
A cognitive perspective on addressing societally-induced gender differences in STEM subjects

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Matija Franklin

Department of Psychology
University College London

Elif Naz Çoker

Department of Psychology
University of Cambridge

Johnny Hugill

PUBLIC

Rebecca Lees

Diversity and Inclusion team
House of Commons

The effects of adults on child behaviour

Gender is one of the first categories to which children are introduced, and one of the first traits with which adults define children. As such, people hold gender-specific stereotypes and have gendered expectations [1]. Research on the formation of gender identities and roles in early childhood has established that boys and girls are treated in a gendered way by the adults in their lives, be it parents, teachers, or even strangers [2]. From birth, a child's gender is treated as a central part of its identity. A famous study found that out of the first questions parents receive after their child is born, 80% is about the child's sex [3]. Most adults make gendered associations and categorisations and treat children in relation to these gendered categorisations. The gendered treatment children receive introduces them to gender social norms, which shape their beliefs about what is expected of them in relation to their gender. [4]. This, in turn, influence how children view themselves and their capabilities.

Infants are born into a society that has very definitive ideas about gender norms. Even before the emergence of any visible differences in physical appearance or behaviour, boys and girls are viewed and treated differently. A famous study introduced girls to adults as John and dressed them in blue, and boys as Jane and dressed them in pink [2]. Adults treated children differently based on whether they were introduced as a boy or a girl, irrespective of their actual gender. Girls were given "girls' toys", boys were given "boys' toys", and girls were treated more gently than boys.

While children's ideas about gender identities and roles are still forming, they are more attuned to cues that provide them with information about gender-normative behaviour [5]. Children learn about gender roles by observing people's behaviour. They mostly learn from people that are selected as their "role models" – usually adults or children with whom they have a close relationship. Children use other children's behaviour as cues for gender-appropriate behaviour. Girls observing other girls playing with a gender-neutral toy are more likely to play with that

toy, just as boys imitate and learn from other boys [6].

Play is a crucial part of a child's developmental trajectory, physically, cognitively, emotionally and socially. It is also a crucial learning opportunity, resulting in the development of various skills. Learning through play allows children to build gross and fine motor skills [7], refine executive functions such as flexibility in cognitive strategies and memory capacity [8], and internalise the workings of their environments [9]. Parents, teachers and other caregivers follow gender norms and take cues from gendered marketing, when deciding what toys to give to boys and girls. When given toys based on their gender, children undergo different experiences of play, which lead to the differentiated development of key skills [10]. If children are not given certain toys, they lose out on potentially valuable learning experiences during a sensitive developmental period. These gendered experiences in play can lead to visible differences in abilities.

Parents, caregivers, and teachers tend to encourage boys and girls to play with different toys [11]. "Girls' toys" such as dolls, soft plush toys, and miniature kitchen items encourage verbal interaction and a closer proximity between parent and child [12]. This can be linked to the earlier verbal skills observed in girls [12]. On the other hand, "boys' toys" such as cars, building blocks, and action figures can promote the development of spatial abilities [12]. Furthermore, developing spatial abilities in boys may lead to one of the largest observed sex differences – the sex difference in mental rotation tasks [11]. Children with better spatial abilities and mental rotation tasks may be more likely to gravitate towards pursuing STEM degrees and careers in the future, as they are necessary for excelling in these fields.

Differential developmental trajectories are the result of two crucial learning mechanisms. First, is learning through *labelling*. *Gender labelling* is the acquisition of behaviour through reinforcement; specifically, being told that a certain behaviour is more appropriate for a certain gender [13]. Boys are told what behaviours and interests are suitable for boys, and the same happens with girls. Gender labels are further engrained as children learn that gender-appropriate behaviours and attitudes are rewarded. This relates to the second mechanism, *learning by reinforcement*, which occurs when children's behaviours and atti-

tudes are externally conditioned through reward such as social encouragement by adults [13].

