How the perception of female students of people interested in mathematics influences their willingness to pursue mathematics in future study and career

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Abstract

Studies and careers with a high level of mathematics are still dominated by males; the current male stereotype of mathematicians is often proposed as a cause of this. In order to better understand the current stereotype in terms of gender, we used the Traditional Masculinity-Femininity (TMF) Scale. 129 students of two high schools were asked to fill out how they would rate themselves and people interested in mathematics on a femininity-masculinity scale and what their future plans were with respect to mathematics. We found that males, who more inclined to identify with the stereotype they had, were more likely to pursue a career with a high level of mathematics, but for females this effect was not seen. The TMF questionnaire was followed up by semi-structured interviews with three female high school students to understand how aspects other than gender influenced their view on people interested in mathematics. The main finding was that, even though the stereotype they had was male, the general personality traits they linked to a person interested in mathematics were more of influence on their future decisions than the gender of the stereotype. They perceived people interested in mathematics as plain and boring and therefore did not want to join this group.

Introduction

Female are getting driven away from careers with a high level of mathematics, this is sometimes compared to a *leaking pipeline* (Makarova, Aeschlimann, & Herzog, 2016). The *leaking pipeline* results in an international underrepresentation of women in mathematical careers for different reasons than mathematical talent, skill and abilities (Kahn, & Ginther, 2017). The gender difference in career domains is to this day present in the Netherlands as well. Males are dominating the Science, Technology, Engineering and Math (STEM) careers, while women are dominating the Education, Health and Welfare (EHW) careers (Onderwijsraad, 2020).

Various studies have suggested that the current strong masculine image of mathematicians plays a role in the lack of females in career paths which need a high level of mathematical knowledge (Kahn, & Ginther, 2017; Makarova, Aeschlimann, & Herzog, 2019). The highly male stereotype of science in general causes girls to develop in fields where they can more easily identify with, like language or social skills (Lazarides, & Lauermann, 2019; Carador, Damian, & Wiegand, 2020). The male stereotype causes a loss in motivation for science in females (Dietrich & Lazarides, 2019). Overall, male stereotypes tend to drive away girls from mathematics even when they would be skillful enough.

Since the male stereotype in the STEM field is driving competent women away, a stereotype change is needed. A proposed solution has been to present feminine role models to girls through media (21st Century Fox, Geena Davis Institute on Gender in Media, & J. Walter Thompson Intelligance, 2018; Geena Davis Institute on Gender in Media. (n.d.)). Unfortunately, presenting feminine role models does not always seem to have the desired outcome. In contrast, highly feminine role models seem to demotivate girls in STEM areas, since most women cannot identify with those either (Betz & Sekaquaptewa, 2012). Instead, when female students are confronted with similarities between men and women, they express stronger motivation to get involved in STEM-related activities than when they are confronted with gender differences (Jasko, Dukala, & Szastok, 2019). So, the characteristics of a role model presented might actually matter more than the gender of the role model.

Not any female role model has the potential to change the existing male stereotype in mathematics, but the way of identification with a role model is of huge influence for women. In this paper, we explore the nature of a role model where women interested in mathematics can recognize themselves in. Our research purpose is to understand the characteristics of such a role model that motivates females study mathematics at university and thus enter a mathematical career domain. Therefore, the focus of this research study is on how females view themselves with respect to current societal and personal stereotypes of people interested in mathematics.

Literature research

First, we should explore the existing image of people interested in mathematics. Early research from 1980 already mentioned that high school and college students described mathematicians as rational, wise, responsible, and cautious. These characteristics are typically linked to males. This difference between mathematicians and self between females and mathematicians was linked to a loss of interest in mathematical fields (Brush, 1980).

More recent research by Epstein et al. (2010) showed that mathematicians are presented as mad, mostly male and almost invariably white. People who are interested in mathematics are also described as eccentric, elite and geeky. A possible reason is that mathematics in itself can come across as a secret code language, that is difficult to understand, and therefore, people who do understand it should be either mad, magical or highly intelligent (Epstein, Mendick, & Moreau, 2010).

In order to ever change a stereotype, awareness of the origins of current stereotypes is needed; parents, teachers and culture are of most influence (Kahn, & Ginther, 2017). Parents and teachers can influence their children with their own stereotypes. When they believe that boys are better in mathematics than girls, boys are more likely to think that they are capable of mathematics themselves. As a direct effect, teachers and parents may help boys more than girls with their math problems. This may guide them through their decision-making process in future careers; finally leading to more boys in mathematics and therefore confirm the existing ideas about male dominance (Kurtz-Costes, Rowley, Harris-Britt, & Woods, 2008).

Another way current stereotypes are disseminated is through cultural representation; for example through media. Girls who watch more programs with leading female scientists seem to believe that they are more capable in doing science themselves (21st Century Fox, Geena Davis Institute on Gender in Media, & J. Walter Thompson Intelligance, 2018). Not only the representation of mathematicians is important, but also the representation of mathematics as a difficult subject can be a cause for people to distance themselves from a university study and a career in mathematics (Epstein, Mendick, & Moreau, 2010).

In order to assess the characteristics and gender of people interested in mathematics, various research instruments have been used in the past. Already, in research from 1960, stereotype of mathematicians with respect to career was investigated. In a research study of this era participants were asked to rank mathematicians on a 7 point scale of semantic differential items (Brush, 1980). Future research on the characteristics of mathematics has often followed a similar research strategy. The disadvantage of using such a list of characteristics is that it is hard to determine if all possible characteristics are covered in a single list of questions. Especially since culture and time can be an important issue in determining suitable characteristics.

Next to characteristics, stereotypes of mathematicians have been discussed with respect to gender. There are various research instruments that have been used for this. For example, the *Draw-A-Scientist Test* (DAST), where a person is asked to draw a scientist and conclusions can be based on this. An example of a study using this method is Picker and Berry (2000), in which the researchers found that twelve- and thirteen-year-old students almost exclusively drew males when asked to draw a mathematician. Another often used research instrument is the *Implicit Association Test* (IAT), which asks a participant to choose if certain math-related topics are considered masculine or feminine based on implicit associations the participants have (Makarova, & Herzog, 2015).Such methods have a disadvantage that the gender is mainly seen in terms of male and female, instead of seeing gender on a spectrum. Thus understanding of characteristics of a potential role model is compartmented.

Previous research has stressed the importance of masculine and feminine personality traits for understanding the gender gap in STEM careers, in ways that are more nuanced than the existing literature on this topic suggests (Makarova, Aeschlimann, & Herzog, 2016).In order to find a research instrument that accurately measures masculinity and femininity, it is important to understand the current view on gender. The concept of gender has been first introduced in the 1970s, but the view on it has changed since then. Femininity and masculinity were originally seen as two opposing entities, where for example characteristics like athletic and powerful were seen as masculine. Later on, the idea that those characteristics were per definition masculine changed to the idea that gender expression is learned (Smiler, 2004).

The *Traditional Masculinity-Femininity Scale (TMF)* (Kachel, Steffens, & Niedlich, 2016) is a validated research instrument that proposes a way to measure gender on a spectrum. It could therefore be a useful instrument to identify a stereotype about people interested in mathematics. It is a 7-point-scale (from highly masculine to highly feminine), on which participants can indicate how feminine or masculine somebody thinks their own ***interest, attitudes and beliefs, behavior and outer appearance*** would traditionally be seen (Kachel, Steffens, & Niedlich, 2016). Scaling these four characteristics, instead of asking precise questions (for example, "how often do you wear pink?"), lets respondents compare themselves to the rest of any society. This makes sure that the instrument is applicable within different cultures and time periods. In other words, the results of the TMF shows how people contemplate they relate or conform to social standards (Kachel, Steffens, & Niedlich, 2016).

