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Using Technology to Visualize Gender Bias

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Abstract. Science and technology have been typically associated with masculinity. Research contradicting this belief has been mainly focused on our unconscious awareness. In this paper, we propose two interactive systems designed to make gender bias noticeable. One that combines physical and virtual environment and present the numbers of college applications (Gender by Numbers, that interacts with our conscious mind) and one that uses QR codes to visualize a gender bias riddle (Riddle Me This QR, that interacts with our unconscious mind). We conducted a study that aimed to infer which of the strategies could trigger a difference using the conscious and unconscious measures. We found that Gender by Numbers only reinforced the mentality that men should pursue engineering and women should go into a more characteristic job like kindergarten teacher or nursing. Riddle Me This QR uncover the possibility of mentality change. The next step is up to each individual to have the will to break that prejudice.

Keywords: Gender Bias, Technology, High School, Tangible, Riddle

1 Introduction

Social biases have long affected our society [1]. Currently, our global marketplace is more and more guided by technology [2] and men still dominate, despite the vast growth in the number of women in science, technology, engineering and math (STEM) fields [3], [4]. This is a common phenomenon that has long been held true, creating beliefs and assumptions that specific occupations require either masculine or feminine traits – it is what we perceive as a stereotype, matching society’s collective knowledge [5], [6]. Whereas prejudice is observed as the operation of social stereotypes [7]. If women enter a technology area, we consider it a win-win for them as the world gains new perspectives on problem-solving [4]. Diversity in the working classes leads to creativity, productivity, and innovation [8]. Research on ways to reduce prejudice has been primarily focused on intergroup interactions with different groups. Gordon Allport was one of those researchers who focused on conscious response and self-reporting. Patricia

Devine and others, on the other hand, observed that bias can be engaged in unconscious awareness, hypothesizing that to break the bias habit there must be awareness, motivation and training [9]–[11]. There are at least two ways to raise awareness about implicit bias: one is to openly inform people of its presence with lectures and workshops; the second is making the bias salient, that is, calling attention to the likelihood of a specific bias in others can boost self-awareness of their own biases [9].

2 Related Work

Implicit cognition can be measured using a simple test named The Implicit Association Test (IAT). This test detects our stronger pairs of associations, identifying implicit stereotypes. To understand IAT, imagine you have a basket of apples, both green and red, and you need to separate them as fast as you can, green to the left and red to the right. As the difference between them is the colour, the task is easily done. Now imagine you need to separate them by condition, fresh or rotten (regardless of the colour). Your sorting speed would decline. The IAT uses this tactic to associate our speed with tasks about race, gender, religion, age, and so on [12], [13].

Devine assumed that the implicit bias is identical to a habit, that can be diminished over a mixture of self-awareness, involvement about the hurtful effects of the bias and the deliberated use of strategies to overcome them. In a study, all participants were requested to complete the Race Implicit Association Test, getting their results in the end. While the control group went home, the other group watched a 45-minute interaction slideshow that included an education and training piece. In the educational part information was brought in the sense that prejudice was a habit that could be overcome, the development of the implicit bias and its damaging effects. While in the training part strategies were introduced to reduce implicit bias, the acquirer of information about our-group members and it was explained that those strategies needed to be practiced to break the prejudice habit. All participants repeated the measurement in the following two, four, six and eight weeks later. Devine found that those who participated in the intervention had lower their implicit values than the control group, maintaining it, through the eight weeks. The study did not affect the racial attitude nor the motivation, however participants did increase their involvement about discrimination and awareness of their self-bias. In the end, giving the participants strategies to overcome their own bias is not enough, they need to have confidence in themselves that they could use the strategies to overcome their bias [10].

Our work focused on the design and evaluation of two prototypes that uses technology make the bias salient. To that effect, we explored studies related to the extent of the message persuading someone. Baesler and Burgoon [14] were interested in the impact of messages. They bestowed messages centered on statistical evidence and narratives in three time periods (i.e., immediate, 48 hours later, one week later). Both demonstrated persuasive power; however, to last at least one week of persuasion, the message had to be composed of statistical and memorable content. A study by Woolley [15],

showed evidence that when a group of people cooperate among themselves, their intelligence is greater than a group of individuals. Furthermore, that inclination to cooperate efficiently is related to the number of women in the group. However, when the problem is associated with gender, the efficiency stops. The author Skorinko [16], thought that students could learn about stereotypes if riddles (surgeon is male, surgeon is female) were used in the classroom, discovering first-hand if their ability to solve problems is influenced by stereotypes. “A father and son are in a horrible car crash that kills the dad. The son is rushed to the hospital; just as he’s about to go under the knife, the surgeon says, ‘I can’t operate – that boy is my son!’ Who is the surgeon?”. In four studies she explored the cognitive performance (time taken to solve and recognition of difficulty), subjective learning (if they learn) and objective learning (knowledge) about gender stereotypes with the use of opposite riddles. Her results showed that both riddles indicated an increased understanding about gender stereotypes (subjective learning). As for the riddle comparison, when the solution was female, students were slower and rated the riddle as difficult, but it provoked a better performance in the quiz (objective learning), unlike when the solution was male.