Mathematical anxiety and its consequences

A context that we will explore in detail is a gender difference in mathematics performance, caused by *Mathematics Anxiety*, which has a profound impact on differences in subject interest in later education and thus career selection. Mathematics Anxiety is a specific kind of test anxiety for mathematics learning and problem-solving that, on average, affects girls more than boys [14]. This very prominent subject-specific gender difference in performance is not the result of innate differences in ability [12]. It is the result of a societally-induced *stereotype threat* causing a context-specific anxiety; in this case, the context of a math's test. At a surface level, it seems like Mathematics Anxiety only leads to performance drops for maths tests, however, it will also disrupt the development of "math anxious" children's abilities and subject-specific knowledge. Many have proposed that, since mathematics is a vital skill set required for Science, Technology, Engineering and Mathematics (STEM) jobs and higher education, Mathematics Anxiety can trigger a life-long avoidance of mathematics and related quantitative disciplines [14]. On average, a person with a STEM job will out-earn a person with a non-STEM job, thus this issue has major economic and policy implications [15].

There is no existing gender difference in mathematical ability [12]. In other words, both boys and girls are equally capable at excelling at mathematics. However, in the context of a test, or any formal assessment of mathematical ability, there is often an evident gender difference in mathematics performance [16]. The main contributing factor to the gender difference in mathematics performance is Mathematics Anxiety [14].

A notable study found evidence that significantly more males than females intend to pursue further study in mathematics [17]. This is especially true from the lower half of the achievement distribution. This implies that a male secondary school student that, compared to the average, does not perform well in mathematics, is more likely to continue his pursuit in mathematical study. A large-scale study demon-

strated convincingly that Mathematics Anxiety in girls, but not boys, is a significant predictor of bad performance in the field [16].

Evidence from educational neuroscience shows that Mathematics Anxiety is related to a distinct pattern of neural activity in brain areas associated with numerical computations and negative emotions [18]. When mathematics-anxious children perform mathematical calculations, they show hyperactivity in right amygdala regions, which are important for processing negative emotions.

A significant source of negative attitude and anxiety comes from early education. Like most adults, most teachers have biased gender-specific beliefs about girls' and boys' mathematics ability. This bias usually takes the form of teachers giving boys more attention during math classes and more opportunities to answer questions, solve problems and state their opinions about the lecture's content [19]. Such gendered treatment influences children's attitudes towards mathematics. Namely, girls have more negative attitudes, which, in turn, results in girls performing worse.

Teachers who have Mathematics Anxiety impart these negative attitudes to some of their students, and this transition falls along gendered lines. A famous study found that female students are more likely to be anxious about mathematics if they have highly mathematics anxious female teachers, who endorse the stereotype that "boys are good at mathematics, girls at reading" [20]. Girls who endorsed this stereotype were most likely to have low mathematics scores at the end of the school year.

What policy makers and regulators should do

To target the fact that people interpret boys' and girls' objectively similar behaviours differently, we recommend that the UK government should develop educational campaigns that make the following messages salient to adults:

1) Giving children the opportunity to express a variety of emotions, behaviours and attitudes is crucial for healthy psychological development, and will positively influence the abilities and interests of both boys and girls.

2) Parents should be mindful of the large influence they have on their children. A meta-analysis of the relationship between parents' gender schemas and their children's ideas about gender roles found that the two were significantly correlated [21]. This is especially important given the finding that parents that engage in behaviours that challenge existing gender stereotypes (e.g., father cooks or mother repairs machinery) are better at helping children of both sexes to develop a sense of self-worth [22].

3) Parents should encourage children to play in mixed-gender groups. A 2003 study found that children who played in mixed-gender groups were more likely to make non-stereotypical activity choices and have intermediate levels of active-forceful play (i.e., play with more active and forceful physical contact, fighting, and taunting) [23]. Beyond parental encouragement of children, policy decisions could also be made in this regard.

To target the fact that children have gendered developmental trajectories as a result of receiving different resources, retailers should remove gender labels from their toy display and adverts. Instead of labelling items as toys "for boy" or "for girls", major retailers should organise them by category. This will encourage adults to choose toys based on a child's specific interests rather than their gender. In the United Kingdom, large retailers such as Marks & Spencer, Sainsbury's, Tesco, Boots and Toys "R" Us have already removed gender-targeted marketing and labelling in their stores and advertisement campaigns [24]. This is an effective way of changing consumer purchase patterns that will allow boys and girls to play with toys that they have not played with before.