The TMF scale has not been used as an instrument to measure femininity and masculinity in mathematics yet. But some of its aspects have been investigated in earlier research with respect to masculinity and femininity. We review the literature aiming at reporting how people interested in mathematics can be described with respect to interest, outer appearance, behavior and attitudes and beliefs.

First, math is considered a masculine ***interest*** (Koenig, 2018); so, an assumption might be that females who are willing to pursue a career in mathematics would rate their interests as more masculine. For ***outer appearance***, in general, women with a feminine appearance are deemed less likely to be scientists (Bancherfsky, Westfall, Park, & Judd, 2016). So, there is a stereotype that women in science are not dressed femininely. Therefore, we expect to find that females willing to study mathematics at university and pursue a mathematical career are likely to confirm this stereotype, and see themselves as having a less feminine appearance. A DAST study done among Mexican students showed that almost all students thought that mathematicians were either dressed formally or casually. So, for Mexicans, the outer appearance might be considered more neutral instead of masculine (Aguilar, Rosas, Gabriel, Zavaleta, & Romo-Vázquez, 2016).

In terms of **attitudes and beliefs**, there is an indication that young girls already seem to be believe that their femininity cannot co-exist with an interest in science. A case study of Carlone et al. (2015) found that there was no room to be both "girly" and "scientific". A data analysis, also part of the study of Carlone et at. (2015), showed that girls of ages 9 to 13, who were initially successful in their science education, found balancing their performances of femininity with their performances of science increasingly difficult. They, as a result, decided to focus on their femininity as opposed to their scientific career.

With respect to mathematics, gender and **behavior,** Warrington and Younger (2000) concluded that, in year 11 of the English school system, boys' aggressive behaviour in the classroom discouraged girls from fully participating. As a result, teachers tended to have lower expectations of their female

science students. Physicist Howard Georgi (2000) contended that mathematical sciences such as physics reward assertive, instrumental personality types, and, therefore, discriminate against women (Aguilar, Rosas, Gabriel, Zavaleta, & Romo-Vázquez, 2016).

In summary, the following research question will be central in this research: *To what extent does the masculinity/femininity measured on the TMF scale of Dutch high school students of age 16-18 and their stereotypes contribute to the likeliness of them in continuing studies and career with an emphasis on mathematics? And how can role models change this stereotype to the extent that feminine women feel welcomed in careers with a high level of mathematics?*

In this study, stereotype is considered as the current image a person has of people interested in mathematics. Furthermore, a role model is regarded as a person that is interested in mathematics and may be able to change the current stereotype about male dominance.

In other words, we aim to understand the male stereotype of mathematicians and how this differs from the self-image females have in order to provide insight into future role models for women. Specifically, we ask the following research sub-questions:

- What is the representation of self in terms of masculinity/femininity per gender?
- What is the representation of a mathematician in terms of masculinity/femininity per gender?
- How does the current image of self differ from the image of a mathematician in terms of masculinity/femininity in the characteristics of outer appearance, interest, behavior and attitudes and beliefs?
- Are future study plans influenced by certain characteristics of the representation of self in terms of masculinity/femininity per gender? How?
- Which people currently influence the image a person has of somebody interested in mathematics?
- Could female students be able to change their current image of a person interested in mathematics when they are faced with another image than their stereotype?

Methodology

This is a mixed-method study. First a quantitative part; a questionnaire based on the Traditional Masculinity and Femininity scale (*TMF scale*) (Kachel, Steffens, & Niedlich, 2016). The questionnaire was filled in by 137 high school students from two different high schools of a city in the east of the Netherlands. The students took the questionnaire a few weeks before they were going to take their final high school exams, after which they would be able to go university. The questionnaires were followed by a qualitive research; three female participants of the questionnaire were selected for an interview in order to gain insight in why certain females are not willing to follow a study with mathematics.

Quantitative data collection: the questionnaire

The questionnaire is based on the questions of the TMF scale as proposed by Kachel et al. in 2016. The existing TMF questionnaire asked participants to rank themselves on a 7-point-scale (from highly masculine to highly feminine) on various topics. The accuracy of this questionnaire was found to be 97% (Kachel, Steffens, & Niedlich, 2016).

Since the TMF scale has not been used for an indication of stereotypes and was not tested with the age group of high school students, some interviews were held before distribution of the questionnaire in this study to make sure the data collected was valuable for the goals of the research.

Before sending the questionnaire to the students, a female math teacher of a Dutch high school was asked to check whether the questions were understandable for students at Dutch high schools. She made some suggestions on the wording, mainly because some clarity had been lost in translation from English to Dutch. Additionally, this teacher has worked at one of the schools were the questionnaire was distributed and helped distributing the questionnaire to other schools.

Next to this, a focus group interview was held with four female students of a master's in applied mathematics in the Netherlands. The goal of this interview was to detect if the questionnaire was a valuable instrument to identify the gender of people interested in mathematics. The meeting was set up in such a way that these mathematicians were asked to fill in the questionnaire and the questionnaire was discussed afterwards. The mathematicians were asked on the assumptions they had to make in order to answer the questions and whether the questions were understandable. Their answers showed that the questionnaire was set up in a way that the questions seemed to be about female mathematicians only, instead of people interested in mathematics in general. Therefore, after this meeting the order of the questions was changed.

Next to this, the focus group also emphasized the need of collecting data from males and females, since they thought male mathematicians were not necessarily very masculine in the aspects discussed by the TMF scale. They therefore proposed that a comparison between males and females was needed to give a broader image.

On top of the two interviews, meetings with the supervisor were held to make sure that all questions would be valuable with respect to the research question. She provided useful information on the questionnaire components, wording and order of the questions.

Six teachers of different high schools in a city in the east of the Netherlands were approached via a videoconference and later through mail. The teachers were asked to hand out the questionnaire in their classes and to their colleagues. The referencing from one person to the next in order to create a sample is referred to as *snowball sampling* (Denscombre, 2017). While the sampling of a specific group as representation of a bigger group is referred to as *cluster sampling* (Denscombre, 2017). In

this case, this approach was selected since asking an entire high school exam group to make sure that there is no bias in the selection (Denscombre, 2017). The files and mail sent can be found in appendices 1.1, 1.2 and 1.3 (Dutch) and 2.1, 2.2 and 2.3 (English). At four of six schools, the teachers eventually did not hand out the questionnaire, even after sending them reminders through mail.

Finally, we got, 137 responses of two different schools. 6 did not agree with the consent form and 2 responses were not taken into account since the answers given were incomplete. So a total of 129 questionnaires were used for analyzing. Of the responses, 59 identified as male and 69 as female, 1 person did not identify as either. 55 of the respondents were going to do exam at HAVO level and 74 at VWO level. HAVO students are prepared to go to a university of applied sciences, while VWO students are prepared to go to a research university after their high school graduation. Of the 129 responses two third (86) already knew exactly what study they were going to do after their graduation. The latter shows that the students are indeed thinking about their future study and careers around their final exams at high school.

Quantitative data analysis

In research of Neuhaus (2018) on gender and interest, a self-to-prototype score has been introduced. This score was used to represent the difference in how a person sees themselves compared to prototype they thought fitted a certain coding class.

