Gender Differences in Innovation and Competitive Settings

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List of Abbreviations

2SLS	Two-Stage least squares
API	Application programming interface
CEM	Coarsened Exact Matching
CEO	Chief Executive Officer
CV	Curriculum Vitae
EPO	European Patent Office
IBU	International Biathlon Union
IPC	International Patent Classification
IRR	Inverse rate ratio
ISSN	International Standard Serial Number
IV	Instrumental variable
JIF	Journal impact factor
Max	Maximum
MD	Medical Doctor
MeSH	Medical Subject Heading
Min	Minimum
NIH	National Institutes of Health
OLS	Ordinary least squares
PATSTAT	Patent Statistical Database
R&D	Research and Development
RPG	Research Project Grant
S&P	Standard & Poor's
SD	Standard deviation
SE	Standard error
SRG	Scientific Review Group
U.S /U.S.A.	United States of America
USD	US-Dollar
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
XML	Extensible Markup Language

General Introduction

Women and men are different. They are different in a biological sense, but also different in their characteristics, preferences, and behavior (Croson and Gneezy 2009, Hyde 2014). Through socialization processes and gender role expectations (Eagly 1987), these differences are nurtured from an early age. Even if differences may be small initially, they often grow larger over time (Lorenz 2000) and form career trajectories and choices at later stages in life (Bell et al. 2019, Hoisl et al. 2022).

As men and women enter the workforce, gender differences also shape organizational and economic outcomes. The channels through which these gender differences materialize can be broadly categorized as supply- and demand-side factors (e.g., Fernandez-Mateo and Kaplan 2018). While supply-side factors describe women's and men's choices and behavior, demand-side factors pertain to bystanders' actions. On the supply-side, it has been shown, for example, that women and men think about different problems and engage in different problem-solving strategies (Nielsen et al. 2017, Koning et al. 2021). Similarly, it has been suggested that women and men differ in their preferences for competition (Croson and Gneezy 2009), a potential reason for why women tend to avoid such settings more than men (Niederle and Vesterlund 2007). On the demand-side, there is mounting evidence that outsiders evaluate outcomes differently, depending on the focal actors' gender (Foschi 1996). In many settings, gender, as a salient personal attribute, serves as a diffuse status characteristic that is used to infer quality of products and individuals (Ridgeway 1991, Correll and Ridgeway 2006), often to the disadvantage of women. For example, it has been shown that women[1] medical doctors are being trusted less (de Vaan and Stuart 2022), or that paintings by women artists are auctioned at lower prices (Adams et al. 2021). As there is no evidence for innate gender differences in talent, skills, or abilities (Valian 2007, pp. 32-34), such gendered evaluations can lead to market inefficiencies, like gender gaps and "glass ceilings" (Cotter et al. 2001), with profound implications at individual, organizational, and societal levels (Petrongolo 2019).

This thesis adds to the growing body of literature at the intersection of economic sociology and psychology on how gender differences shape outcomes via supply- and demand-side factors, by putting the spotlight on women and men top performers in competitive settings. It is particularly important to look at gender differences and their effect on outcomes in these settings for three reasons. First, top performers contribute disproportionately to value creation, economic growth, and

[1] I use the terms "woman/women" and "man/men" as opposed to "female" and "male" because the former refers to gender in the socially constructed sense whereas the latter denotes biological sex that is neither verifiable in larger-scale archival research nor germane to my research questions. I would like to further highlight that gender is a nonbinary construct but in light of my research questions, I limit my arguments and analyses to men and women throughout this thesis.

innovation (Aguinis and O'Boyle Jr 2014), implying a strong lever for gender differences to materialize. Second, it remains to be understood whether gender differences that have been indicated for the general population also apply to men and women in these specific settings (Adams and Funk 2012). Third, due to the underrepresentation of women in the most competitive segments of the labor market (e.g., AAUW 2015), there is an unmet need for large-scale empirical evidence. In combination with the first two points, this evidence is important to not only understand drivers and antecedents of the prevailing gender gap in competitive settings, but also to highlight the gendered potential in human capital that is likely foregone. This evidence can help to derive and articulate countermeasures aimed at increasing the representation of women in such settings.

In three separate chapters, which will briefly be summarized in the following, this thesis aims to advance our understanding of how gender differences shape outcomes in innovation and competitive settings by answering three distinct questions:

1) How do gendered evaluations of top performers spillover to their protégés in a mentor-protégé relationship?
2) How do gender differences between star inventors impact innovation outcomes in inventor teams?
3) How do gender differences moderate the influence of pressure on performance of extreme precision tasks?

