, 21 out of 22 boys (95.5%) selected male-stereotyped images (MM) and 18 out of 19 girls (94.7%) selected female-stereotyped images (FF), for a total of 39 stereotypical choices out of 41 participants (95.1%). In contrast, in the experimental group, the proportion of stereotypical choices decreased markedly, 10 out of 21 boys (47.6%) chose MM and 7 out of 20 girls (35.0%) chose FF (Figure 17). Overall, stereotypical choices in the experimental group accounted for 17 out of 41 selections (41.5%), while non-stereotypical choices (FM and MF) increased to 24 out of 41 (58.5%), compared to only 4.9% in the control group. Row percentages further illustrate this shift. In the control group, 51.2% of choices were MM and 43.9% FF (Figure 18). In contrast, in the experimental group, the distribution shifted toward neutral choices (31.7% FM and 26.8% MF) (Figure 19). Overall, these results suggest that the graphical neutralization of illustrations can significantly influence children's perception and choice, reducing automatic adherence to gender stereotypes.

A chi-square analysis revealed a statistically significant association between stereotypical choices (SC) and group ($\chi^2(3) = 27.4$, $p < .001$) with a contingency coefficient of 0.500, indicating a strong relationship between stimulus type and the frequency of stereotypical choices (Tables 9 and 10). Standardized residuals confirmed that stereotypical choices were more frequent than expected in the control group (MM: +3.50; FF: +3.89) and less frequent than expected in the experimental group (MM: −3.50;

Table 8. Experimental test. Contingency tables.

Group		MM	FF	FM	MF
Control	Observed	21	18	1	1
	Expected	15.5	12.5	7.00	6.00
	% w/in row	51.2	43.9	2.4	2.4
	% w/in column	67.7	72.0	7.1	8.3
Experimental	Observed	10	7	13	11
	Expected	15.5	12.5	7.00	6.00
	% w/in row	24.4	17.1	31.7	26.8
	% w/in column	32.3	28.0	92.9	91.7



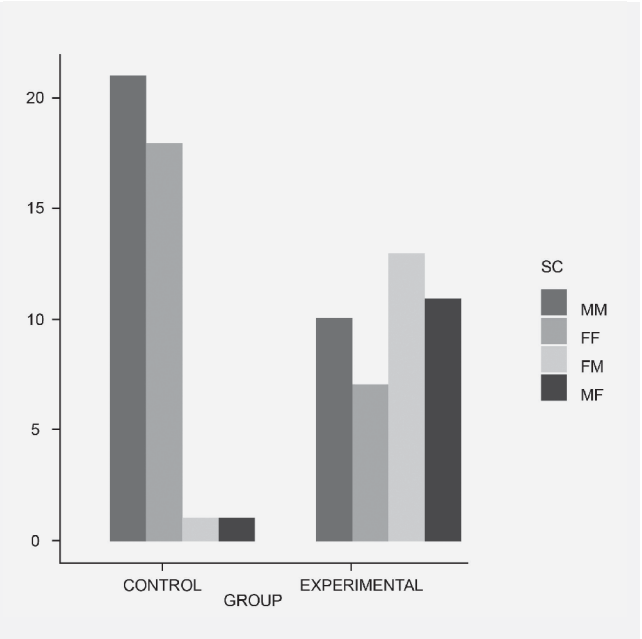


Figure 17 (top right). Groups choices chart in Experimental Test.

Figure 18 (top left). Control groups choices chart in Experimental Test.

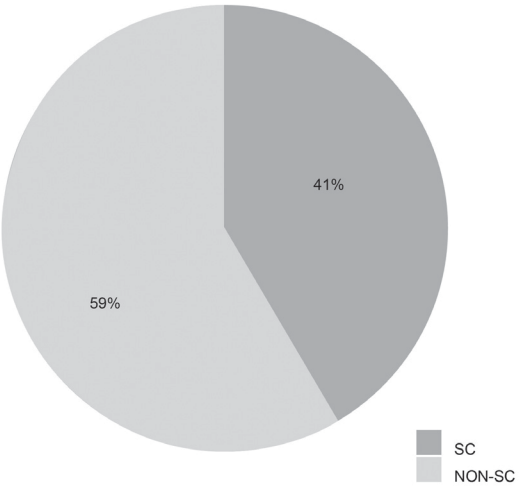


Figure 19 (bottom left). Experimental groups choices chart in Experimental Test.