Based on this, we introduced a self-to-stereotype score for this research. This self-to-stereotype is the difference between how a person views themselves compared to how they view a person interested in mathematics. in the case of TMF this is the difference between two scores of 1 till 7. Therefore the self-to-stereotype score is a number between 0 and 6.

For example, if a girl indicates that the outer appearance of a male is very masculine (7) and they see their own outer appearance as very feminine (1), the self-to-stereotype score of this person's outer appearance is 6, indicating that the stereotype that this person has of a mathematician does not line up with how this person sees themselves.

From this, we can conclude if there is a significant difference between the self-to-stereotype score in males and females using the Wilcoxon rank sum test. The Wilcoxon rank sum test is used to test if th e medians of two samples are comparable (Zulfiqar, & Bhaskar, 2016).We also used Cronbach alpha to measure internal consistency in the questionnaire.

Since we do not only want to know if there is a difference in stereotype in males and females, but als o if this influences a person's willingness to choose a study or career with a high amount of mathem atics, we also performed a linear regression analysis between the self-to-prototype score and the pe rcentage of mathematics a person is willing to do in the future.

All data-analysis was done using R studio.

Qualitative data collection: Interviews

After the quantitative data analysis, semi-structured interviews were held to gain a deeper understanding of why females are not willing to follow a study with a high level of mathematics. We tried to find what the current view they have of people interested in mathematics is, in what aspects they do not identify with them and how this influences their study decisions about their future. The three participants were chosen via *purposive sampling;* handpicking participants for the topic (Denscombre, 2017). We wanted to find females who viewed people interested in mathematics as more masculine compared to feminine (*mean TMF score of mathematician of 4.67*) and themselves as more feminine than masculine (*mean TMF score of self of 2.06*). Also, the participants were not

willing to do more than 10 percent of mathematics in their future study or career. Six people fulfilled this need and were asked to be interviewed, three replied that they wanted to participate.
Not by design, but by chance, all participants went to the same school and were all doing VWO exam in mathematics A. VWO is the theoretical high school education preparing students for university. Mathematics A is the branch of mathematics designed to focus on the practical aspect of mathematics.

Before the interviews, the participants were asked to make a sketch of somebody who influenced their image of what a person interested in mathematics looks like. They were asked to sketch this person taking into account his/her behavior and outer appearance. This is based on the *draw a scientist* approach and was used as a basis to explore how the participants viewed a person interested in mathematics.

The interview questions were used to further understand the participants' view on the characteristics of the TMF scale and their overall gender. They were asked to describe a person interested in mathematics on these characteristics and compare it to themselves. Furthermore, they were asked to describe if these differences influenced their own view on mathematics and whether it influenced future career choices. Lastly, the interview explored if a figure challenging the current stereotype could change the motivation on pursuing a career with more mathematics. This was done by directly asking for it but also by presenting the participants with a mathematician who does present as feminine by current views (female, long hair, painted nails).

Qualitative data analysis

After the data collection, the interviews were transcribed using the software of Amberscript. The transcripts of the interviews were color coded, based on deductive coding (i.e., gender, outer appearance, behavior, interest, attitudes and beliefs) and inductive coding (i.e., people of influence of current image of a person interested in mathematics and possibility to change current view*)*. We then explored commonalities and differences in content across all coded excerpts from the interviews. Finally, we produced the analytical narrative with data excerpts and related the findings to existing literature.

Results

Questionnaire results

Reliability and validity

Reliability

The reliability of the TMF scale found by original literature was high (*Chronbach α = 0.94*). In this research we found a *Chronbach α* of 0.9787, meaning that the internal consistency was high. Different from the original research, removing a question would improve internal consistency, but only slightly.

The TMF scale has not been used or proposed as measurement to identify other people. Therefore, we have to question whether it is a suitable approach. The *Chronbach α* for identifying mathematicians was 0.8508. In the method we noted that in order to alter the TMF scale to identify the mathematicians, a question had to be removed. Most likely the loss in reliability is caused by the renewed purpose of the questionnaire, because the *Chronbach α* of was similar to 0.9728, so only slight less reliable. Since a reliability of 0.8508 is still acceptable, we will view the results of this research quite reliable, but for future research on this topic, a different approach might suit better.

Validity

The TMF scale for self-identification on gender identity has been found suitable by comparison to previous research on gender identity and has therefore been validated enough for the purpose of this research (Kachel, Steffens, & Niedlich, 2016).

The altered TMF scale for people interested in mathematics has not been used before. Validation by comparison to previous research is needed, were the main focus will be on whether the scale captures the current masculine character of people interested in mathematics. The average view of a person interested in mathematics based on the TMF scale is summarized in the following table:

	Males	Females	Total
Behavior	4.305085	4.391304	4.348837
Interest	4.389831	4.246377	4.310078
Attitudes and beliefs	4.423729	4.449275	4.434109
Outer appearance	4.627119	4.405797	4.503876

Table 1: View of a person interested in mathematics

Notable is that all scores are above 4, meaning that all single aspects of a person interested in mathematics are considered more masculine than feminine. Out of all 129 responses, only 4 females and 2 males viewed a person interested in mathematics as more feminine than masculine. Therefore, the proposed TMF scale for people interested in mathematics indeed shows the masculine stereotype found in earlier research.

Also, no significant differences found in how males and females see people interested in mathematics in terms of masculine/feminine on average (*Wilcoxson rank sum test, p-value = 0.7878>0,05*). Therefore, we view the TMF scale as a useable tool to identify a person interested in mathematics with.

A last thing to check is the usefulness of the self-to-stereotype score. In line with earlier research, we hoped to find that people with a lower self-to-stereotype score are more likely to pursue a career with a high percentage of mathematics, since this would confirm that the self-to-stereotype score correctly represents a measure of how well a person is able to identify with how this person views people interested in mathematics.

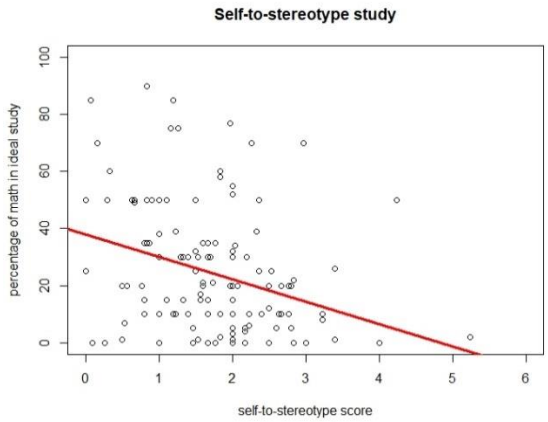

Figure 1: self-to-stereotype score plotted against the ideal percentage of math in future study

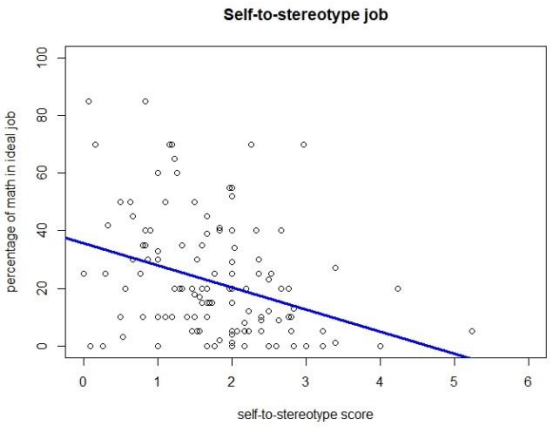

Figure 2: self-to-stereotype score plotted against the ideal percentage of math in future job

In the given plots, we have plotted the self-to-stereotype score against the percentage of mathematics a person is willing to do. The linear regression line shows that, on average, a person with a low self-to-stereotype score is more likely to pursue a study or career in mathematics. In other words, the self-to-stereotype score correctly represents that people who are more able to identify with a person interested in mathematics are more likely to pursue a study with a high amount of mathematics. Therefore, we expect that results drawn based on this score will be correct.