One study used the combination of the virtual and physical environment to create a preliminary concept to display a gender imbalance of the student’s choice for an academic career. Named Gender By Number, with the physical environment as the selection of the sex and academic career of the student while its results would show in the virtual environment show in statistic view [18].

Even though there are studies focused on improving gender inclusiveness in computation [19], [20], some of them believed that the software that people used is the problem: by disrupting the female problem-solving capabilities [21]–[23]. One example is this study that created the GenderMag (Gender-Inclusiveness Magnifier). This technique aids the creators to detect problems with their software with a “gender-specialized cognitive walkthrough” and a group of Gender Mag personality within the five factors in problem-solving approach: *Motivations*, *Information Processing Styles*, *Computer Self-Efficacy*, *Attitudes toward Risk*, and style of *Learning* new technologies [22].

The present article's goal is to test which type of intervention (Gender by Numbers: conscious or Riddle Me This QR: unconscious) has the demonstrated potential to change stereotypes views on occupation and gender. We predict that Riddle Me This QR that interacts with our unconscious mind would indicate a change in the stereotype views on occupation and gender. For this purpose, we conducted a study with forty-five students to interact with one of the prototypes that will be better explained in the next section.

3 Prototypes

In this study, two prototypes were developed centered on our conscious (Gender by Numbers) and unconscious (Riddle Me This QR) mind. Our aim is to explore how a

combined environment (physical and virtual) can facilitate a clear reflection of the uneven number of genders, through statistic (Gender by Numbers) or the answer to a riddle (Riddle Me This QR).

3.1 Measurement of our conscious and unconscious mind – IAT

As we were interested in one of the topics: Gender - Science (generally associating liberal arts with females and science with males), we reproduced that topic to create a measurement of our conscious and unconscious mind (IAT) about two departments currently available in our hometown University: Exact Sciences and Arts and Humanities. We transformed the eight words [24] into five words to assimilate the degrees available in our hometown University. The five Exact Sciences words (biology, biochemistry, economics, engineering and mathematics), the five Arts and Humanities words (culture, education, communication, languages and psychology), have the equivalent number of female and male gender words; five male gender words (father, uncle, man, grandfather and son) and five female gender words (mother, aunt, woman, grandmother and daughter). Both projects have the same instructions; a computer with a keyboard is needed; the “E” key should be pressed to associate to the group on the left side of the screen and the “I” key for the group on the right. The project is composed of seven parts, only two parts are important to measure the stereotype - part 4 and part 7 – with the rest being mainly for practice (see Appendix A).

The purpose of this project is to measure the time participants take to associate engineering/male and engineering/female, as well as their counterparts, humanities/female and humanities/male. Each word appears 500 milliseconds after interacting with a key, registering the time the user takes to press the correct button (time in milliseconds) and the number of mistakes the user makes. After part 7, the participant's time is calculated by the difference between the time for Engineering/Male against Engineering/Female. At the end of the IAT, the participant is presented with four questions (based on Project Implicit [24], see Appendix B). All the information was saved in a text file.

3.2 Gender by Numbers - conscious

Gender by Numbers has been recreated based on [18] with the data from our home country. From 1063 degrees, we created 23 names to use as tags (based on the areas established by the Education/Training and Course Area [25]) for example, for the degree Computer Science, we had the name Engineering and Related Areas and 2 tags for sex. All we needed was to associate each tag with the amount of data for each institution. A raspberry pi three and the Phoenix MFRC-522 RFID tags used as the physical environment to show the data in the virtual environment, screen. To interact with the prototype, the user only had to choose a tag corresponding to a course and a tag corresponding to their sex to see the numbers. (See Fig. 1).

