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Gendered Gatekeeping in the Recruitment and Support of (Prospective) PhDs and Postdocs in a Mathematical Cluster of Excellence

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ABSTRACT
Gender disparities persist in the field of mathematics in German science and academia. From one scientific career level to the next, the proportion of female scientists decreases and women are still underrepresented in the top positions in science/academia. Gatekeeping is assumed to be one reason for the persistence of this disparity. Gatekeepers influence access to and advancement in the science system: They recruit researchers and provide support in the form of knowledge relevant for career advancement and open the way for further career steps, i.e., they hold an important decision-making position regarding the future of prospective female scientists. The study investigates if and if so, how gender disparities are reinforced in recruitment and support processes by gatekeepers in a mathematical cluster of excellence in Germany. Qualitative semi-structured interviews were conducted with 44 scientific gatekeepers in leadership positions. The results show how recruitment and support practices, perceptions, and criteria of scientific potential are interwoven with gender stereotypes, thereby creating potential barriers for female PhD students and postdocs.

KEYWORDS
Gatekeeping; gender disparities; mathematics; qualitative research

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INTRODUCTION

Statistical analyses show that the proportion of women in higher education and in non-university research institutions in mathematics for all scientific qualifications and scientific career levels increase (GWK, 2019, 2020, 2021, 2022). Nevertheless, the existing recruitment potential of female mathematicians of the previous to the next scientific qualification or scientific career level has not been exhausted. This means that the ratio of male mathematicians is far higher than the ratio of female mathematicians at all scientific career levels (Langfeldt & Mischau, 2015a). As a result, women continue to be underrepresented in scientific leadership positions including professorships (GWK, 2023).[1]

Many factors affect a successful scientific career as well as the persistence and reproduction of gender disparities in career paths, therefore influencing the attainment of top-level scientific positions in mathematics. Depending on the research approach, potential influencing factors are considered at the micro-, meso-, or macro-level, i.e., they can be identified on the individual, organizational, or societal level.

At the micro-level, both quantitative and qualitative studies have highlighted potential influencing factors for the persistence of gender disparities in mathematics[2]: Career orientation/motivation and career planning, self-perceptions or self-confidence, the implementation of career knowledge (e.g., taking necessary career steps at the right time), and the development or application of appropriate career strategies (e.g., visibility, self-presentation, publication behavior, networking) (Abele, 2003; Curdes et al., 2003; Langfeldt & Mischau, 2018; Mihaljević-Brandt et al., 2016). In addition, gender differences may also be found due to self-identification as a mathematician, the development of a sense of belonging or a mathematical habitus, self-assessments of success, experiences of performance recognition, competence attribution, or experiences of discrimination in everyday mathematical work (Burton, 2004; Flaake et al., 2006; Good et al., 2012; Herzig, 2010; Lahdenperä & Nieminen, 2020; Langfeldt et al., 2014; Mischau et al., 2010; Piatek-Jimenez, 2008; Solomon, 2012; Solomon et al., 2016; Vogel & Hinz, 2004).

At the meso-level, potential influencing factors include gendered or gender-differentiating structures of organizations and arrangements of social relations and the mathematical culture itself. Quantitative and qualitative studies have highlighted several factors that contribute to the persistence of gender disparities in mathematics at that level: For example, practices of competence attribution and recognition cultures shaped by gender stereotypes and potential gender differences in support or regarding the integration into formal and informal networks (Langfeldt, 2014; Langfeldt et al., 2014; Pieper-Seier, 2009). Moreover, gender-differentiating effects can be observed from working structures and cultures as well as in exclusion by decision-makers in gatekeeping processes (e.g., through publication- or selection-committees) (Popejoy & Leboy, 2012; Topaz & Sen, 2016; Vogel & Hinz, 2004).

At the macro-level, studies have identified gender stereotypes as an "omnipresent" influencing factor (Langfeldt & Mischau, 2015b). These studies have also found interdependences between the male-dominated mathematical culture, ostensibly based on the meritocratic ideal including its scientific myths (e.g., an ideal image of a successful and brilliant mathematician), and the gendered implications and effects of these interdependences on the factors at the micro- and meso-levels (Langfeldt et al., 2014).

Thus, existing studies have identified multiple factors (and their interdependences) that may influence the persistence and reproduction of gender disparities in career paths in mathematics. No study, however, has explicitly made a mathematical cluster of excellence[3] the object of research yet. Moreover, no previous research has focused on the processes and mechanisms of gendered gatekeeping in recruitment and support practices in this field. Our article seeks to fill this research gap and examines the gatekeepers' practices of and perceptions about the recruitment and support of PhD students and postdocs in a mathematical cluster of excellence in Germany.

Theoretical framework

We take a theoretical perspective in which the individual, organizational, and societal levels can be understood and researched as interrelated. Therefore, the phenomenon of gatekeeping in recruitment and support is examined from a social constructivist (sociology of knowledge) and interactional perspective in the tradition of Berger & Luckmann (1966) and Blumer (1969) as well as in consideration of the approach of "doing gender" established by West & Zimmermann (1987). These perspectives are complemented by field-theoretical thoughts of Bourdieu (1992) and Bourdieu & Wacquant (1996).

In the sociological social constructivist tradition of Berger & Luckmann (1966), it is assumed that even though the societal appears to the individual as objective reality, this reality is socially constructed meaning that all actors take part in its (re)production and transformation. With recourse to the paradigm of symbolic interactionism (Blumer, 1969), the social construction of reality is considered to be realized in the practices of actors based on their interpretations. According to this approach

> human beings act toward things on the basis of the meanings that the things have for them … the meaning of such things is derived from, or arises out of, the social interaction that one has with one's fellows … these meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things he encounters. (Blumer, 1969, p. 2)

These theorists, however, do not explicitly focus on gender, inequality and power relations, or the role of the context in which the actors interact. Thus, we also refer to West & Zimmerman (1987), who transfer interaction theory to the study of gender and who are specifically interested in the ways in which gender is (re)produced in everyday practices (the approach of "doing gender") based on the

interpretations of different actors. They claim that "an understanding of how gender is produced in social situations will afford clarification of the interactional scaffolding of social structure and the social control processes that sustain it" (West & Zimmermann, 1987, p. 147).

The approach of West and Zimmermann aims not to view gender as a characteristic of individuals, but rather to focus on the social processes in which gender is produced and reproduced as a distinctive category and its interrelation with what they call the institutional and cultural level.

To analyze the specifics of the organizational context in which these interactions occur and the effective power relations within that context, Bourdieu's field-theoretical considerations are included (Bourdieu, 1992; Bourdieu & Wacquant, 1996), which have also been widely referred to in the sociology of science.[4] Bourdieu developed a relational theory (the habitus-field theory) that links the structural conditions of science with the habitual dispositions of individuals and the production of knowledge in the field (Lenger & Rhein, 2018). He describes the (scientific) field as a place of games or struggles for power in which scientists of different status groups with different positions of power struggle for dominance and recognition within the rules accepted in their specialized disciplines (Bourdieu & Wacquant, 1996). As well as the accumulation of scientific capital through scientific output, these more or less explicit or implicit rules may include permanent availability and motivation for science or the need to be assessed externally as worthy of support and capable of performing (Beaufaÿs, 2003, e.g., describes so-called *Leistungsindikatoren*, or performance indicators, based on which professors evaluate the potential of early-stage researchers).

