Beyond appearances: A serious game to challenge gender stereotypes in STEM*

Federico Paulesu[1,*,†], Teresa Di Bella[1,†], Antonio Buccoliero[1,†] and Rossana Actis Grosso[1,†]

[1]*University of Milano-Bicocca, 20126 Milan, Italy*
[1]*Independent Researcher*

Abstract
Despite increasing cultural awareness of gender equality in STEM, implicit biases such as the Gender-Science Stereotype (GSS) continue to influence perceptions of competence. This study investigated the role of gendered appearance cues in modulating academic competence judgments. Two experiments assessed how features such as hair color, hair length, make-up, beard, and glasses affected the perceived likelihood that male and female faces authored either a scientific abstract or a literary plot. In Experiment 1, while no overt GSS emerged for female targets, competence ratings significantly decreased when women displayed heavy make-up or blonde hair, particularly in association with science authorship. Glasses consistently increased perceived competence. Experiment 2 revealed a clear GSS for male targets, with male faces rated as more likely to author scientific texts, especially when paired with a full beard and dark hair. Notably, blonde hair lowered competence ratings for men as well, extending the "dumb blonde" stereotype beyond its traditional female target. Building on these findings, a serious role-playing videogame was designed to challenge appearance-based stereotypes, assigning highly competent scientific roles to characters with stereotypical feminizing traits. This interactive approach offers a promising tool for promoting stereotype awareness and reducing implicit biases in STEM contexts.

Keywords
gender-science stereotype, serious game, STEM

1. Introduction

To this day, Science, Technology, Engineering and Mathematics (STEM) fields are still largely represented (65% worldwide) by the male population [1], with women comprising only the remaining 35%. This unbalance in representation is sustained by the so-called Gender Science Stereotype (GSS) according to which men are more competent than women in STEM fields while women, conversely, are more versed in arts and humanities[2]. While meta-analytic evidence suggests a progressive weakening of explicit gender-competence stereotypes in Western societies [3], implicit biases may continue to manifest under specific situational or perceptual conditions [4][5].

Theoretical models of social perception emphasize the role of automatic, stimulus-driven impressions formed from visible facial cues, which activate deeply rooted social stereotypes, often outside of conscious awareness [6][7]. Physical characteristics linked to gender expression—such as cosmetics use and facial hair—have been shown to modulate perceived competence and agency. For instance, Workman and Johnson [8]demonstrated that heavy make-up enhances perceived femininity, while Dixson and colleagues [9] reported that facial hair increases perceived masculinity and dominance in male faces. These appearance cues could modulate the activation of GSS by amplifying stereotypical associations between competence and masculine traits.

Moreover, studies long addressed the "dumb blonde" stereotype, a well-documented bias according to which blonde-haired women are perceived as less intelligent and more naïve than women with darker hair [10]. Prior work on person perception has also shown that wearing glasses enhances perceived intelligence and trustworthiness [11], potentially counteracting negative effects of other feminizing features.

2. Theoretical background

A recent study [12], capitalizing on the aforementioned biases, was aimed at exploring the possible interaction of gendered appearance cues (i.e. hair colour, hair length, make-up for women and beard for men) as well as competence-related features (i.e. glasses) in influencing the perception of academic competence in men and women. The study employed two experiments manipulating photographs (see Figures 1 and 2 for an example of the stimuli employed) of female (Experiment 1) and male (Experiment 2) faces by varying Hair Colour (three levels: Black, Brown, Blonde), Hair Length (two levels: Long, Short), Glasses (two levels: Absent. Present), and either Make-up (for women; Three levels: None, Light, Heavy) or beard (for men; Three levels: Shaved, Stubble, Full). Participants rated the likelihood that each depicted person authored either a scientific abstract or a novel's plot.

In experiment 1, no main effect of Genre emerged, suggesting a possible confirmation of the meta-analytic study by Eagly and colleagues [3]. which focused on female targets, results showed that feminine appearance cues, particularly heavy make-up and blonde hair, negatively influenced perceived academic competence. However, the presence of glasses consistently improved perceived competence, acting as a counterbalance to the negative impact of feminizing traits. Notably, there was no overall bias in associating women more with literature than science, suggesting a potential shift in gender-science stereotypes at an explicit level, although implicit biases remained active.

In experiment 2, which focused on male targets, a clearer stereotype emerged. Male faces were more strongly associated with science authorship, particularly when accompanied by stereotypical masculine features such as full beards and darker hair. Glasses again had a consistently positive effect on perceived competence. Interestingly, blonde hair was linked to lower competence ratings for men as well, indicating that certain appearance-based biases—like the "dumb blonde" stereotype—may not be entirely gender-specific.