Current market research finds that advertisement for construction sets and action figures almost exclusively features boys, that often engage in aggressive behaviour. Advertisement for dolls, grooming and beauty toys features girls, who often appear passive. New studies suggest that this might not be an effective advertising strategy. Both young children and parents express discontent about biased representations in ads that show boys and girls performing gender-typical behaviours [25]. Furthermore, both young children and parents commented that the advertised stereotype did not reflect the truth. Children did not like seeing boys dressed in blue, playing with cars and action figures, and girls dressed in

pink, playing with dolls and cooking-related toys. The children further said that their peers have a variety of interests, and that not all of them are gender-stereotypical.

Finally, policy makers should address the fact that teachers treat boys and girls differently, which results in stereotype threat. As simple yet effective way of doing so, would be if teachers kept a note of the opportunities they give to students during a mathematics class. Students should be given the opportunity to answer questions and express opinions. To be clear, we are not advocating for a strict equality of outcome. Students will differ in their mathematical ability and their interest in maths as a subject. The dynamics of different classrooms will inevitably differ. The same is true when things are viewed through a gender lens. Certain classrooms might have more girls that are enthusiastic about maths, while other classroom might have more boys that are enthusiastic to raise their hands and answer questions. However, this recommendation argues for an *equality of encouragement* for each individual in a classroom, and thus between genders.

Equality of encouragement – a policy aim that tries to achieve systems in which all individuals are equally encouraged to participate in an activity, in the context in which that activity is usually performed.

Policy that aims to address societally-induced gender differences in early education and development could benefit by employing equality of encouragement as a policy goal. Setting this goal serves as a good foundation for policy that tries to promote diverse, developmentally enriching experiences for children.

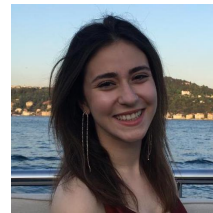
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About the Authors



Matija Franklin is a behavioural scientist at the Policy Research Group and a PhD student at University College London. His research involves ways in which decision-making can be predicted and improved, as well as ways of modelling the relationship between information framing and judgment. Matija is interested in the ways in which a behaviourally-informed approach to policy-making might improve government services and practices.



Elif Naz Çoker completed her MPhil in Social and Developmental Psychology at the University of Cambridge in November 2018 and was a member of Homerton College. Her research focused on exploring relationships between parents' mental wellbeing and early socio-cognitive development of infants. She later joined the Cambridge Social Decision Making Lab as a visiting research student and worked on a project exploring people's perceptions of and intentions to reduce meat consumption to help mitigate climate change. Elif is interested in the intersection of policy- and decision-making, especially wanting to explore how choice architecture and nudging can help individuals make more conscious choices for the wellbeing of societies and the environment. Originally from Turkey, she holds bachelor's degrees in Psychology and Sociology from Columbia University (Summa Cum Laude, Phi Beta Kappa) and in Political Science from Institut d'Etudes Politiques de Paris (Cum Laude).



Johnny Hugill is Research Manager at PUBLIC, a venture firm and research house focused on helping technology startups and government to work together. He sits on the Cabinet Office Open Contracting Steering Group and has advised central government on its innovation strategy. Before that, Johnny studied Philosophy at Sidney Sussex College, where he researched on trust, cooperation and group conventions. He has worked with the Wilberforce Society on a number of policy reports, including universal basic income and the intersection between behavioural insights and gender equality. He is delivering a special lecture series on digital transformation for Cambridge MPhil Public Policy students.

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Dr Rebecca Lees works in the Diversity and Inclusion team in the House of Commons. Prior to joining Parliament, Rebecca was awarded her PhD from the Faculty of Classics, Cambridge. Her thesis examined the relationship between gender norms and Latin grammar. During her PhD Rebecca completed an internship at the Centre for Science and Policy, Cambridge, where she led a project for the Arts and Humanities Research Council on engagement between policy-makers and arts and humanities scholars.

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