For our purpose, gender is understood as a social construction and the subjects (in this article the "gatekeepers") as well as their actions and interpretations as central to the (re)production of gender disparities. Subsequently, and according to a complementary interactional approach of "doing gender," we take these disparities not as structurally given, but (in the sense of doing) as a phenomenon (re)produced in social processes and everyday interactions (such as recruitment or supervision practices). In consideration of Bourdieu's field-theoretical approach, the focus is on the specifics of the context or field (in our case a mathematical cluster of excellence in the scientific field) and the power relations in the field. Within this context, gatekeepers can play a significant role in reproducing or overcoming gender disparities in the science system in general and in excellent research environments like the one we studied in particular (e.g., Husu, 2004). For that reason, we chose to interview scientists in leadership positions as gatekeepers because it is assumed that they would be able to influence someone's advancement in the science system due to their (field-specific) powerful positions. Within the framework of recruitment, supervision, and employment for research projects or working groups, they (may) provide the respective scientists with career knowledge and career strategies relevant for advancement in science and academia, predict their perspectives, i.e., decide whether they have the potential to succeed in the scientific system, and pave the way for further qualification or career steps. They thus play an important role in controlling status transitions (Kahlert, 2013). The gatekeepers' ways of thinking and acting have an influence on the context and on the concrete supervision or recruitment situation in which they participate in the doing of gender from their powerful positions.

With this theoretical background, the factors influencing gender disparities at the micro-, meso-, and macro-levels are understood as mutually constitutive factors that cannot be separated from one another. Supposedly individual career factors such as self-identification or career motivation are influenced by practices or patterns of interpretations by gatekeepers. In turn, the gatekeepers' ways of acting and interpretation are based on and (may be) transformed by their experiences and interactions and are also interrelated with the field and the broader societal environment they act within.

Based on the theoretical framework, the study is conceptualized by considering the individual, the organizational, and the societal level and their interrelations. In terms of methodology, individual actions and interpretations (using interviews) on the organizational structure of the field and on societal ideas about gender are focused. It is assumed that the actions and interpretations of the gatekeepers constitute the field and that the field's requirements have an effect on the interpretations and actions of the gatekeepers. It is also assumed that the relation between field and gatekeepers depends on their different power positions.

The present study

This section introduces the specific context that was analyzed, overall study, and research question.

Research setting

The research setting is a cross-institutional, mathematical cluster of excellence funded by the German Research Foundation (Deutsche Forschungsgemeinschaft) under Germany's Excellence Strategy for a (first) period of seven years from January 2019. The cluster includes three universities, two non-university research institutions, and a graduate school. Research in this cluster is mainly project-oriented. Within these projects, two-year postdoctoral positions and three-year PhD positions are offered. These projects were led by the scientists in leadership positions we interviewed.

As well as research on various areas of application-oriented mathematics, career development and gender equality are important cornerstones of the cluster's image. One declared goal of the cluster is to establish an excellent inter- and transdisciplinary research environment, to connect local mathematical talents, and to recruit international and excellent students and scientists of all career stages. Another declared goal is to increase the proportion of female mathematicians within the cluster (but also in mathematics in general). For this purpose, the cluster has implemented numerous equality measures to improve the situation of female scientists and to promote their career paths (e.g., financial support, networking events).[5]

The research context is thus a novelty for several reasons. For the first time, sociological researchers have access to a mathematical cluster of excellence. In addition, the self-image of the cluster provides interesting perspectives. We are examining a cluster that is not only committed to excellent mathematical research in interdisciplinary application fields, but has also set the promotion of excellent scientists of different career stages and gender equality as top priorities.

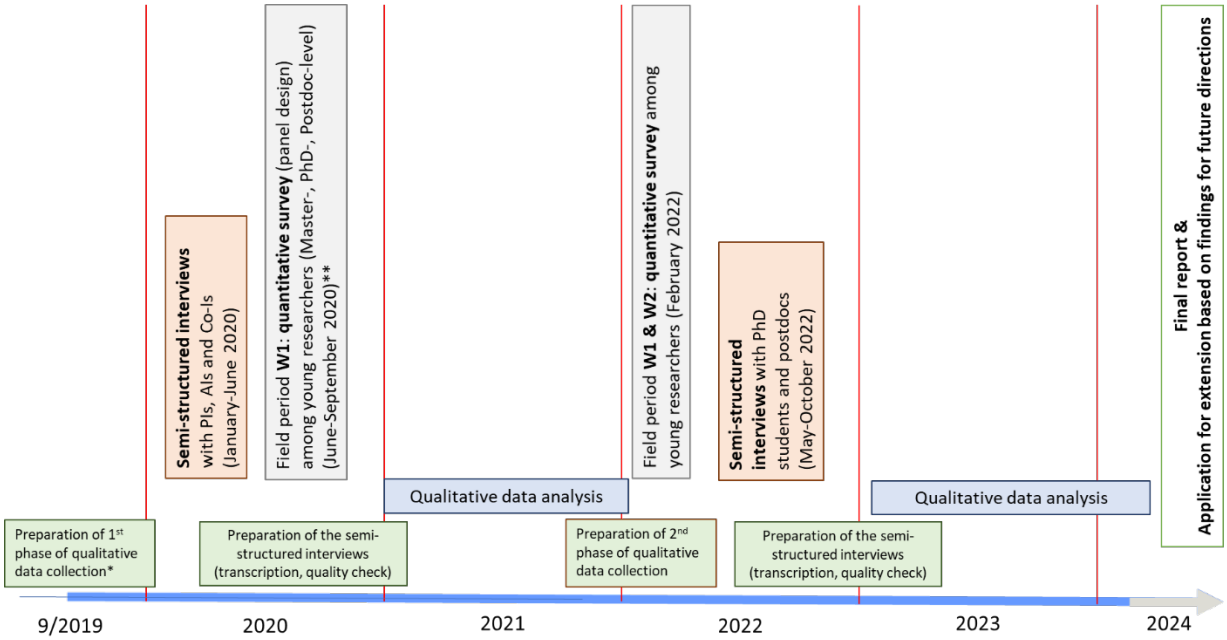
Overall study and research question

The results from the qualitative research presented in this article are embedded in

a larger sociological and empirical mixed-method project that is part of the equality measures established in the cluster (see Figure 1).

Figure 1

Overview of the research project (including the co-operation project)



Note. *The figure concentrates on the research steps of the qualitative part. **The quantitative survey was conducted by our cooperation partners we met regularly to exchange ideas. PIs = principal investigators; AIs = associate investigators; Co-Is = co-investigators.