Table 9. Experimental test—Chi-square test.

	Value	df	*p*
X^2	27.4	3	<.001
N	82		

Table 10. Experimental test. Contingency coefficient.

Nominal	Value
Contingency coefficient	.500

Table 11. Experimental Test. Post Hoc Test (Standardized Residuals).

Particpant Gender	SC	Control Group	Experimental Group
Male	Male	3.35	−3.35
	Female	−3.35	3.35
Female	Male	−3.89	3.89
	Female	3.89	−3.89

Table 12. Descriptives dependent variables in Experimental Test.

	Group	CS	CE	CCU	BCS	CDE	RGAA	CSC
Mean	Control	6.02	5.98	5.93	5.73	5.15	5.73	1.83
	Experimental	6.07	5.98	4.46	3.05	5.78	3.34	4.46
Median	Control	7	7	7	7	5	7	1
	Experimental	7	7	5	3	7	3	5
SD	Control	1.11	1.19	1.49	1.53	1.51	1.47	1.61
	Experimental	1.10	1.11	1.85	1.70	1.47	1.84	2.24

Table 13. Experimental Test. Independent Samples T-Test (Note. H^a: Control ≠ Experimental).

		Statistic	*p*
CS	Mann–Whitney U	821	0.835
CE	Mann–Whitney U	831	0.920
CCU	Mann–Whitney U	461	<.001
BCS	Mann–Whitney U	234	<.001
CDE	Mann–Whitney U	645	0.051
RGAA	Mann–Whitney U	292	<.001
CSC	Mann–Whitney U	329	<.001

Table 14. Experimental Test—Homogeneity of Variances Tests.

		F	df_1	df_2	*p*
CS	Levene's	0.00986	1	80	0.921
	Variance ratio	1.004	40	40	0.990
CE	Levene's	0.36396	1	80	0.548
	Variance ratio	1.163	40	40	0.635
CCU	Levene's	1.95314	1	80	0.166
	Variance ratio	0.652	40	40	0.180
BCS	Levene's	0.06903	1	80	0.793
	Variance ratio	0.811	40	40	0.512
CDE	Levene's	0.56801	1	80	0.453
	Variance ratio	1.047	40	40	0.885
RGAA	Levene's	2.36925	1	80	0.128
	Variance ratio	0.636	40	40	0.157
CSC	Levene's	7.29298	1	80	0.008
	Variance ratio	0.519	40	40	0.041

Table 15. Experimental Test. Tests of Normality.

		Statistic	*p*
CS	Shapiro–Wilk	0.707	<.001
	Kolmogorov–Smirnov	0.349	<.001
	Anderson–Darling	11.58	<.001
CE	Shapiro–Wilk	0.710	<.001
	Kolmogorov–Smirnov	0.339	<.001
	Anderson–Darling	11.35	<.001
CCU	Shapiro–Wilk	0.912	<.001
	Kolmogorov–Smirnov	0.224	<.001
	Anderson–Darling	2.97	<.001
BCS	Shapiro–Wilk	0.944	<.001
	Kolmogorov–Smirnov	0.175	0.013
	Anderson–Darling	2.03	<.001
CDE	Shapiro–Wilk	0.889	<.001
	Kolmogorov–Smirnov	0.221	0.013
	Anderson–Darling	3.23	<.001
RGAA	Shapiro–Wilk	0.887	<.001
	Kolmogorov–Smirnov	0.242	<.001
	Anderson–Darling	3.91	<.001
CSC	Shapiro–Wilk	0.923	<.001
	Kolmogorov–Smirnov	0.202	0.002
	Anderson–Darling	2.67	<.001

FF: −3.89) (Table 11). These results suggest that the graphical neutralization of illustrations effectively reduced children's automatic adherence to gender stereotypes.