Overall the methods seem to have provided us with useable data.

Identification and gender

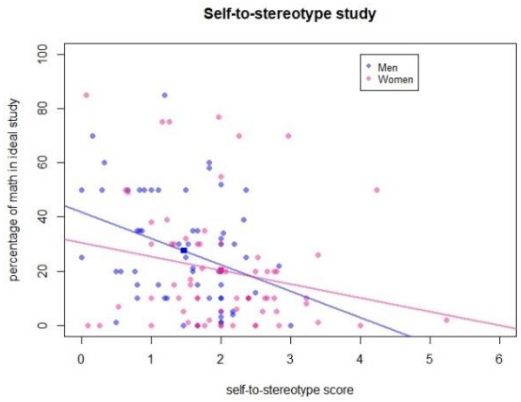

Figure 3: self-to-stereotype score plotted against the ideal percentage of math in future study per gender

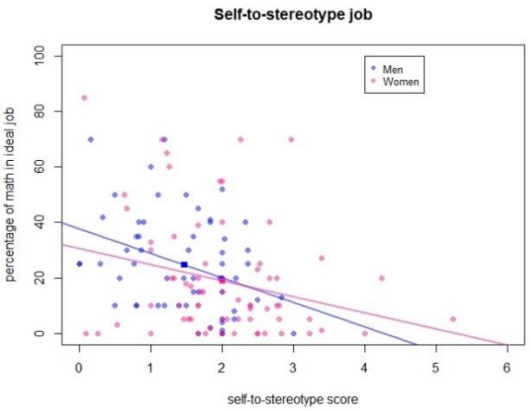

Figure 4:self-to-stereotype score plotted against the ideal percentage of math in future career per gender

First, we have split out the self-to-stereotype score by gender and plotted the regression line belonging to it. The colored squares represent the respective average scores. The linear coefficient of men (*-9.756*) compared to women (*-5.064*) show that the influence of whether a stereotype of a person fits the image of self on the amount of mathematics a person is willing to do in the future, is currently bigger in men.

Unlike what we expected, the gap between gender in mathematical job seems to be smaller than the gap between gender in mathematical studies. There are various possible explanations, one being that there is indeed a change going on with respect of females in mathematical jobs. Another

explanation is that the exam students are not fully aware of the amount of mathematics in their future job. Therefore we decided to focus on analyzing the study results.

Per characteristic

The goal of this research was to determine which of the four characteristics, *behavior, interest, outer appearance and attitudes and beliefs* is the strongest contributor in order for females to determine if they want to have a high amount of mathematics in their future studies.

Therefore, we calculated a self-to-stereotype score for each of these characteristics as identified by the participants of the questionnaire. The self-to-stereotype score is calculated as the difference between a person's view of themselves and a person's view of person interested in mathematics on the 7-point TMF scale. For example, a certain person identifies their own behavior as very feminine (1), and the behavior of somebody interested in mathematician as masculine (6). The self-to-stereotype on the aspect of behavior is 6-1=5.
If the self-to-stereotype is 0, the person sees themselves the same as a person interested in mathematics on this aspect, if the score is 6, the person sees themselves very different from a person interested in mathematics.

In the following plots, we have first plotted the average self-to-stereotypes calculated with the average from the TMF. We then plotted the self-to-stereotype scores per characteristic. The trendlines of the plots are added to the average scores.

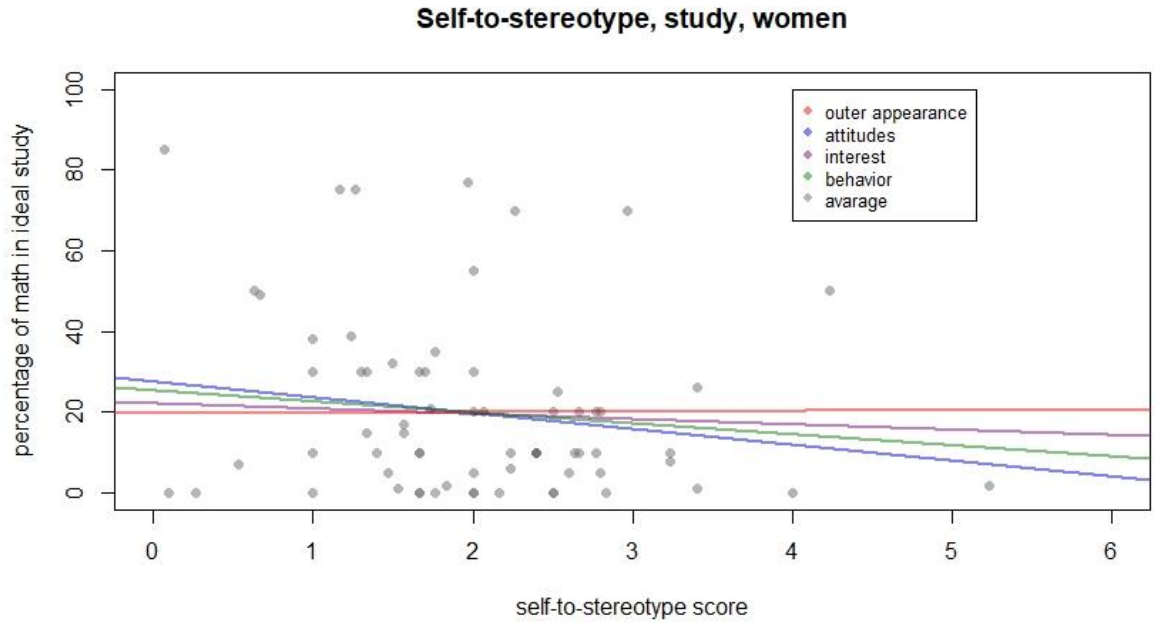

Figure 5: self-to-stereotype score of women plotted against the ideal percentage of math in future study, trendline per characteristic

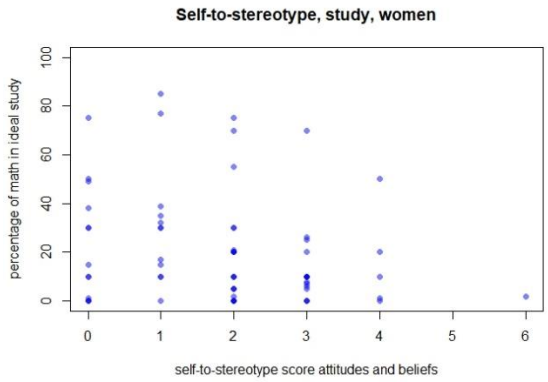

Figure 6: self-to-stereotype score of attitudes and beliefs for women plotted against the ideal percentage of math in future study

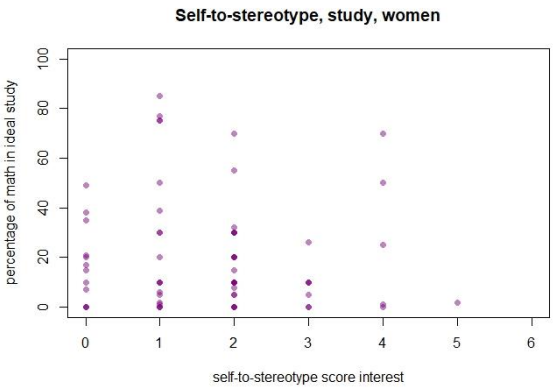

Figure 7: self-to-stereotype score of interest for women plotted against the ideal percentage of math in future study