The overall study includes a quantitative and a qualitative part. For the quantitative part, our cooperation partner conducted surveys on the perspectives of master's students, PhD students, and postdocs regarding their careers and the career conditions in the cluster. We were responsible for the qualitative part. For that part, scientists in leadership positions in the cluster were interviewed. To deepen the quantitative results and contrast the findings with the results from the interviews with the scientists in leadership positions, interviews with PhD students and postdocs were conducted in the second phase of the overall research project, which are, however, not part of the present study.

The aim of the overall project design was to identify the social processes and mechanisms that reproduce gender disparities in career paths in mathematics and especially in the cluster of excellence. We examined the possibilities and conditions for successful status transitions and the interrelations between withdrawal from academia and disciplinary and/or organizational exclusion.

The focus of this article is on gendered gatekeeping. The research question is therefore as follows: Are gender disparities reinforced in recruitment and support processes by gatekeepers in the cluster, and if so, how?

METHODS

The paper is based on findings of the qualitative study (see Figure 1) in which 44 scientists in leadership positions were interviewed using a semi-structured

questionnaire (Flick, 2014; Hopf, 2007). Here, the participants, the qualitative research procedure, and the data analysis are described.

Participants

Our sample contained all principal and associated investigators of the mathematical cluster of excellence. At the time of the data collection, this group comprised 34 people, 30 of whom were interviewed. To gain more insight from women, who were underrepresented among the principal and associated investigators, 14 scientists who were also involved in the management of research projects as co-investigators were additionally interviewed. At the time of the interviews, all 44 scientists held leadership positions within the cluster. Due to the interdisciplinary orientation of the cluster, the group of interviewees included not only mathematicians, but also six scientists with a different (at least primarily different) disciplinary assignment (e.g., physics, engineering, computer science). Twenty-nine interviewees were men and 15 were women; 33 held a professorship and 11 belonged to another status group (senior researcher with permanent or non-permanent positions).

Table 1

Career level of the sample (n = 44) by gender

		Career level	
Gender		Professorship	Senior researcher
Male	29	24	5
Female	15	9	6
Total	44	33	11

Procedure and data analysis

The data collection and the research process are structured according to the methodological suggestions regarding the theoretical sampling by Glaser & Strauss (1967):

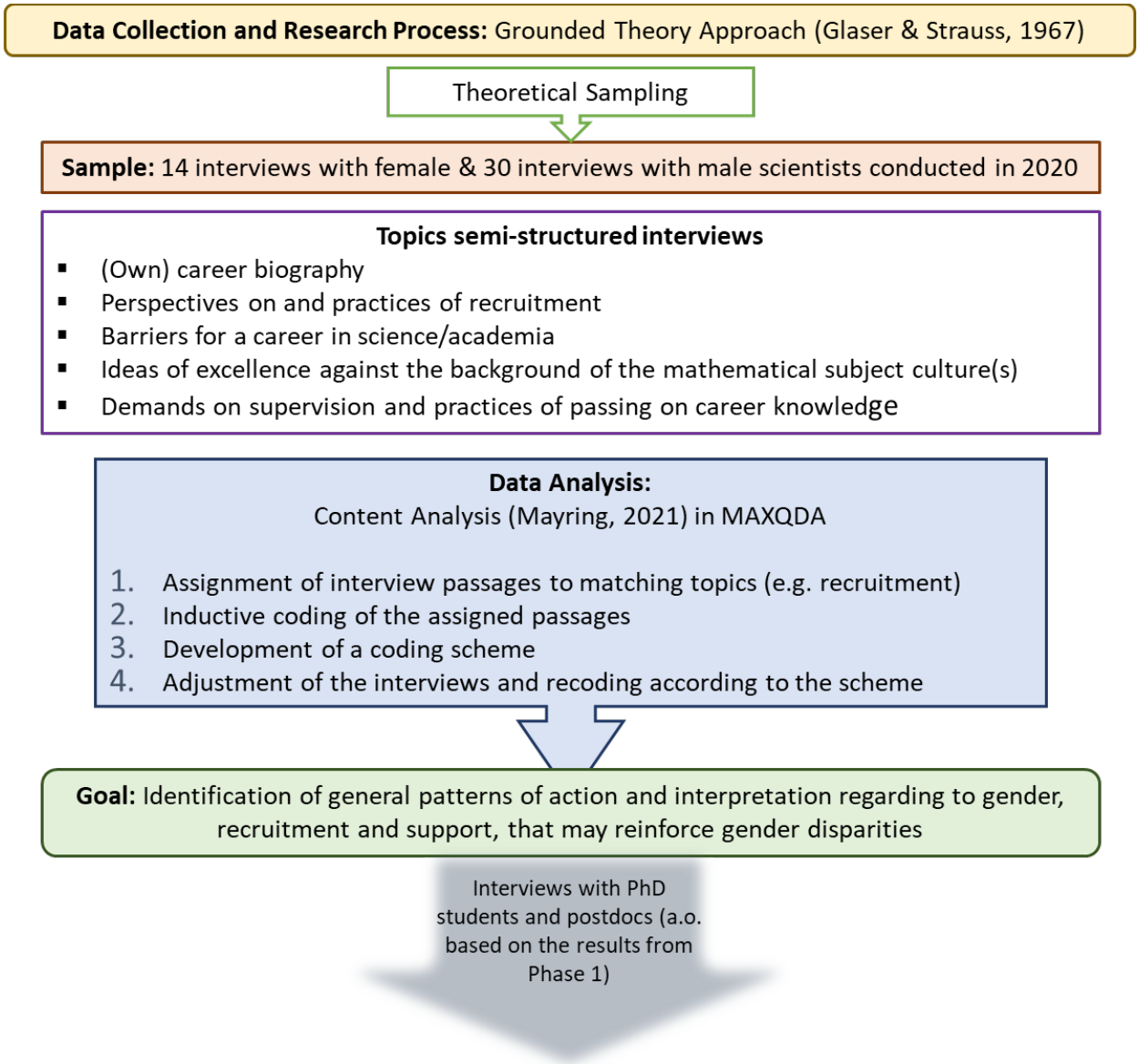
> Theoretical sampling is the process of data collection for generating theory whereby the analyst jointly collects codes and analyzes his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges. (p. 45)

Moreover, the research is set up in an openly manner, i.e., we had preliminary assumptions and focuses in mind, which were derived from the present state of research about gender relations in mathematics, but we were open to new factors and interdependences that have been revealed as relevant in the ongoing research in the field.