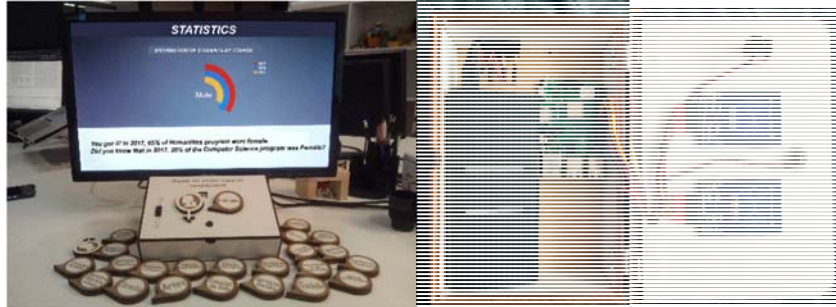


Fig. 1. On the left the interface of Gender by Numbers, with the example of the number of male students' applicants in the area of Humanities. The inside of Gender by Numbers. In the middle, we can see the power bank connected to the raspberry pi 3, and on the right, we see the back part of the tag readers.

3.3 Riddle Me This QR – unconscious

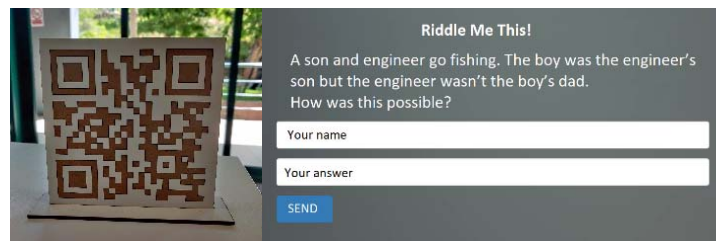


Fig. 2. The two components of Riddle Me This QR. To visualize the riddle, participants had only to access the wifi connection created by the raspberry pi and scan the QR code to access the riddle.

Riddle Me This QR was inspired by [16] but with a different implementation, using QR codes to transmit the riddle. A QR (Quick Response) code is a form of barcode that allows us access to a web information, in this case, a riddle (see Fig. 2). The information of the riddle is stored in the previously mentioned raspberry pi. The QR code generator was used to open a website where the riddle is shown – through the raspberry pi [26]. All answers and participants' names were saved in the raspberry pi.

4 Method

Our study aimed to answer the following questions: *Can the mindset of gender bias of students be changed with technology? Which type of intervention (Gender by Numbers or Riddle Me This QR) has the demonstrated potential to change stereotypes views on occupation and gender?*

4.1 Design

Forty-five students at the local high school (15 female, Mage=16.71, SDage=0.99) participated in this study (15 students for each experiment). The study used a between-participants design with a control group (just waits), experiment 1 (Gender by Numbers) group, experiment 2 (Riddle Me This QR), registering the time they took to complete the IAT (milliseconds) and their responses to the explicit test serving as the dependent variables. The study is composed by: (a) IAT, (b) Interaction with one of the prototypes (A or B) or just wait (each with 15 minutes), (c) IAT.

4.2 Procedure

Before the study, students were asked to take home a written consent form for them and their parents to sign. On the day of the study, students were randomly assigned to three groups: the control group, the Gender by Numbers group and the Riddle Me This QR group. The experiment consisted of three phases. In the first phase, the student had to do the IAT. In the second phase, the student had to interact with one of the prototypes with a maximum duration of 15 minutes: In experiment 1 (Gender by Numbers), students participated together (based on the fact that when a group of people cooperate among themselves their efficiency is greater than working alone, especially if there are of opposite genders [15]). Interacting with the pieces, to see the real numbers of each course. In experiment 2 (Riddle Me This QR), students interacted with the riddle individually (to learn by themselves about the stereotypes). Finally, in the third phase the student does the IAT.

5 Results

The times of the measurements for the three studies are shown in Table 1. The best result outcome would be in the intervals of -5 to 5 seconds, i.e., take for example in Table 1, in the control group, the number -12.14 means that the students took 12 seconds more on average to associate engineering/female than to associate engineering/male. While if the number were positive, the opposite would happen, on average, the students would have taken 12 seconds more to associate engineering/male than associate engineering/female. As said before the intervals between -5 to 5 are the best outcome as they would associate to any professions as female or male occupation.

Table 1. The average times in seconds for each group in the pre-study, post-study and its difference.

	Pre-study	Post-study	Difference
Control Group	-12.14	-11.41	0.73
Gender by Numbers	-3.69	-8.25	-4.56
Riddle Me This QR	-10.37	1.44	11.80

Table 2. The average time in seconds of each in the pre-study and post-study and its difference in the engineering/male on the left and engineering/female on the right.