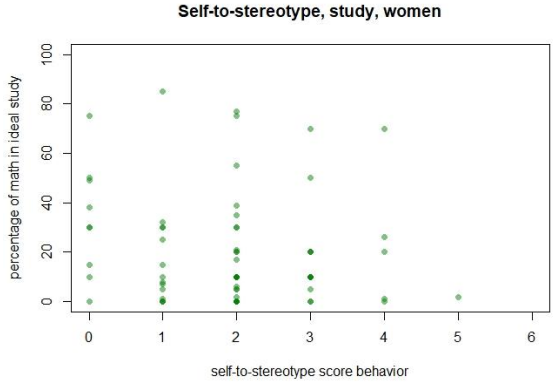

Figure 8: self-to-stereotype score of behavior for women plotted against the ideal percentage of math in future study

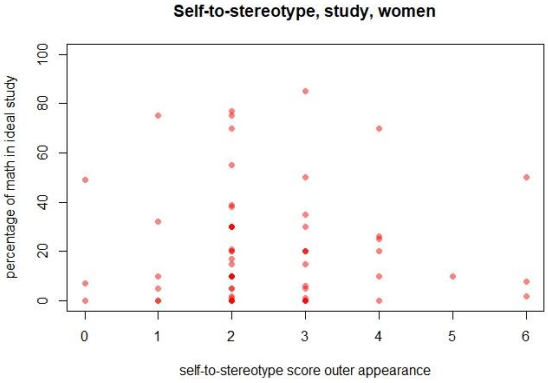

Figure 9: self-to-stereotype score of outer appearance for women plotted against the ideal percentage of math in future study

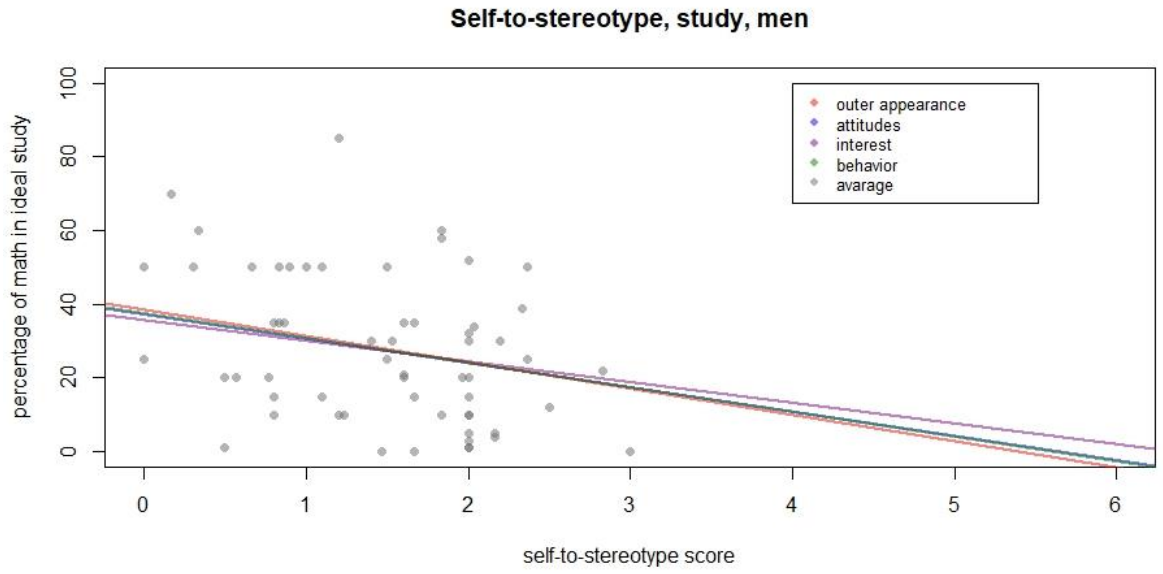

Figure 10: self-to-stereotype score of men plotted against the ideal percentage of math in future study, trendline per characteristic

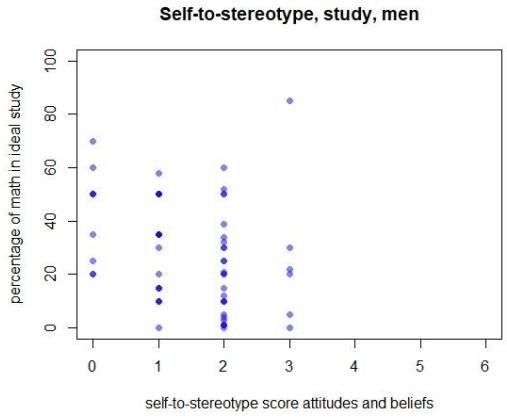

Figure 11 :self-to-stereotype score of attitudes and beliefs for men plotted against the ideal percentage of math in future study

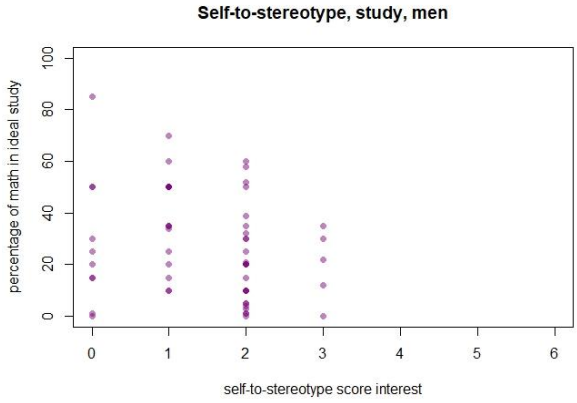

Figure 12: self-to-stereotype score of interest for men plotted against the ideal percentage of math in future study

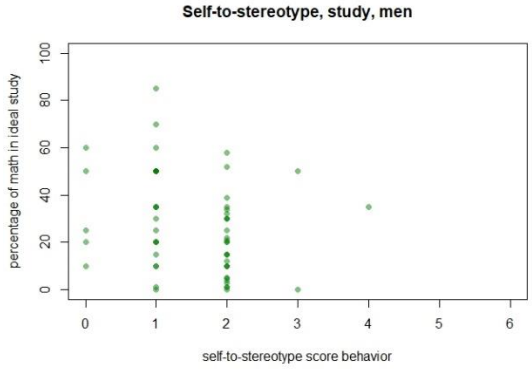

Figure 13: self-to-stereotype score of behavior for men plotted against the ideal percentage of math in future study

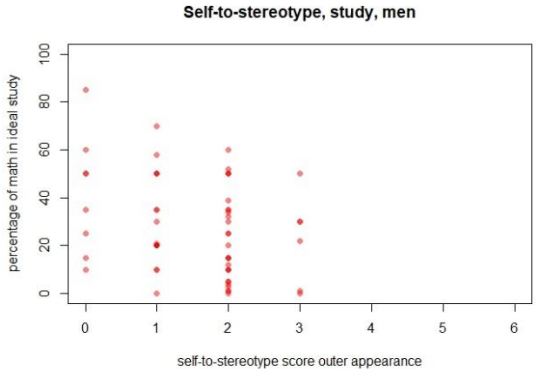

Figure 14:self-to-stereotype score of outer appearance for men plotted against the ideal percentage of math in future study

From these pictures we see that it seems that men are more able to identify with a person interested in mathematics, since the self-to-stereotypes are, with one single exception in behavior, bound by 3. While for all characteristics, there were six women (8.7%) who rated a score above 3, this were not necessarily the same women for all characteristics. The average self-to-stereotype scores of men are also bounded by three, while there are seven out of 69 (10.1%) women with an average self-to-stereotype scores higher than three.