The guideline topics for the interviews were developed based on the factors that may influence gender disparities that have been identified in the literature. These topics were further developed during the research process. In the interviews, the following topics were covered: the interviewee's career biography, perspectives on and practices of recruitment (especially recruitment of PhD students and postdocs for project positions), notions of excellence (especially what is needed to be or

become a successful scientist/mathematician), and barriers for a career in science/academia. Another topic was the demands on supervision and practices of passing on career knowledge. Gender was a cross-cutting theme, i.e., we asked about gender-specific aspects such as the relevance of gender equality policies or assumed differences between men and women for all main topics. For the topics, subtopics were defined for which we asked open questions. Due to the qualitative nature of the research, the interviewees were free to choose their focus within these thematic guidelines and therefore establish important aspects according to their relevance (Hopf, 2007). Figure 2 shows the qualitative research process.

Figure 2
Data collection and data analysis in qualitative part of the study



The interviews were conducted between January and June 2020. They lasted approximately 60 minutes each and were audiotaped. The interviews were transcribed and anonymized, and the transcripts were reviewed for quality. For the analysis itself, we did not use the grounded theory approach for coding. Instead, we used Mayring's (2021) content analysis, which is both connectable to

quantitative concepts of presenting findings and suitable for handling large amounts of data.

For data analysis, the material was coded in several steps using qualitative content analysis in MAXQDA (VERBI Software, 2021). In the first step, deductive categories were formed, i.e., the interview passages were assigned to the matching topics (e.g., recruitment). In the second step, the passages assigned to the topics were categorized inductively, i.e., the central patterns of interpretations were derived from the passages and subsequently abstracted. In the third step, a coding scheme was developed based on the inductive categorization. In the fourth step, this scheme was adjusted and all interviews were coded again using the adapted scheme (for the analysis, see Mayring, 2021). As our goal is to identify patterns of action and interpretation regarding gender, recruitment, and support that may reinforce gender disparities, the focus is not on frequencies, but subjective perspectives in their variety and their interplay.

RESULTS

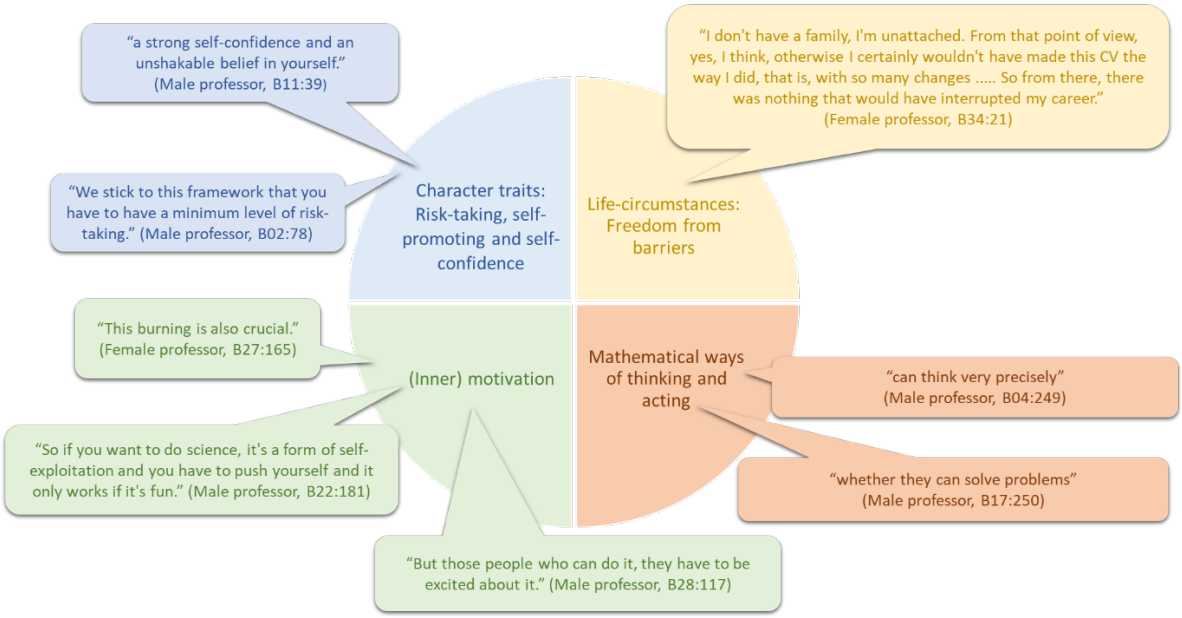
This section presents selected findings from the interviews along three dimensions. In the first section, ideas about what is needed to be successful in science/ academia[6], or what we call "the image of the (potentially) successful scientist" are introduced. In the two following sections, findings regarding the recruitment and support practices of the gatekeepers and the perspectives they have on their practices are presented. At the end of each section, we show how the respective focuses are interrelated with aspects of gender.

The (gendered) image of the (potentially) successful scientist/ mathematician

In the interviews, we asked about the criteria for success and barriers for a career in science/academia. The views of the participants about what a successful scientist should be like are interrelated with gendered ascriptions about motivation, character traits, and life circumstances. As can be seen in Figure 3, we found four characteristics or preconditions with which the interviewed gatekeepers associate the potential to succeed in the scientific system:

1. Intrinsic motivation.
2. Character traits: risk-taking, self-promotion, and self-confidence.
3. Life circumstances: freedom from barriers.
4. Mathematical ways of thinking and acting.

Figure 3
Participants views on (potentially) successful scientists



Intrinsic motivation
To have the potential to succeed in the science system, the interviewees referred to the need for intrinsic motivation, which is mainly revealed by a kind of exuberant enthusiasm or excitement, possibly including a tendency toward self-exploitation or the urge to sacrifice oneself completely to science.

Character traits
The gatekeepers identified character traits such as risk-taking, self-promotion, and self-confidence as non-negotiable in becoming successful in science/academia. The interviewees elaborated on the importance of risk-taking and explained the necessity by reference to the difficulties of the science system in general and the resulting uncertainties (e.g., temporary contracts, uncertain career prospects). Self-confidence is needed to cope with setbacks ("if you're not successful for a longer period of time," male professor, B11:39) and self-promotion to "sell" one's work or "inspire others … for one's own mathematics" (male professor, B04:249).

Life circumstances
Another criterion for becoming successful in science/academia is connected to the life circumstances of the prospective PhDs and postdocs. Being free from barriers is a basic requirement to being committed to science and its demands. Both female and male gatekeepers see childcare as the main barrier in the science system.

Mathematical ways of thinking and acting
As another basic requirement, the interviewees identified competences that enable mathematical thinking and acting, for example, problem-solving skills and precision.