Chapter 1: The Effect of Mentor Gender on the Evaluation of Protégés' Work

In the first chapter, which is coauthored by Marc Lerchenmüller and Karin Hoisl, we investigate whether the evaluative discount experienced by accomplished women spills over to their protégés in a mentor-mentee relationship. We investigate this question in the context of the life sciences, where prior research has shown that women receive less recognition for their work (Ma et al. 2019). As protégés are usually at the beginning of their careers, it is expected that mentor gender can influence the evaluation of their work via both supply- and demand-side channels. On the demand-side, protégés may be particularly susceptible to mentor gender being used as an informational cue by evaluators (Kram 1983, Li et al. 2019a). Since protégés lack an established track record, evaluators might turn to their mentors, and their mentors' gender, in search for information about protégé quality. The evaluative discount experienced by women mentors may spill over and also dim the esteem of their protégés. On the supply-side, it is possible that men and women mentors guide their protégés into producing different kinds of work (Leahey 2007, Leahey et al. 2010). For example, it has been suggested that women shy away from competition more than men (Niederle and Vesterlund 2007), and it is possible that women mentors guide their protégés into producing work in less competitive fields.

To investigate the effect of mentor gender on the evaluation of their protégés' work and disentangle both of these accounts, we create a granular dataset on 4,556 highly qualified postdoctoral students who received mentored early career funding from the U.S. National Institutes of Health (NIH). We then compare how papers published by protégés of women and papers published by protégés of men are evaluated by the scientific community. We measure evaluation through the number of citations a publication receives, as citations are the institutionalized metric for quantifying the (cumulative) evaluation of scientific work (Merton 1988).

We document an evaluation discount in form of 10% fewer citations to papers published by protégés of women versus papers published by protégés of men. Supply-side factors, i.e., women mentors guiding their protégés to producing different kinds of work, account for up to 45% of the citation discount. The remainder is explained by demand-side factors, i.e., evaluative bias within the scientific community. The demand-side bias is particularly concerning as it implies mentor gender tarnishes the evaluation of protégés' work net of its objective quality and content. We can further show that this relative citation discount on the demand-side is driven by men and authors from fields close to the focal research, who are likely familiar with the mentor and his or her gender.

The results contribute to the literature on mentorship (e.g., Noe 1988) and gender gaps in competitive settings (Fernandez-Mateo and Fernandez 2016), but may hold even broader implications. Our findings highlight that gendered evaluations experienced by senior women who qualify as mentors can transcend to their collaborators. It also shows that as long as there are dynamics at play that put senior women at a relative disadvantage, having them as mentors will not suffice to narrow gender gaps in competitive settings via supply-side channels. A mere increase in the presence and prominence of women is not effective if structures and norms on the demand-side that shape (biased) evaluations do not change, too (Etzkowitz et al. 1994).

Chapter 2: Knowledge Recombination in Teams with Women versus Men Stars

The second chapter, which is coauthored by Mona Reber and Himani Singh, extends the idea that top performers' gender is not only associated with differences in their own behavior and output (supply-side) but also with how they are viewed by those around them (demand-side). In teams with top performers, it is likely that beyond direct contributions, top performers' gender influences how team members interact with them and each other. For example, in teams with women top performers, lower perceived status differences might make it easier for lower-status team members to speak up (Nembhard and Edmondson 2006). Accordingly, we investigate how teams with women versus men star inventors differ in their knowledge recombination outcomes.

Research has shown that star inventors have both positive and negative effects on team processes when it comes to knowledge creation. On the one hand, they contribute their own knowledge, experience, and expertise, but on the other hand, they can limit knowledge exchange by, for example, leading to star-centric knowledge flows (Grigoriou and Rothaermel 2014, Kehoe and Tzabbar 2015, Chen and Garg 2018, Liu et al. 2018a, Morris et al. 2021). Considering innovation as the recombination of existing knowledge elements in new ways (Schumpeter 1934a, Nelson and Winter 1982, Kogut and Zander 1992), the exchange of all team members' knowledge rather than focusing on the stars' knowledge may, however, be conducive to knowledge creation processes.

In light of these ambiguous effects of star inventors on knowledge creation in teams, the star inventors' gender may become relevant. Non-star team members' knowledge elements are expected to be shared and integrated more widely in teams with women stars, mainly due to gendered role expectations and status perceptions, like women fostering open and social teamwork (Ridgeway and Diekema 1992, Carli and Eagly 1999). As direct contributions by women and men star inventors are not expected do differ, we hypothesize that the presence of a woman star fosters knowledge recombination breadth in teams more than the presence of a man star.