The mean and variance of the average self-to-stereotype also suggest that men are more able to identify themselves with the current image they have of a person interested in mathematics. We conclude significant difference in self-to-stereotype between male and female participants (*Wilcoxson rank sum test, p-value = 0.001183<0.05*).

	Mean	Variance
Male	1.48	0.51
Female	2.01	0.88

Table 2: mean and variance of average self-to-stereotype score per gender

The regression line of the appearance of women is the only one having a positive (*0.178*) direction vector. Meaning that women who can identify with the outer appearance of somebody interested in mathematics are currently not more likely to choose a job with more mathematics. There are various ways to interpret this. A first possible explanation could be that women simply do not care very much whether they look like a mathematician. Another possible explanation is that women are so different from mathematicians that all women feel they cannot identify on this aspect at all. This second explanation would only make sense if the majority of the women would report a high self-to-stereotype score on outer appearance, and this is not the case.
Therefore, we conclude that women are not as much focused on outer appearance of a mathematician. This is a very interesting finding, since this could explain why the current focus on the representation of female looking role-models does not have the desired outcome in attracting women into mathematical job.

To determine which of the characteristic is most influential among the four points, we performed a *multiple linear regression (MLR) analysis.* With this we tried to determine which coefficients have the biggest contribution to the total self-to-stereotype score.

	Estimate Women	Estimate Men
Appearance	0.29431	0.15586
Attitude	0.16059	0.26887
Behavior	0.27383	0.27985
Interest	0.18046	0.32464

Table 3: coefficients of multiple linear regression on average self-to-stereotype score

From the multiple linear regression, we can conclude that appearance is the biggest contributor for woman's self-to-stereotype score, while it is the smallest for men. The fact that outer appearance is currently the biggest contributor for women might seem to be in conflict with the fact that we just said that appearance is not that big of an influence. This is no true. It just means that, of the four characteristics, appearance is the biggest contributor to the average self-to-stereotype score a person.

Notable, is that behavior is for both men and women the second biggest contributor and the extent to which it contributes is about similar for both sexes. It might therefore be interesting to focus on the behavior of role models in order to contribute to a change of the current stereotype, since the effect will be about similar for men and women.

It might seem strange that not all four aspects have an equal contribution to the self-to-stereotype score. This is because the self-to-stereotype score has been calculated based on the complete TMF scale, which also included questions on how a person views themselves and mathematicians in general. So, we could interpret the scores of the MLR as how the contribution is to what a person views themselves compared to how a person sees a mathematician.

So, in conclusion, women are mostly influenced by outer appearance when comparing themselves to somebody interested in mathematics. But they do not necessarily conclude from this that when they do not look like a person interested in mathematics in terms of femininity, that they do not want to pursue a career with a high amount of mathematics. In order to better understand the comparison females make between themselves and people interested in mathematics, we conducted interviews. In the next section we report results from an open-ended question of the questionnaire and afterwards the findings from the interview.

Analysis of the open-ended question

59 of the 129 people (*46%*) answered the open ended question about who has influenced their view of people interested in mathematics. The question was "*Is there anyone who has influenced your image of how a mathematician looks like (e.g. in terms of interest; attitudes and beliefs; behavior; outer appearance) such as a teacher, someone in your family or a friend?*"

12 students (*9 M, 3 F; average TMF self-score: 5,07*) answered that they could not name anybody who was of influence.

Even tough, we explicitly asked to answer based on the four characteristics, only a handful of respondents used any of these terms in their response. Therefore, an analysis on these characteristics would not be helpful. Instead, the answers have been analysed based on three main themes, namely; *gender, influence and nature of relation*.

Of the respondents, 30 (*14 M, 16 F; average TMF self-score: 4,00*) students reflected in their answer on the gender of a person who influenced them. Of these, 8 people (*3 M, 5 F; average TMF self-score: 3,46*) answered that the person who was of biggest influence to them is female or feminine and 18 people (11 *M, 7 F; average TMF self-score: 4,74*) said the person was male or masculine, 4 people (0 *M, 4 F; average TMF self-score: 2,21*) reflected on both genders. This shows that a majority (*60%*) of the students may visualize a male person when they are asked about a person interested in mathematics, agreeing with the literature.

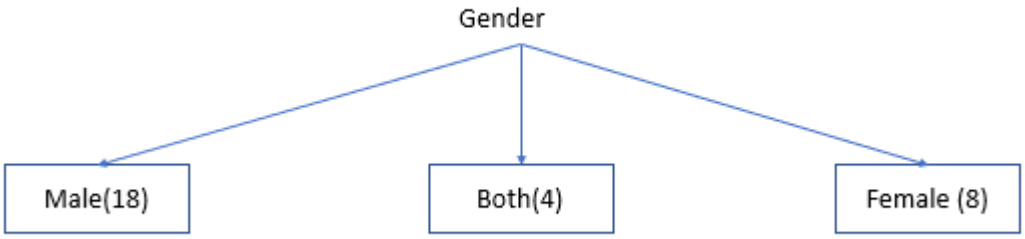

Figure 15: distribution answers open question labeled by gender

Even though the question did not ask about *how* a respondent was influenced by the person that was influential to them, various students reflected on whether they found mathematics more or less interesting because of their role model. When this role model caused a loss in interest or motivation

for mathematics, we will call the influence *negative*. However, when the role model caused an increase in interests or motivation for mathematics, we will call this influence *positive*.

Figure 16: distribution answers open question labeled by influence

There were 3 people who experienced a negative influence (*1 M, 2 F; average TMF self-score: 3,72*) and 8 who experienced a positive influence (*4 M, 4 F; average TMF self-score: 4,27*). So, both sexes seem to have both positive and negative influences.
But, since most of the interactions were considered positive, we could assume that a suitable role model might indeed increase motivation for mathematics. Since the influence of role models was not an objective for this research and only 12 people reflected on this, no valid conclusions can be drawn from this. Future research on what aspects of a mathematical role model leads to what influence might be useful in order to create better role models in the future.

Most importantly, we asked people to identify who influenced their image of what a person interested in mathematics looks like.

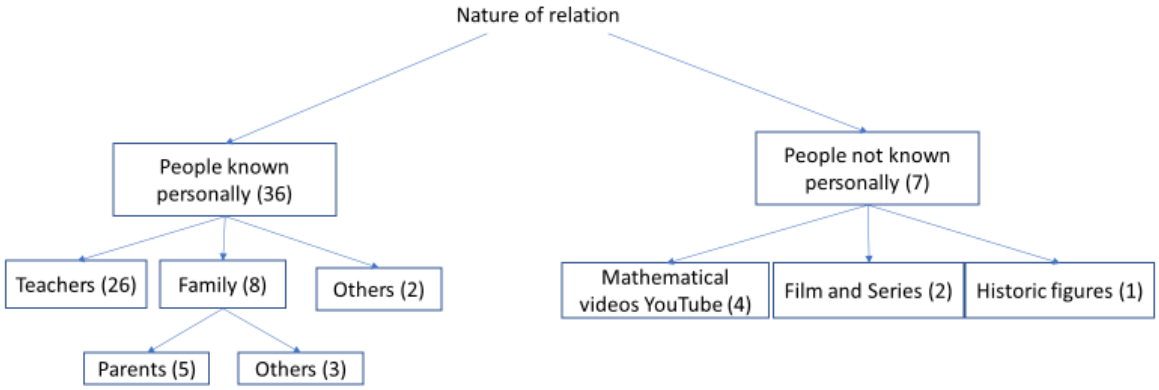

Figure 17: distribution answers open question labeled by nature of relation

It is interesting that most respondents reflected on a person they personally knew. We have to be aware that this effect could be caused by the fact that students had to fill in the questionnaire during a math class. So they might have thought about a teacher because the teacher was physically present at the time of filling in the questionnaire. Next to this, teachers or family members were mentioned as an example in the question, possibly making it more likely for a student to answer this. Also, influence by media might happen less consciously than influence by people you know.
But, even considering those points, teachers and family members still play an very prominent role in the image a person has about a mathematician. This means that the often proposed role model change based on representation in media might not be the way to go.