Gendered ascriptions about intrinsic motivation, character traits, and life circumstances
When the gatekeepers referred to female PhD students and postdocs, the

ascriptions that they are less motivated to pursue a scientific career in general was present. This can be exemplified in the following two quotations:[7]

> My personal experience … female students who are now doing a doctorate … I have to do a lot more convincing with them, even if they are very, very good, but I still have to convince them to do a doctorate first. (Male professor, B36:59)

> Of all my doctoral students, the best was a woman, and she didn't want to make a scientific career, although I persuaded her as if she were a sick horse. …. And I think that in this case it was simply a matter of choosing between family or a scientific career … She simply wanted to invest less time. (Male professor, B37:43)

What can be seen in these quotations as well as in other interviews is the belief that female PhD students and postdocs need to be convinced to pursue a scientific career. This necessity to be more persuasive is interpreted as a lack of motivation or will on the side of the female scientists. To explain this lack of motivation or will, the second interviewee assumes that women prefer private life. It is implied that they want to devote themselves to the family. What is noteworthy is that in this pattern of interpretation, it seems not to be possible to have both a family and a scientific career. It can be interpreted that self-sacrifice for science and self-sacrifice for the family are incompatible.

Male scientists, in contrast, are perceived as competitive, self-confident ("The men, for them, the PhD is perhaps another award somehow. I'm better than the other," male professor, B36:59), eager, and self-motivated ("I want to have a doctorate that's great somehow," male professor, B36:59). If these statements are contrasted with the image of the (potentially) successful scientists, one characteristic of which is an intrinsic motivation for science, one can see that this kind of motivation is ascribed implicitly to men and not to women.

Moreover, and regardless of the gatekeepers' gender, they ascribed solely to men the characteristics of self-confidence and the tendency to be self-promoting ("men more easily … stand out and praise themselves," male professor, B33:113) and the willingness to take risks ("Maybe you have it easier as a man because the willingness to take risks is also often higher anyway," male professor, B06:75). Women, in contrast, were characterized as insecure ("I do think that women in general might let themselves get insecure there," female senior researcher, B25:109), "reluctant" (male professor, B18:88), and "silent" (male professor, B30:188). It is the character traits of males that are connected with the image of the (potentially) successful scientist.

The interviewees linked the argument that women are less risk-tolerant or have a higher need for security to the issues of reconciliation, i.e., the assumed

incompatibility of care and science: "I think the path is just relatively risky. And it's the case with many women that they are perhaps a bit more concerned with security, also because of the responsibility for the family" (female professor, B34:151).

The gatekeepers explained both the assumed lower risk-taking (as seen in the quotation above) and the assumed lower motivation using the priority of private life. They also implied that women have (and want to have) the main care responsibility. In these cases, turning to the family and thus foregoing a career is not interpreted as a structural problem or as a problem of the traditional scientific culture and its (alleged) requirements (e.g., permanent availability) or scientific myth, but rather as an individual decision of the woman (and therefore a lack of will or motivation). The interviewees' own practices or behaviors were not used as an explanation.

The quotations above show that the gatekeepers perceive ideal scientific character traits. The successful scientist lives in complete self-sacrifice and free from external influences, but without any interest in security. Instead of critically reflecting on this image itself, it serves the interviewees to estimate the chances of the PhD students and postdocs to be successful in the scientific system. The views they have of women's character traits, motivation, and life circumstances, however, do not fit the image of the (potentially) successful scientist. Furthermore, whenever the scientists in leadership positions refer to gender differences related to the requirements for success in science/academia, they connect these requirements to the scientific field in general. We did not find references to gender differences in mathematics talent, however.

Recruitment practices and perceptions

This section examines the recruitment practices of the gatekeepers, their perspectives on these practices, and their selection criteria.

The interviewed gatekeepers primarily recruit PhD students and postdocs they already know from their work (i.e., their students or existing employees), people from their existing external networks (i.e., people outside the cluster with whom they had prior contact, e.g., at conferences), or people who were recommended to them by other scientists. The gatekeepers recruiting practices are independent of their own gender. Moreover, they perceive this type of recruitment positively, as the following quotation exemplifies:

> If for some reason you have a candidate and know him and can
>
> estimate that he is suitable for the project, that is of course the
>
> optimum. The other end of the spectrum, which is the most difficult,
>
> … is to really advertise it completely openly and hope that you find
>
> someone who fits. (Female professor, B15:100)

Internal recruitment is not only favored, as can be seen in the quotation, but widely practiced in the cluster context. When scientists in leadership positions recruit using open, external advertisements, they do so rarely out of choice, but rather out of a need to comply with formal regulations or due to a lack of alternatives.

The interviewees legitimized the practice of internal recruitment with the following arguments:

1. The responsibility for the project results and the lower risk if the candidates are predictable.
2. The responsibility for the further qualification of (prospective) PhDs and postdocs with these positions.
3. A lack of qualification of external applicants or, formulated positively, the suitability of known candidates due to their precisely fitting profiles.

The third argument is explicitly gendered by the interviewees, whereas the others have gendered effects.

Responsibility for the project
The gatekeepers emphasized the potentially negative effects on their own reputation as relevant to recruitment. For them, it is not possible to escape the logic of the scientific funding practice (i.e., successfully complete projects within a limited time frame). Here, the recruitment practice is explained with the risk potential for the interviewees themselves:

> When you have a project, you want to carry it out successfully and try to minimize the risk and always look at the excellence of the person. … I don't really care whether someone is a woman or a man or whatever, it doesn't interest me, but I try to find out, is the person behind the project, does she want to do it, is she good enough to do it? (Male professor, B37:132)

This quotation exemplifies how a risk assessment is made by the gatekeepers. The more estimable the candidates are in terms of their qualifications, but also in terms of their enthusiasm, the lower the risk for the success of the project.

Responsibility for the further qualification of PhD students and postdocs
When the interviewees used the argument of responsibility for the qualification of (prospective) PhDs and postdocs to legitimize their internal recruitment practices or decisions, they referred to the necessity of further financially securing their employees ("if you have local talent that fits, then there's no reason not to take advantage of it, it's a responsibility we have for our junior staff that we do that," male professor, B40:57). Moreover, they indicated that one has to decide in favor of those who are assumed to be able to cope with the requirements ("you can't in good conscience put someone in a doctoral position who you're not sure can do it," male professor, B06:210).

Moreover, they mentioned two central recruitment criteria:

1. Suitability: the right prior thematic knowledge.
2. Project capability: project skills.

Suitability for project
The gatekeepers specified the (desired) qualifications of project staff as professional knowledge that fits exactly to the research project: "These short projects, where you have to deliver something in a short time that has to fit" (female senior researcher, B21:89); "I have to be on the lookout for an employee who has exactly the right profile, the right prior knowledge … as much as possible to handle this project successfully" (male professor, B04:107).

As these quotations show, the interviewees said that project requirements, especially the need to successfully implement and handle projects in a short period of time, made it necessary to recruit candidates that best fit the project. The most important criterion for a good fit is thematic closeness to the project content. However, the interviews show that the criterion of thematic fit leaves room for interpretation, for example, for the following scientist:

> XXX was actually already named in the application … so you could do that, name the people ad personam … So, she fitted in well because she also studied under Prof. XXX nearby, but always had an interest in stochastics and had already learned a lot during her studies and had already partly pursued projects in the direction of XXX, not really what we do, but at the interface, let's say between numeric and stochastic. That's why it was a great fit. (Male professor, B18:214)

Two points become clear from this quotation. First, women can benefit from internal recruitment, provided they are already known or established in the (mathematical) community. Second, the criterion of fit can be applied in a flexible manner. In this case, the applicant was only partly a professional fit, but she was considered a good fit because she was already known.