These findings suggest that graphical neutralization reduces gender-related automatic responses. The comparison between groups reveals significant differences in decision-related confidence/uncertainty (CCU), conformity to gender stereotypes (BCS), recognition of activities associated with a specific gender (RGAA), and changes in choices and behaviors (CSC) (Table 12). Specifically, the experimental group shows higher decision-making uncertainty (CCU), lower conformity to gender stereotypes (BCS), reduced automatic recognition of activity–gender associations (RGAA), and a greater shift toward non-stereotypical choices and behaviors (CSC).

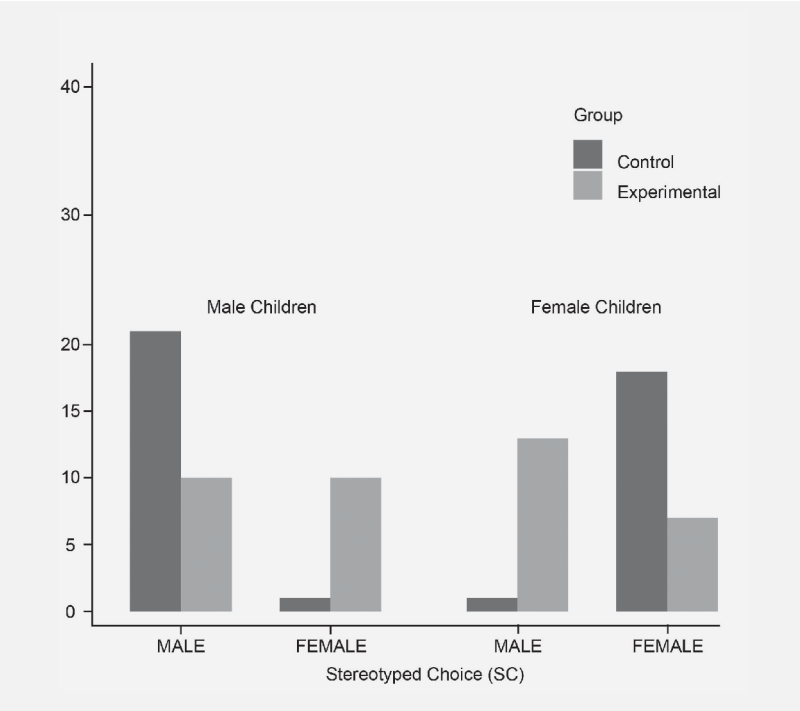


Figure 20. Stereotyped Choices comparison between groups in the Experimental Test.

Confidence/uncertainty (CCU) and Engagement (CE) variables do not show significant differences between the groups in terms of engagement and satisfaction (CS: U = 821, $p = .835$; CE: U = 831, $p = .920$) (Tables 13–15). This finding is particularly important as it demonstrates that graphical neutralization does not reduce children's engagement or enjoyment of the activity. The activity remained equally enjoyable and motivating across both conditions, while successfully reducing stereotypical behaviors.

A gender-stratified analysis confirmed that the effect was significant for both girls ($\chi^2(1) = 15.11$, $p < .001$, contingency coefficient = 0.528) and boys ($\chi^2(1) = 12.22$, $p < .001$, contingency coefficient = 0.470), with a slightly stronger effect observed among girls (Figure 20). Notably, within the experimental group, no significant gender differences in stereotypical choices were observed ($\chi^2(1) = 0.672$, $p = .412$), suggesting that graphical neutralization tends to equalize response patterns across genders.

Qualitative observations during the experimental phase revealed notable behavioral differences between groups. Children in the experimental group exhibited longer decision times and greater verbal reflection before making their choices, suggesting a suspension of automatic, stereotype-driven responses in favor of more deliberate cognitive processing. In contrast, children in the control group typically made rapid, confident selections consistent with gender stereotypes.

In summary, the results demonstrate that the experimental intervention using graphically neutralized illustrations effectively reduced children's stereotypical responses (Control group: 95.1%; Experimental group: 41.5%; χ^2 (3) = 27.4, $p < .001$, contingency coefficient = 0.500), while significantly impacting key cognitive and behavioral dimensions. Conformity to gender stereotypes decreased significantly (BCS: U = 234, $p < .001$), as did decision-making confidence and uncertainty (CCU: U = 461, $p < .001$), recognition of gender–activity associations (RGAA: U = 292, $p < .001$), and changes in choices and behaviors awareness (CSC: U = 329, $p < .001$). Importantly, engagement and satisfaction remained unaffected (CS: U = 821, $p = .835$; CE: U = 831, $p = .920$), indicating that the activity continued to be enjoyable and motivating. These findings support the thesis that visual neutralization can modify children's perception and adherence to gender stereotypes without compromising their engagement in the activity.