The influence of teacher with regards to math attitudes have been researched before, but mostly with respect of how teacher's beliefs and attitudes of gender influenced students (Gunderson, Ramirez, Levine, & Beilock, 2012). A future study on characteristics of mathematics teachers on the TMF scale might be valuable.

Interview results

In a semi-structured interview with three students, we tried to establish why some female students were not willing to do a study with more than 10% of mathematics. The interview questions and transcription of the interviews in both Dutch and English can be found in the appendix 1.5 and 1.6 (Dutch) and 2.5 and 2.6 (English).

Even though these participants are similar in their answers on the questionnaire, they did express a different view on their liking to do mathematics and their own ability in mathematics. Participant 1 (*p1*) likes mathematics at high school level, she is confident that she will pass the final exam coming up. She is not going to do a lot of mathematics in the future, because she has a different interest; she wants to become a lawyer. Participants 2 (*p2*) expresses a big disinterest in mathematics and also mentions this as the main reason that she does not want to gravitate towards any studies with mathematics. She feels she is probably able to pass the exam nevertheless. The third participant (*p3*) expresses that she really dislikes doing mathematics. She also feels like she is not able to do it and she has felt this way as long as she can remember. Therefore, the main requirement she had for her future studies was that mathematical skills were not needed. The following table summarizes this information:

	Likes to do mathematics	Feels she is able to do mathematics at high school level
Participant 1	**Yes**	**Yes**
Participant 2	**No**	**Yes**
Participant 3	**No**	**No**

Table 4: overview of interview participants' views on mathematics

The students produced the following drawings before the interview.

Figure 18: Drawing participant 1

Figure 19: Drawing participant 2

Figure 20: Drawing participant 3

Enlargements of the pictures can be found in the appendix (1.6 and 2.6).

In terms of **gender**, all participants drew a male person. This was expected, since all of them already described people interested in mathematics as more masculine compared to feminine. When asked to reflect on it, they directly linked being interested in mathematics to being male.
p1: "It's a man, because I do have the idea that people who are interested in mathematics are more often men, whereas I have had more female teachers. But still, I do have that image."
p3: "I have an association with mathematics and men anyway, I think."
Even though all participants seem to view people interested in mathematics as male, none of them could describe where they picked up this information.

Next to gender, we can derive some aspects of **outer appearance** from the drawings. The clothing they are wearing seems very plain. The participants seem to be agreeing to each other about that, they used the following words to describe the clothing dressed by a person interested in mathematics; *safe, simple, monotonous, normal, boring, dull*. Interestingly, according to participant 2, the clothing of female mathematics teachers was not necessarily less feminine. Instead, when making the comparison to people who are not as clearly interested in mathematics, for example teachers of non-STEM classes, all participants saw a clear difference in respect to plainness. Their clothing is *more cheerful, more colorful,* and overall *nicer*. If they compare this to their own clothing, the clothing of people who were not interested in mathematics matched up to their own style more.

The way people are dressed does not seem to stand on its own for the participants. They viewed the simple way the people interested in mathematics dress as an expression of their personality overall. The fact that clothing can be used to express personality has been reflected on by literature before (Lower, 2018). Also, the **interest** the participants believed people interested in mathematics would have were seen as *neutral* by the participants. For example, participant 1 expected people interested in mathematics to only do standard and calmer sports. All participants seemed to agreed with each other that the people interested in mathematics like to be motivated to stimulate their thinking by for example doing chess or puzzles. The participants could not see themselves do that in their free time.

In terms of **behavior,** people interested in mathematics *like to be alone, think logically and structured, are calm, orderly and reserved*. All participants described that they were more open and outgoing compared to people interested in mathematics.

Less differences were found in the aspects of **attitudes and beliefs,** all participants only reflected on their current teacher. They found their current mathematics teachers to be *funny, openminded, helpful and accepting*. So, no direct change of this is needed in order to motivate the female students to do mathematics.

So we have some strong suggestion that masculinity of current stereotypes is not the problem, but the lack of outgoingness of people interested in mathematics is a bigger problem with respect to identification. This personality trait is mainly expressed through the outer appearance they have. Another personality trait is that people interested in mathematics are structured, which can be seen in their interests and behavior. These findings would not explain why females are less likely to be drawn to a mathematical work field, since the findings are not directly linked to gender. It does not explain whether females are more outgoing themselves or are just more influenced by the image of others in this aspect. Future research on this might be interesting.

The participants mainly used teachers to base their image of a person interested in mathematics. The high school students expected their teachers of mathematics to be a good example of the

people studying that subject. In other words, they did see their teachers as a typical person to base their willingness to do a study with a high level of mathematics. Which might explain how images caused by teachers directly influence students in their process of choosing a math related study.

Other influences were family, friends and classmates. These influences were direct, where the person was an example of somebody interested in mathematics and the participants based her idea of a person interested in mathematics on them.
P3: But I don't know, a friend of mine is also going to study mathematics and I'm like "what the fuck is wrong with you? Why would you go and do that voluntarily....
Eline: But does he also fit in your picture of what you just drew?
P3: Yes, it fits.
Eline: But do you find him boring too?
P3: No, not necessarily, he is very nice. But I do think, he does not do very much outside of school or something like that.
Eline: Mmm, just not very sociable?
P3: No, he doesn't have to, that's fine. Not everyone has that, but yes.

The influence can also be indirect, were they were told how they should think about a person interested in mathematics.
Eline: And is there ever negative talk about mathematicians at home?
P3: Yes, my father is an extraordinary professor of theology, so he's very much into humanism and suchlike, and we always make jokes about science people, yes..

All participants showed some indication that they were able to change their current view of mathematicians.
p1: I do think that if there was someone around me who looked a bit like me, who did study mathematics, I would know that they are there, so then I might be more motivated.
p3: "I think that when that image is gone, I might have been a bit more open to mathematics. If I just had a nice, younger teacher." When they were introduced to the interviewer who was a female interested in mathematics and did not fit their current stereotype, they described that not the image of that person, but the image of mathematicians had the potential to change for them.
p1: "So that is really a bit of a prejudice that I should put aside. That I'm like, oh, so there are also nice people who study mathematics."