<u>Engineering/Male</u>	Pre-study	Post-study	Difference	<u>Engineering/Female</u>	Pre-study	Post-study	Difference
Control Group	42.54	36.37	-6.17	Control Group	54.68	47.78	-6.90
Gender by Numbers	52.96	50.24	-2.72	Gender by Numbers	56.65	58.49	1.84
Riddle Me This QR	54.51	57.75	3.24	Riddle Me This QR	64.88	56.31	-8.57

In the control group, there was not much difference, improving their times by only 1 second. In Gender by Numbers, there was an increase by almost 5 seconds, and finally, in Riddle Me This QR, we see a very significant improvement, by almost 12 seconds. Table 2 presents the analysis regarding the engineering/male and engineering/female. With this separation of engineering/male and engineering/female, we better analysed the reason for the previous results (Table 1). In Table 2 on the left, we see that in the control group and the Gender by Numbers group, the average times decrease, this was not observed for the Riddle Me This QR. In Table 2 on the right, the same happens with the control group, decreasing their times as the Riddle Me This QR group, with an improvement of 9 secs.

A Mann-Whitney test was conducted to analyse if there was any difference in the post-study. In the unconscious measure, the times associating engineering/male of the control group (Mdn=36210 milliseconds) were significantly less than those in the other two groups after interacting with the Gender by Numbers (Mdn=48945 milliseconds) $U=49$, $p=0.008$, $r=-0.481$ and Riddle Me This QR (Mdn=47790 milliseconds) $U=46$, $p=.005$, $r=-0.504$. However, only between the experiences was found a significance for the conscious measure, specifically in the third question (“Do you associate engineering to female or male?”). In experiment 1 (Gender by Numbers), students were associating engineering/male (Mdn=3), while in experiment 2 (Riddle Me This QR), they were associating engineering/ female (Mdn=4) $U=55$, $p=.016$, $r=-0.456$.

Analysing the groups individually, the pre-test and post-test with a Wilcoxon Signed Ranks Test, we found that in the control group, the times in engineering/female was compared with the times in engineering/male, the pre-test and post-test. In the pre-test, milliseconds were significantly higher on engineering/female (Mdn=51577 milliseconds) than on engineering/male (Mdn=42062 milliseconds), $T=14$, $p=.009$, $r=-0.675$. The same happened on the post-test, the times in milliseconds were significantly higher on engineering/female (Mdn=44850 milliseconds) than on engineering/ male (Mdn=36210 milliseconds), $T=15$, $p=.011$, $r=-0.66$. For the experiment groups, no significant difference was found for the times they took to associate engineering with females or engineering with males. Nor was the significance found between the explicit questionnaires.

6 DISCUSSION

Our study addresses whether any of the interventions (Gender by Numbers or Riddle Me This QR) shows the potential to change stereotype views on occupation and gender. For this purpose, we collaborated with a high school to interact with their students to answer this question. Our results showed that for the unconscious measure, the students in the control group in the post-study were significantly faster-associating male/engineering than the other two groups (Gender by Numbers and Riddle Me This QR). By analysing the difference between the pre-study and post-study, we can see the effects in implicit measure, while in the control group, the difference is small, in the experiments group, we can see a much larger difference. In the Gender by Numbers, by showing the real numbers of engineering application, it reinforced the mentality that only men should pursue engineering. While in Riddle Me This QR, the opposite happened, the mentality that a woman can pursue engineering appears to be started to get noticed. In the conscious measure, only a significant association was detected between the two experiment groups (Gender by Numbers and Riddle Me This QR). That association was found on the third question (“Do you associate engineering to female or male?”). While in one experiment, an association of engineering/male was detected (Gender by Numbers), in the other (Riddle Me This QR), the opposite was detected, an association of engineering/female. This difference can be explained because each experiment highlights a different part of our mind (unconscious and conscious). While Gender by Numbers highlights the present situation, as there are more men than women in engineering areas, Riddle Me This QR highlights that male are not the only ones that can pursue engineering.

7 CONCLUSIONS AND FUTURE WORK

Tonso and Adichie tell us about their view on what was happening with women and engineering, the very low enrolling numbers, perpetuating it as a male career [27], [28]. High school students used one of the two prototypes mentioned above to visualize which had the demonstration potential to type views on occupation and gender. Both interventions raised interest and curiosity among students. This study suggested that Riddle Me This QR has the potential to drive the change in stereotype views, and the next moves are the individuals' desire or motivation to change. We believe that the use of technology to make the bias salient is a promising new direction for that end. Future work will explore a new prototype that combines the two presented prototypes to combine the best of the two approaches - the numbers and the riddle, the conscious and the unconscious.

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