4. Discussion

The present study set out to investigate whether the graphic neutralization of gender-coded visual variables in children's illustrations can reduce the activation of gender stereotypes in preschool-aged children. The findings provide converging quantitative and qualitative evidence that visual design choices play an active role in shaping children's gender-related interpretations and decision-making processes.

At baseline, the results confirm that children aged 4–5 already display a strong and systematic adherence to gender stereotypes. The very high proportion of stereotypical choices, together with the significant association between gender and selected activities, aligns with previous research showing that gender schemas are well established in early childhood and guide interpretation even in the absence of explicit verbal cues (Martin & Ruble, 2004; Shutts et al., 2010). Importantly, baseline data show not only stereotypical preferences, but also high decisional confidence and rapid choice execution, suggesting that these associations operate as largely automatic cognitive shortcuts rather than reflective judgments.

Against this background, the experimental manipulation demonstrates that graphic neutralization produces a substantial disruption of these automatic responses. When gender-connoted visual cues were reduced through controlled modifications of color saturation, pedomorphic traits, and symbolic objects, stereotypical choices decreased dramatically in the experimental group compared to the control group. This effect was statistically robust and accompanied by a marked increase in non-stereotypical choices, indicating that children did not simply randomize their responses but engaged differently with the visual stimuli.

Crucially, the reduction in stereotypical choices was not associated with lower engagement or satisfaction. Measures of enjoyment and task involvement remained comparable across conditions, suggesting that graphic neutralization does not diminish the attractiveness or usability of the illustrations. This finding is particularly relevant from an information design perspective, as it counters the assumption that inclusivity-oriented visual strategies necessarily entail a loss of expressiveness or motivational value.

The analysis of behavioral and cognitive variables further clarifies the mechanism underlying this effect. Children in the experimental group showed lower levels of decisional confidence (CCU), reduced behaviors conforming to stereotypes (BCS), and a lower tendency to automatic recognition of gender-associated activities (RGAA). Rather than indicating confusion or disengagement, this pattern points to a temporary suspension of stereotype-driven heuristics. Qualitative observations support this interpretation: children exposed to neutralized illustrations hesitated more often, took longer to decide, and occasionally verbalized uncertainty or alternative interpretations. These behaviors suggest a shift from automatic categorization to more deliberative processing.

The results therefore indicate that the graphic neutralization of gender markers in illustrations reduced stereotypical choices and gendered activity attribution in the immediate context of the task, without diminishing children's engagement or satisfaction. This finding is relevant beyond the specific experimental setting because illustrated materials participate in the early organization of social categories, preferences, and perceived possibilities for action. However, the present study does not measure long-term interests, self-concept, or educational choices. Its implications should therefore be understood primarily in relation to the design of preschool visual materials and to the ways in which illustrations may support or reduce gendered interpretations of activities, objects, and roles.

STEM remains a particularly relevant application in the Italian context, where available evidence shows a marked gender gap in the choice of STEM degree programs even among girls with high demonstrated competence. Integrated data linking INVALSI standardized assessments with university enrollment records indicate that girls are less likely than boys to enroll in STEM degrees, suggesting that divergence in educational choices cannot be explained by academic performance alone (Falzetti, 2024). For this reason, gender-aware visual design in early educational materials may be considered one possible area for future research on the longer developmental chain linking early representations, self-perceptions, interests, and later educational choices.

Nevertheless, the present data do not allow direct conclusions about STEM preferences or long-term educational trajectories. Establishing such links would require studies that include specific measures of domain interest, self-efficacy, and perceived belonging, as well as longitudinal designs following children across later stages of schooling.

Future research should also examine whether similar effects occur across different illustration styles, levels of realism, and genres of children's visual communication, including narrative picturebooks, preschool science materials, informational books, and classroom worksheets.