So, providing young females with suitable images could indeed help them to feel more welcomed in the mathematical field; these images could be their role models. What such a role model should look like varies among the different participants. But there are some similarities that can be found. All seemed to agree that modern clothing and enthusiasm were the main characteristics a person should have to motivate them to do a study with more mathematics.
p2: personally I think just someone who is enthusiastic and can also empathize with the students. Because yes, such a person must know that not everyone likes his subject. His or her... Yes, you just have to think of that as a teacher. And I think that someone who looks a bit modern has an influence on motivation.
Interestingly enough, the participants did not agree with each other on the gender of a person who could change their image of a person interested in mathematics.
p1: "I would like it if it were a girl, because I have the idea that mostly boys are interested in mathematics".
p2: "Man, woman would not really matter to me I think".

Another change suggested does not have to do with the stereotypes of the female students, but more with the stereotypes of people currently in a mathematical work field. Participant 3 described how she felt when people interested in mathematics or other sciences judged her based on her feminine appearance. She believes that people in science might think that she is not able to tackle technical problems and therefore do not present those to her.

p.3: "I had one of those 'night of the nerds' things. That was for science students and I just went along in the third year (of Dutch high school) because my friends were going. I thought, well, okay, nice, and then I was offered, say, a lip gloss, while others were offered... My girlfriends were offered lip glosses while other girls, were offered, say a kit to build an miniature airplane"… "*we were with a group of all, yes, blond girls, all with dresses, and that was another group... All of them looked a bit smarter...*"

If this is indeed the case, it would make sense that it is harder for feminine students to enter the mathematical work field because they are under more pressure to prove their abilities compared to the more masculine students.

Discussion

This research was performed to understand how females perceive people interested in mathematics and how this influences their own future study and career choices. To do so, we provided students of two high schools in the east of the Netherlands with a questionnaire based on the Traditional Masculinity-Femininity (TMF) Scale. The aim of this questionnaire was to understand participants' current gender image of themself and of the gender image they have of people interested in mathematics.

The data of the questionnaire was analyzed, by introducing a self-to-stereotype score. Some data found seemed to confirm earlier research. First, we found that the men on average were more likely to do a study with more mathematics compared to women, which is in agreement with the fact that there are currently more men working in math-intensive fields (Onderwijsraad, 2020). The open question of the questionnaire, which aimed to understand how participants created their current image of people interested in mathematics, led us to believe that mathematics teachers were the person most people based this image on. Kahn and Ginther (2017) also suggested that teachers played a big role in students' image of mathematics and mathematicians.

In some aspects, the data did not seem to be in line with earlier research. For example, the effect of the leaking pipeline, as mentioned in Makarova et al. (2016), did not seem to hold. Instead the number of mathematics women who wanted to do mathematics in their career seemed to be about the same as during their studies, while men seemed to be willing to do less mathematics. So in our research, the leaking pipeline seemed to be true for men more than for women. Also, research by Kahn and Ginther (2017) suggested that culture, including media, was a big influence on the image people have of a person interested in mathematics, but only a few students reflected on culture and media in their answer to the open question.

The data analysis also consisted of comparing the scores of how a person sees themselves with how a person views a person interested in mathematics. The results showed us that men who are better able to identify with a person interested in mathematics in terms of gender were more likely to choose a study with a higher amount of mathematics compared to men who could not identify with people interested in mathematics. For women, this effect was less present overall. Even more so, only looking at outer appearance, we found that women who were able to better identify with a person interested in mathematics were not more likely to choose a study with more mathematics. This result leads us to question earlier conclusions drawn by Dietrich and Lazarides (2019), that the masculine image of mathematicians is causing a loss in motivation for female students. It might for example be the case that certain characteristics of mathematicians cause this effect, and females might be more influenced by these characteristics. If this is indeed the case, the current suggestion on representing women to motivate women to go into science studies and careers, as done by for example the Geena Davis Institute of Gender in Media (n.d), might not have the desired effect.

In order to better understand the finding, three female participants who saw themselves as very feminine and did not want to pursue a study or career with more than 10% of mathematics were interviewed. During this interview, we found that, even though the students perceived people interested in mathematics as male, the females did not see their non-conforming gender as the biggest reason not to pursue a study with a high amount of mathematics. In fact, they perceived people interested in mathematics as neutral and boring, mainly in their interest and outer appearance, and therefore did not feel they would fit with them. The interviewed girls seem to be able to change the current image they have of a person interested in mathematics when they were confronted with a mathematician who did not fit their stereotype.

Conclusion

With this research, we sought to understand how the stereotypes of mathematicians in terms of gender influenced females in their study and career choices. The TMF scale was a helpful tool to determine the gender image of a person's self and their image of a mathematician. With this instrument, we got an image of the influence of outer appearance, interest, behavior and attitudes and beliefs. We found that in terms of self-to-stereotype scores of all TMF characteristics, the effect of being able to identify with a stereotype in terms of gender was bigger for men compared to women.

This does not mean that women overall were not influenced by the stereotype they had of a person interested in mathematics. Instead, the women interviewed seemed to care more about whether the person was dressed according to fashion standards than whether it was as masculine/feminine as they are. They seemed to have the belief that, to them, the neutral looking mathematicians where not interesting and that they did not want to surround themselves by them. In future research, it might be interesting to focus on whether this effect of representation of self by clothing is indeed bigger for females than it is for males.

Currently, both males and females seem to have teachers as the biggest example of what a person interested in a mathematics looks like and behaves. We also concluded that the females interviewed were able to reconsider their view once they were presented with a person who did not fit with their image of a mathematician. These two findings combined mean that if there were more mathematics teachers who are presenting in a way that is more appealing to females, more females might decide to go into a direction with a higher level of mathematics. Explicitly, this means that we need to search for teachers who are more dressed according to fashion standards, have hobbies that are traditionally seen as less boring and show more enthusiasm in their lessons. Even though this solution seems simple, some problems will be faced when implementing it. There already is a shortage of mathematics teachers in the Netherlands (Voorwinden, 2020), which might make it harder to search for perfectly suitable teachers in terms of becoming influential for females. And, as discussed before, even females who do decide on a study in a mathematical field might drop out later on (see *leaking pipeline* in Makarova, Aeschlimann and Herzog, 2016).

Remarks and possible future research

There are a few remarks that should be made concerning this research.

First, we have to be aware that for this research, 81% (104 of 129) of respondents of the questionnaire were all from the same school. Also, all three participants of the interview were from this school. So their experiences with mathematics might be influenced by additional factors to the ones found in this study. During the interviews, the idea of people interested in mathematics treating feminine presenting students differently was presented. Future research on this might be interesting, for example speaking to people currently working in a mathematical field about their stereotypes of feminine students.

Next, the TMF scale is designed as a self-assessment tool and therefore is not validated to be used as a tool to assess others with. Since the research was based on individual person's perspective and the *Chronbach* α was 0.8508, we concluded that the TMF scale is a useful tool for the given purpose.

Also, the stereotype a certain person has of a mathematician is not the only influence of a person who is willing to pursue a career in mathematics. Findings of Barth et al. (2018) suggested that ability beliefs are powerful predictors of occupational interest, and gender stereotypes play a secondary role. This shows that only a change of stereotype might not be sufficient to change the number of

females in math-intense careers. A proposed solution is to show females that many STEM careers require skills that are not usually associated with STEM, such as writing. Female students' participation in STEM might be increased by showing that some stereotypically feminine skills are also important for success in these careers (Barth, Kim, Eno, & Guadagno, 2018).

Lastly, the main focus of this research was on the female perspective. It is therefore hard to say if some of the conclusions might be applicable for (more feminine presenting) males as well. A future research on what tends to drive males towards a career with a high level of mathematics might be interesting in order to get a more complete image of how people are influenced by current stereotypes of mathematicians, maybe even disregarding gender.

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