Project capability
Competences for project implementation and knowledge transfer (project capability) are required:

> There are of course many things that go into such an interview, in a certain sense communication skill, especially for this position because it is a bit interdisciplinary, …. which really means other skills in addition. … It's not just whether someone has a good grade on the master's certificate, but that someone is also in a position to

> be creative and active and to some extent a bit independent. (Male senior researcher, B38:71)

The interviewee indicated that, as well as grades, other project-related criteria become relevant for the recruitment decision, and he related these skills to the interdisciplinary focus of the cluster. It is noteworthy that none of the interviewed gatekeepers implied that there were gender differences in these skills for project capability.

The interviewees identified qualifications or the quality of the application as the most important criteria in recruitment for project positions. However, they had different interpretations of the meaning of "qualified" in terms of thematic closeness and they also applied "soft" criteria that were not objectifiable, and therefore, could be a problem when comparing applications.

Gendered aspects related to recruitment

Whereas the previously described practices and perceptions were not seen as gendered by the gatekeepers (their gendered implications are discussed below), they explicitly referred to gender differences when it came to the assessment of the applicant situation. They emphasized the general willingness to recruit women ("We're always happy when we somehow find a woman," male professor, B02:138). To clarify why this desire cannot always be realized, the interviewees indicated that no women have applied to the open positions and they explained this circumstance with reference to the generally low percentage of women in the recruitment pool. This problem leaves them at a loss because they do not know how to meet the equality policy targets ("I cannot demand that it must be 50/50 if in the field of science that is simply not achievable," male professor, B13:59). Another pattern of interpretation is revealed in the following conversation sequence:

> B: We would like to attract women, good women, but so far, it's a bit difficult. The only reason is that there are basically far fewer applications from women and qualification-wise it's even worse.
>
> I: What do you mean by qualification-wise even worse?
>
> B: That means … we have two applications from women, but they are not qualified for the position. (Male professor, B28:79-81)

In the last sentence, the interviewee refers to another problem, also observed by other gatekeepers in the recruitment process: Even if women apply, they do not meet the requirements or are not qualified for the position. It is important to note that the scientists in leadership positions do not perceive women in general as less qualified than men, but in deciding whether they fit the specific position requirements, the interviewees referred to their lack of appropriate qualifications.

Other interviewees also indicated that the problems in the application situation were insurmountable on the personal level ("We're not going to change the overall setting around us by doing that—only if others do the same," male professor,

B03:125). However, the gatekeepers gave suggestions to improve the situation for female mathematicians. The suggestions ranged from early support of female students (e.g., hire them at the master's level) to the establishment of role models in higher positions. The interviewees emphasized the long-term nature of these strategies.[8] Within such an interpretation pattern, the gatekeepers neither see their own responsibility nor the immediate options for action they have in the current recruitment situation.

As already mentioned, women who are already known may be recruited internally. Given that female mathematicians are not sufficiently integrated in the system, however, internal recruitment practices favor men, as described in the following quote:

> The man's grades are just as good as or maybe even a little worse than the woman's, but he has a few letters of recommendation from known colleagues and they're super good. The woman's [letters] are also super good, but you don't know the people that well. …. And the scientist, if he knows the colleagues who write the recommendation well, he'll read the letters of recommendation and … he will know exactly that this is the right person for my project. (Male professor, B03:103)

Project needs make it necessary to recruit scientists who fit. The right fit, as indicated in the quotation, is even more important than grades. Here, the right fit is identified by letters of recommendation from colleagues. Due to a lack of integration of female mathematicians, however, the interviewed gatekeepers may only know other scientists with male employees. Gender differences are therefore embedded in the practice of recruitment itself.

In terms of estimating the chances of success of the project, we found no direct references to gender differences. Thus, according to the gatekeepers, the risk of not succeeding does not necessarily depend on the gender of the employed person. We have shown, however, that criteria such as qualifications, enthusiasm, and motivation, which were used to estimate the chances of success of a project, are already gendered and have gender-differentiating effects.

Supervision practices and perceptions

This section examines the supervision practices of the scientists in leadership positions and the perceptions they have of their supervision.

From the gatekeepers' perspectives, the qualifications of the (prospective) PhDs and postdocs are no longer used as a criterion for eligibility. In general, the interviewees see supervision as an important cornerstone of their work. Differences in the intensity of the supervision between gatekeepers can be explained independently of their own gender by their general support preferences. Some prefer a relaxed style, while others prefer to stipulate what must be done. Support

is also provided differently within a given work context depending on the gatekeepers' assumptions about the supervised person, and is offered with varying intensities according to individual needs:

> People are all different, and there are two categories. There are people who motivate themselves and who are looking for … further tasks, questions, or activities. So you just have to get that started. But there are also, and relatively often, PhD students who need support all the time. You always have to talk to those people regularly. … You have to tell them every step and even force them a little bit to do this or that. (Male professor, B28:135)

In this quotation, a difference is made between independent people and those who "need support all the time." The interviewee also implies that PhD students need more support, an implication that can also be found in other interviews. Figure 4 shows types of support provided within the same and between different work contexts.

Figure 4

Types of support provided by gatekeepers to PhD students and postdocs

Transfer of career knowledge*	Providing the environment for peer-support**	Individual and/or emotional guidance and career planning***
"I explicitly tell them, they also have to take care that their face is somehow known." (Male professor, B43:72)	"The atmosphere that prevails in the group depends … on how I act." (Male professor, B04:251)	"We also need to be there to reassure the students a little bit." (Male senior researcher, B45:160).
"It's important … that you know people …. and I try to address that with my people." (Female professor, B15:164)		"You talk a lot about: Do you want to continue? Do you want to quit? And if it continues, what are the next steps?" (Female professor, B15:156)
"What I always tell the young people is that when you go to conferences, you should also talk to your older colleagues." (Female professor, B34:135)		

Note. *Communication of relevant knowledge for a successful career in science/academia (e.g., visibility, networking). **Creation of a supportive work atmosphere. ***Help with individuals' emerging problems on the emotional level or help with issues related to the planning of a career.

Transfer of career knowledge

Almost all the gatekeepers stated that they explained in conversations or (teaching)

events the relevant knowledge for a successful scientific career. This includes that one needs to be visible through publications in relevant journals, present on field-relevant conferences, and to do networking. The interviewees did not mention any gender distinctions in passing on this knowledge.