From this perspective, the findings may inform the design of picturebooks, worksheets, non-fiction materials, and early-learning resources in which children encounter representations of play, care, movement, science, technology, professions, and everyday activities. Reducing the salience of gender-coded visual cues may be relevant for STEM-related representations, and for domains traditionally associated with either boys or girls, such as sport, construction, nursing, domestic care, or technological play. The broader contribution of the study concerns the role of visual design in expanding the range of activities that children may perceive as available to them.

5. Limits of the Study

This study presents certain limitations that should be taken into account when interpreting the findings. First, the sample, composed of children from a relatively homogeneous socio-cultural context, limits the extent to which the results can be generalized to other populations. Although the sample size was adequate for the exploratory aims of the study, further research involving larger samples could help strengthen the generalizability of the findings. Moreover, the visual markers employed to represent or neutralize gender stereotypes—such as hairstyles, clothing, chromatic palettes, and objects—are products of specific cultural and social conventions and may therefore acquire different meanings across diverse geographical and cultural contexts. Consequently, the effectiveness of the proposed graphic neutralization strategies may vary depending on the gender norms and representations specific to each context.

An additional limitation concerns the absence of quantitative time measurements during the experimental procedure. As a result, it was not possible to examine potential differences in response processes across the experimental conditions or to provide precise information regarding the duration of the testing sessions.

A further limitation concerns the visual style of the stimuli. The present study used simplified, hand-drawn, character-based illustrations designed for preschool-aged children. This choice was coherent with the nursery-school context of the experiment, but it limits the generalizability of the findings to other forms of children's science communication, including photographic, diagrammatic, or more verisimilar scientific illustration. Future research should examine whether the reduction of gender-coded cues operates similarly across different illustration styles, school grade, and levels of visual realism.

6. Future Work

In light of these considerations, future research should involve larger and more culturally heterogeneous samples, integrate the systematic collection of temporal measures, and adopt cross-cultural comparative approaches and longitudinal research designs in order to assess the generalizability of the findings, the temporal stability of the observed effects, and the applicability of the proposed design strategies across different educational and socio-cultural settings. Future studies should also compare different illustration styles and degrees of visual realism, from simplified preschool-oriented drawings to more realistic, diagrammatic, photographic, or scientific forms of representation. This would clarify whether graphic neutralization operates similarly across different genres of children's visual communication, including picturebooks, worksheets, nonfiction materials, and early STEM education resources. Such work would help assess the generalizability of the present findings and the applicability of the proposed design strategies across different educational and socio-cultural contexts. Our future research will focus particularly on STEM-related materials for early childhood education, where the design of visual representations may play a role in how children encounter activities, tools, and roles that are often culturally gendered.

7. Conclusion

The results suggest that the design of books and scientific materials featuring explicitly genderless illustrations may reduce the implicit association between specific activities and a particular gender. This implies that, in educational contexts, illustrations that do not link activities to gender markers can be used to promote a freer and less biased access to content, particularly for girls.

The neutralization of illustrations can be implemented through several design strategies. First, by eliminating gender connotations and representing characters without distinctive traits referable to a specific identity, such as explicit sexual markers (e.g., breasts, beards, hips), as well as clothing, objects, or hairstyles that are culturally associated with a particular gender. A further strategy involves reducing pedomorphic features—elements that accentuate childlike characteristics, such as disproportionately large heads or eyes—by avoiding excessive emphasis on such proportions and instead favoring softer, more essential, and less detailed lines. Finally, a neutral color palette may be adopted by desaturating colors traditionally attributed to specific genders.

These findings have practical implications for the design of preschool educational materials. They suggest that illustrators, educators, and publishers should not treat visual style as neutral, since color, hairstyle, clothing, facial detail, posture, and symbolic objects can contribute to the gendered interpretation of activities and roles.

For STEM-related materials, this approach may be particularly useful. Tools, experiments, construction activities, technological devices, and scientific exploration can be represented without systematically attaching them to masculine or feminine visual markers. In early-childhood contexts, where children often encounter science and technology through narrative images, worksheets, games, and picturebooks, reducing the salience of gender-coded cues may help present these activities as broadly accessible rather than implicitly associated with one gender.

8. Ethics Statement

The study was reviewed and approved by the Ethics Committee of Università Iuav di Venezia. Written informed consent was obtained from parents or legal guardians before children's participation.

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