Building on these findings and highlighting some of the traits of a "typical" scholar, we aimed to present counter-stereotypical representations of them through a serious game, to move the first steps of disrupting the association between looks and competences.
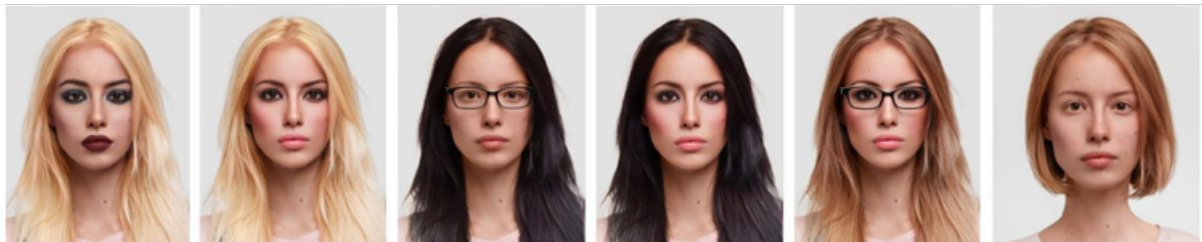
Figure 1: Example of stimuli presented in Experiment 1

Figure 2: Example of stimuli presented in Experiment 2

3. Serious Game

Based on the theoretical framework presented in the previous section, here the initial design of a serious game that faces the topic of GSS will be presented. The game is being developed in Python, using the

free open source platform Pygame. The development is currently in its first stages, and this phase focuses on the development and testing of its core components: characters, narrative, mechanics and user interfaces (UI). The final product will be a roleplaying game (RPG) in which the player controls different characters, each one with different skills, personalities and tasks. This game aims at engaging players in a narrative that challenges these implicit stereotypes. By making the player control diverse avatars whose appearances do not align with traditional stereotypes, the game encourages critical thinking. In this way, the game aims at promoting awareness of stereotyping in players.

3.1. Videogame and narrative framing

The development of this game focused on ensuring that the gameplay and the dynamics effectively reflected the core concept of subverting stereotypes through the characters' roles. This required a careful consideration and choice of the game genre and of the quest design. In choosing the game genre, RPG seemed the most suitable for this purpose for several reasons. First of all, RPGs allow to develop and impersonate varied character roles. Secondly, the narrative background of RPGs makes it possible to introduce and explore the characters' personalities and appearances, which, in this case, is really useful for setting up the initial stereotypes that the gameplay will challenge. In this way, the player can have a direct connection with the character and the narrative that highlights the subversion of expectations. Finally, progression in the game is designed specifically to emphasize the importance of each character's unique skills and contributions, giving further importance to every individual's abilities despite their physical appearance. In this way, the characters' tasks are aligned with their professional roles, not their appearance, systematically subverting expected stereotypes.

Character	Portrait	Sprite	Occupation	Personality	Underlying abilities
Elena			Scientist	Talkative, dramatic, gossipy, flirty	Brilliant, analytical, problem-solver, detail-oriented
Alex			Scientist	Outgoing, jovial, distracted, charming	Rigorous, achiever, cooperative, perfectionist
Marco			Technician	Friendly, casual, helpful, kind	Meticulous, methodical, patient, resilient
Sofia			Secretary	Sociable, empathetic, reliable, curious	Strategic, resourceful, assertive, decision-maker
Luca			Janitor	Analytical, thoughtful, introverted, old-fashioned	Strong, hands-on, action-oriented, inventive
Luisa			Security Guard	Sarcastic, witty, serious, reserved	Caring, insightful, critical thinker, observant

Table 1
Presentation of the characters.

3.2. Visual and character design

The game characters were conceptualized starting from the results of the aforementioned study [12], where features such as hair color, make-up, beard and glasses were manipulated to assess their influence on perceived competence and gender expression. Each character has two arts: a traditional drawing that shows up during dialogues (portrait) and their pixel-art version (sprite). They were drawn in a cartoon-like style using Adobe Photoshop with the aim of exaggerating their stereotypical features; each character design includes second-order features that are opposed to their narrative role. Characters' portrait, sprites, occupation and personality are exemplified in Table 1.

3.3. Narrative

When the player first starts the game, a narrated prologue introduces the background of the story, presenting all the six characters: the scientists (Elena and Alex), the IT technician (Marco), the secretary (Sofia), the security guard (Luisa) and the Janitor (Luca). After the prologue, the player can choose which character they want to play first, but will eventually play all of them throughout the game. Indeed, every character's contribution is crucial to complete the game quests, which are designed according to the characters' role (e.g. scientist) and not to their stereotypical appearance. The goal of the game is to find out the cause of a mysterious explosion in the laboratory, by exploring, collecting cues and reconstructing events. Each character, with their own characteristics, contributes differently, using their skills and knowledge. For instance, Elena the scientist, despite her heavy make-up and her long blonde hair (according to the theoretical framework presented in Chapter 1) is the head of the scientific lab and needs to perform crucial scientific puzzles. On the other hand, Luca the janitor, though "intelligent-looking", needs to perform practical tasks such as moving objects around a room. These tasks and the narrative settings, all contribute to subverting the stereotypes associated with the physical look and personality of the characters, by creating scenarios and behaviors that will foster critical thinking in the players who will learn to avoid the automatic associations between aesthetic features and intellectual qualities.