Providing the environment for peer support
While some interviewees see the guidance of the (prospective) PhD students and postdocs as their responsibility, others referred to the importance of "learning by doing" by observing older scientists and peers in the work context:

> If the PhD students who have been there a bit longer do it right,
>
> then the new ones look: "Aha! That's how they do it, then that's
>
> how I do it too." … I think it's really a culture that is established.
>
> (Male professor, B04:251)

The supervisors see their duty in providing the environment or creating an atmosphere for peer support (see Figure 4). The supervision is quite general and formal; it is granted to all the PhD students who need it.

Individual and/or emotional guidance and career planning
The scientists in leadership positions offer emotional support or guidance that can include guidance in situations that are perceived as problematic as can be seen in the following quote: "Sometimes, especially during doctorates, the students have a phase of self-doubt, and there are phases where no new ideas come, and you have to explain that this is completely normal" (male senior researcher, B45:160). In determining who has phases of self-doubt, this interviewee makes no gender differences (but a status difference). This senior researcher specifies another kind of self-doubt, an insecurity with regard to the content or a lack of ideas and establishes both as normal.

Guidance in such specific situations is usually provided in individual face-to-face interactions. With the provision of supervision that is more tailored to the individual, it becomes differentiated, but also more exclusive, as can be seen in the next quote:

> And what we have here at the institute is an annual employee
>
> career interview … at least once a year. But in reality, I do it much
>
> more often, a conversation where I address things …. so that at
>
> least it's clear that there's a certain possibility afterwards, but it's
>
> also clear that the individual essentially has to make their own
>
> decision afterwards. So I can just say that's the possibility, but I
>
> also don't want to pull anyone in one direction, so to speak. (Male
>
> professor, B13:81)

The informal supervision this interviewee provides includes talking about future career steps or career planning. While this interviewee seems to hold back with the assessments of whether the supervised person should stay or leave, another scientist described the career planning guidance as an estimation of the person's chances of success: "We also talk about their career planning and then—depending on the individual—also how I estimate whether the people should rather stay in scientific career or not" (male professor, B43:72).

This interviewee not only points out possible paths, but also assesses whether the supported person should follow this path.

Gendered aspects about supervision
The gatekeepers do not see, or did not mention, any gender differences in their supervision practices (except for individual emotional guidance and career planning; see below). The transfer of career knowledge and the provision of an environment for peer support is understood to be gender neutral. Especially in the field of career planning, however, the gatekeepers indicated that they support women more than men in the decision to pursue a scientific career as exemplified in the next quote:

> When women are struggling, then … I'm maybe not treating them quite the same—there, I try even more to convince them. …. But at the end of the day, I can't say, "You have to aim for scientific career because that's good for us," right? At the end of the day, the candidates have to make the decision on their own about what they want to do. (Male professor, B43:72)

The external motivation to pursue a scientific career is seen as a kind of persuasion. In regard to career planning, the belief that women need more convincing to pursue a scientific career was also observed in other interviews and may be related to the stereotype described in the previous section that women have a lower intrinsic (career) motivation. Moreover, the male interviewees who expressed the belief that female (prospective) PhDs and postdocs need to be persuaded described the persuasion as almost crossing a border ("I also had the feeling that I'd probably overpowered them [i.e., the female scientists he supervised] with too much good will," male professor, B13:85). In this respect, the supervision of female scientists is more complicated than the supervision of their male counterparts:

> There was a doctoral student, and in the process of the doctorate, the communication did not go well and that had to do with a lot of things. It actually started in her parents' home, with expectations there, and that was a non-academic environment. There was simply the question from the start, "Why should the girl study at all?" And

> that led to very high pressure that this woman put on herself. … That is perhaps an important point in general, that the social environment, the social expectations play an essential role in this whole gender aspect and you cannot absorb some things arbitrarily. …. And at this point, there is a difference between men and women, I think because women feel a stronger social pressure. They are there now, they have the chance to do a doctorate, then it [the doctorate] must also work, and that is, unfortunately, where you come to communicative limits, which can be caught … only with difficulty. (Male professor, B22:185-194)

Here, the conflict between supervisor and (female) supervisee is explained with external factors (family, social environment), which put pressure on the female PhD student. The gatekeeper assumed the role of an outside observer who had no active share in the conflict. In addition, he relinquished responsibility for the situation by indicating that the problems of the supervised woman, which were based on experiences outside the cluster/science, could not be solved from his side. Another gatekeeper referred to gender differences in the communication related to mathematical topics:

> If everything goes well, then everything is great, but if there are difficulties, that means more effort on my part with a woman to manage this crisis. It's little talked about, but it's like that and then of course if I don't want to do that, then I only take men … I hope you understand that. …. In mathematics, managing a PhD student is difficult. Certainly, when difficult moments arise and then the person doesn't know—it's a crisis—doesn't know how to go on—algebra especially is a pretty difficult subject. …. How a woman reacts, how a man reacts, maybe they react differently. …. I mean then it is of course simply more difficult … I admit, when I'm dissatisfied, then I find it difficult to express criticism towards women. (Male professor, B30:198-206)[9]

This quotation raises two points. First, some supervisors do recognize gender differences in the expected behavior of PhD students in difficult situations related to mathematical topics. Second, that for male supervisors, it is more difficult to criticize female mathematicians than male mathematicians. For these two reasons, the professor thinks that supervisors have to make more effort when supervising women.[10]

DISCUSSION: GENDERED GATEKEEPING IN AN EXCELLENT MATHEMATICAL RESEARCH ENVIRONMENT

It was shown how perceptions and practices of recruitment and support as well as images of success in science/academia are interwoven with gender stereotypes held by the gatekeepers in a mathematical cluster of excellence. We found that these perceptions and practices favor gendered gatekeeping and therefore reinforce gender disparities even in an excellent research environment. Our results confirm the findings of previous research in similar (though non-mathematical) environments (e.g., Engels et al., 2015; Husu, 2004; Wolffram, 2018). Gendered gatekeeping is powerful in the everyday working structures in the field of mathematics, especially in the recruitment of PhD students and postdocs for project positions and their supervision. We found gendered, exclusionary ideas of scientific potential and suitability, inequality-(re)producing practices, and a tendency on the side of the gatekeepers to externalize the responsibility for the reproduction of gender disparities. The following sections summarize the key findings.

Gendered ascriptions of scientific potential

We found that the gatekeepers ascribe differences in terms of character traits, (intrinsic) motivation, and life circumstances of male and female mathematicians, which, when connected to the image of the (potentially) successful scientist, qualify them differently for a scientific career. These ascribed differences are not based on merit, but on potential (the gatekeepers do not doubt women's mathematical competences or their qualifications as such). These findings are consistent with those from other studies in which similar assumed differences and their association with potential for success in science/academia have been cited as barriers for female scientists (e.g., Beaufaÿs & Krais, 2016; Paulitz et al., 2015). Moreover, our results confirm the persistence of the ideal image of a successful and brilliant male mathematician (Langfeldt et al., 2014) and highlight its effects on gendered gatekeeping. A general discussion about the gendered image of a successful or ideal (Parson et al., 2021) scientist/mathematician is therefore still necessary to overcome mechanisms of gendered gatekeeping.

Gendered practices and ascriptions in recruitment and support

We found that the organizational practice of internal recruitment that reinforces gendered gatekeeping is widely accepted for recruiting for project positions within the cluster. It was shown that, in principle, internal recruitment may also benefit women, as long as they are already in the system and have been acknowledged as suitable for the project. However, since women are both underrepresented in the system and tend to be perceived by the gatekeepers as less (suitably) qualified, internal recruitment practices tend to favor men. It is questionable whether the practice of internal recruitment itself can be replaced by other recruitment practices for research projects. The early support of female mathematicians (e.g., by hiring female students from the beginning) may increase their chances of being promoted in such a recruitment environment. More awareness is therefore needed of the importance of early support and networking for career development (Langfeldt & Mischau, 2018). Moreover, additional external formalized recruitment practices

(e.g., from graduate schools) may help make female students known to gatekeepers and therefore increase the proportion of women in the internal recruitment pool. This additional recruitment already exists in the cluster and its long-term effects must be analyzed further. Our findings regarding the criteria applied in recruitment decisions revealed the subjective nature of supposedly objective standards. Here, too, gendered ascriptions of potential may play a role if they unconsciously guide the decision to award a male mathematician a position instead of a female mathematician because it is assumed that they have different priorities.

We also found mechanisms of gendered gatekeeping in the support of PhD students and postdocs. Individual support provided by gatekeepers is generally positive, but becomes problematic when connected to the gender stereotypes that women are less risk-taking and self-confident, less motivated, and more involved in their private lives. Such stereotypes may lead to the assumption that women will be less successful. Moreover, we found that male gatekeepers in particular perceive mixed-gender supervision situations as sometimes more complicated or uncomfortable. Whether this phenomenon is a minor issue or whether it is not spoken about cannot be answered at this point. However, it may appear as a constraint in the support (or even hire) of women, create barriers in the interaction between male supervisors and female supervisees, and affect female mathematicians' sense of belonging to the mathematical community (e.g., Burton, 2004; Herzig, 2010; Langfeldt et al., 2014).

Even if the gatekeepers did not refer to gender stereotypes directly when talking about recruitment and support, it is likely that these (partly unreflected) gendered ascriptions play a role in the recruitment and supervision processes. It is necessary to reflect on the implicit effects of gender stereotypes (e.g., through institutionalized unconscious bias training) and raise awareness among gatekeepers about the specific issues in recruitment and support.

Externalization of responsibility

We found that reconciliation is regarded as the central barrier for a career in science/academia by female and male gatekeepers. It has negative consequences primarily for female mathematicians, however, since they are still regarded as having the main responsibility and aspiration for care work. Our study revealed that the decision to forego a career is not interpreted as a structural problem or as a problem of the traditional scientific culture, but as an individual decision of the woman, an explanatory pattern that Kahlert (2015) found for supervising gatekeepers in other disciplines. In statements about recruitment and supervision, we also found a tendency to explain the difficulties faced by female mathematicians using external societal factors or the problems of the science system in general. The gatekeepers did not mention any connection between insecurity or lack of motivation on the part of women and the support offers they have made or failed to make in this regard that may have reinforced these factors. Instead, and independently of their gender, the gatekeepers said that, individually, they were trying to hire female mathematicians (thus representing the narrative and image of the cluster) or indicated that they supported women even more than men. Their potential contributions to the (re)production of the inequality-promoting structural or cultural conditions are therefore not reflected by themselves. Moreover, the gatekeepers made no connection between gender disparities and their (possible) reproduction through the gendered culture of mathematics itself (Langfeld &

Mischau, 2018). It can be assumed that they were not aware of this linkage, which could lead to more pressure for female mathematicians (Vogel & Hinz, 2004).

Limitations and future directions

Our results show the benefits of a multidimensional and interrelational perspective on the topic of gender disparities. However, his study has several limitations. First, the actors do not (re)produce their gendered perceptions in a vacuum, but act and interpret in a field with specific disciplinary and scientific rules (e.g., claim for excellence, claim for equal opportunity established by the cluster or internal recruitment practices), and its influence must be analyzed further.

Second, this is also a context in which these scientists in leadership positions are in a powerful position. Even if they do not use their powerful positions with the intent to disadvantage female scientists or even if they are willing to change the unequal gender relation, they may unintentionally cause disadvantage when they fall into unconscious stereotypical thinking. Whether the stereotypical thinking leads to actual differences in the behavior of the gatekeepers toward female and male researchers (e.g., by suggesting different career opportunities) needs to be analyzed further. The findings partly point to this, for example, when male scientists revealed that they had found supervision situations with female researchers to be more complicated.

Third, it needs to be clarified whether practices of gendered gatekeeping not only create potential barriers, but also lead to the dropout of female mathematicians. To elaborate on the effects of the ascribed differences on female (and male) PhD students and postdocs, the research will be continued by interviewing these two groups of scientists.

Fourth, our research was conducted in a specific environment: An applied cluster of excellence with the goal of establishing gender equality. It would be fruitful to compare our findings with those from other mathematical fields and institutional contexts, as studies of the science system in general suggest that women are underrepresented in excellent contexts (Meyer et al., 2015), while the proportion of female scientists in inter- and transdisciplinary settings is regarded to be high (Hasse & Trentemøller, 2011; Rhoten & Pfirman, 2007).

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ENDNOTES

[1] The percentage of female mathematics professors in 2021 was 18.9% (Destatis, 2022).

[2] Many sociological studies or studies from other disciplines such as psychology have a focus on gender in academia or in the STEM field. These studies, however, either take a general perspective on the science system or subsume mathematics as a component of STEM without taking into consideration the potentially specific organization and subject culture of mathematics (the need for differentiation is also identified by Master & Meltzoff, 2020). To take this differentiation between disciplines into account, we primarily refer to studies with an explicitly mathematical focus.

[3] A Cluster of Excellence is a research context funded as part of the German Research Foundation's Excellence Initiative. Within such a cluster, scientists from different disciplines and institutions work together on a broader range of topics (in our case topics related to mathematics).

[4] In his studies, Bourdieu refers to the French academic system. For the German context, there are studies, for example, by Beaufaÿs (2003) and Findeisen (2011) that apply Bourdieu's theoretical frame to gender-inequality-reproducing mechanisms of the science system.

[5] Our research is also part of these equality measures.

[6] We refer to both terms because our sample contains scientists from universities (academia) and scientists from non-university research institutes (science).

[7] The interview sequences were translated and smoothed, but grammatical errors were retained (the interviewees are not native speakers) to avoid unnecessary interpretation by the translators.

[8] In these suggestions, the interviewees did not consider that the recruitment potential is statistically already there.

[9] This scientist belongs to the minority of scientists who reflect on their own contribution to the reproduction of inequalities.

[10] Only two male interviewees talked about situations where communication or emotional support was difficult for gender reasons.

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