3.4. Game mechanics

This game contains classic RPG dynamics. (1) Environmental exploration: after choosing an initial character (Figure 3), the player can freely move around the maps, interacting with objects and other characters. This immerses the player in the laboratory setting, making the story more engaging. Interacting with objects reveals crucial clues for the plot, in this way, the player needs to focus and observe every element carefully. Giving the player this freedom to explore and choose whom to interact with makes the discovery process active and engaging.

Figure 3: Character selection screen.

(2) Puzzle and minigames: each quest involves puzzles and minigames inherent to the characters' job, for example, the scientists have quests related to data analysis, laboratory equipment, etc. This is a fundamental mechanic for subverting stereotypes: Elena solving complex scientific problems despite her "stereotypical blonde" appearance and personality concretely demonstrates her competence. Similarly, Luca, the "intellectual-looking" janitor solving logistical problems highlights that appearances can be deceiving. Besides this, puzzle and minigames keep the player engaged and actively involved in problem-solving and progressing in the gaming, making their journey in getting to know about the characters' more memorable than a simple narrative. Aligning these tasks with characters' professional roles reinforces the link between their training and experience rather than their look.
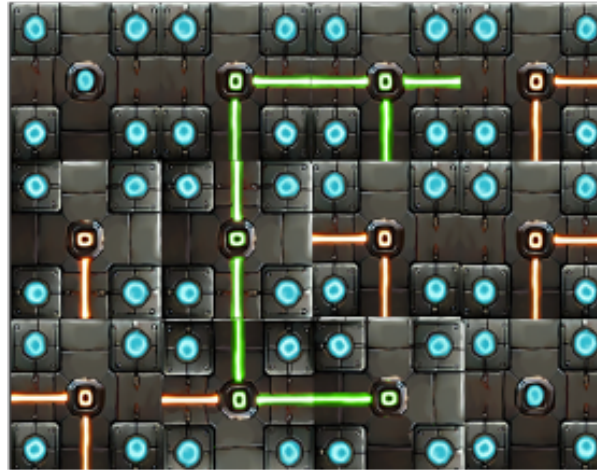
Figure 4: Example of a puzzle minigame where the player is required to create a path by rotating the panels.

(3) Dialogue system: interactions between characters (Figure 6) can be useful to progress and to get to know their personalities, which are related to the stereotypes. Interacting during exploration offers opportunities for dialogues that reveal the true skills and personalities of the characters, going beyond initial impressions based on their appearance. These dialogues are crucial for presenting the nuances of each character's personality, overcoming the stereotypes.

Figure 5: Dialog box prompted after interacting with other characters in the map.

3.5. Future Steps

The development of this serious game is currently in a prototype stage, with core gameplay mechanics, character design and narrative structure established in their initial stages. The next steps will be crucial

to assess the effectiveness, usability and engagement of the game elements, while redesigning the prototype based on real user feedback. The core of the next stage will be user testing, essential to understand how the different components of the game are perceived by the audience. Adult testers will be asked to interact with the prototype by playing through the prologue of the game, evaluating the quests/minigames, aesthetic elements, clarity of the storyline, accessibility and gameplay mechanics in general. A crucial element of the evaluation will be the gathering of data related to whether the characters successfully challenge stereotypical expectations. Parallel to the user testing, further technical and narrative development will continue.

4. Discussion

The present study, intertwining gendered appearance studies and the development of a serious game, has the ambitious aim to promote awareness, critical thinking and offer an educational tool to foster gender equality in STEM. To achieve this, we started by presenting the results of a recent study that allowed us to delineate which aesthetical characteristics can activate or enhance GSS, underlining the importance of strongly gendered features (i.e. make-up and beard) and more perceptual elements (hair colour and hair length). Stemming from these results, we then designed a serious game which implemented them into a narrative-driven role play. The video game aims to counteract the appearance-based expectations, by assigning a highly competent and science-oriented set of skills and personality to characters designed with stereotypical feminine traits (e.g. heavy make-up and blonde hair) or more communal on "hands-on" qualities to characters that presents stereotypical intellectual features (e.g. glasses and full beard). The player is then confronted with their own implicit biases through gameplay dynamics which include character switching, puzzles, and dialogue interactions that compel them to engage with and overcome initial prejudices in order to progress. This interactive medium holds promise as an educational tool for promoting awareness of implicit gender biases in STEM contexts and an initial step in subverting the media representation of scientists and women at large.

5. Declaration on Generative AI

During the preparation of this work, the author(s) used GPT in order to: Formatting assistance. After using these tool(s)/service(s), the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

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