We test this hypothesis in a sample of inventor teams with star inventors and their patents filed at the U.S. patent office in the period of 1990 to 2010. We match teams with a woman star to similar teams with a man star and compare how broadly the teams recombine knowledge across technological boundaries in their patented inventions. In line with our hypothesis, we find that teams with a woman star combine knowledge more broadly. This finding is robust across a series of analyses, including an instrumental variables estimation.

Highlighting the importance of star inventor gender for knowledge recombination in inventor teams advances our understanding of the role of a top performer's distinct characteristics in knowledge creation. It also points to how men and women top performers do not only contribute differently to innovation through their direct contributions (e.g., Koning et al. 2021), but also indirectly via fostering knowledge sharing in team settings. We further highlight the oftentimes overlooked innovative potential of women star inventors. Realizing this innovative potential can have positive economic and societal effects.

Chapter 3: Make No Mistake – Performance of Extreme Precision Tasks under Pressure and the Role of Gender

The third chapter of this thesis builds on the idea that supply-side gender differences among top performers can influence outcomes in competitive settings. In particular, this chapter looks at how men and women differ in their performance of a precision task under pressure. Returning from the team-level (Chapter 2) to the individual level, this chapter revisits the dominant view that women generally perform worse under pressure than men (Gneezy et al. 2003, Cai et al. 2019), a view that has commonly been used as a supply-side explanation for why women shy away from competition (Niederle and Vesterlund 2007, Saccardo et al. 2018).

Literature in psychology and behavioral economics has established that individuals often choke under pressure, i.e., they perform below their optimum when the importance of performing well is high (Baumeister 1984). This is because they are distracted and engage in a conscious and more risk-averse execution of well-learned tasks (Lewis and Linder 1997, Beilock and Carr 2001). On average, this effect tends be stronger for women than men, because women appraise pressure more often as a threat rather than a challenge and are therefore more distracted by it (Cahlikova et al. 2020). In extreme precision tasks, like surgery in emergency medicine, however, the relationship between pressure and performance might reverse, as such tasks profit from de-automatization and a conscious and risk-averse execution (Vickers 2011). It follows that for extreme precision tasks women may perform better under pressure than men.

I test this hypothesis in a sample of professional biathlon athletes. Biathlon is an Olympic Winter sport that combines cross-country skiing with rifle shooting. As biathlon shooting requires high precision while being physically extremely activated, it is archetypical of an extreme precision task (Vickers and Williams 2007). In a longitudinal study of 391 professional athletes and more than 50,000 shooting rounds, I compare athletes' shooting performance in normal races to their shooting performance at the Olympics, when the pressure to perform well is high. In line with the hypothesis, women miss, on average, fewer shots at Olympic versus non-Olympic races while no such differences are found for men.

By highlighting the performance differentials of men and women high performers in extreme precision tasks when much is at stake, this study contributes to the literature on gender differences in performance under pressure (e.g., Shurchkov 2012, Cai et al. 2019). It also adds to research on performance differentials between men and women in competitive settings (e.g., Niederle and Vesterlund 2011), by identifying an important scope condition – the nature of the task – that can alter the dominant narrative of women uniformly performing worse in competitive settings than men. Showing that women and men engage in different competitive strategies as pressure increases also points to potential supply-side complementarities in their human capital. Depending on task requirements, organizations could strategically use these complementarities by, for example, assembling mixed gender teams.

1 The Effect of Mentor Gender on the Evaluation of Protégés' Work

(This chapter is based on a paper coauthored with Marc Lerchenmüller and Karin Hoisl)

1.1 Introduction

Mentors are usually established scientists with a rich publishing record and a certain standing in the science community. Protégés, i.e., junior researchers who are at the start of their scientific career, on the contrary, are difficult to evaluate as they lack a track record. This gives rise to information asymmetries when the community seeks to assess the work by “newcomers” (Kram 1983, Li et al. 2019a). Mentors may provide a critical informational cue – a certifying signal on which others rely for inferences about underlying quality (Podolny 2001, p. 34) – that can positively affect the evaluation of work produced by protégés (Merton 1968, Podolny 1993, Simcoe and Waguespack 2011)[2].

The gender of mentors becomes salient in this context. This is because of compelling evidence that women who have climbed to the senior ranks of the academe, who are poised to serve as mentors, still get undervalued relative to men peers in the science social system. For example, women less often get invited to prestigious editorial boards, get paid less, and receive less recognition for their accomplishments (Rossiter 1993, Amrein et al. 2011, Jena et al. 2015, Hoisl and Mariani 2017, Ma et al. 2019). In short, prevailing conditions in science may decrease the extent to which women relative to men mentors provide a certifying signal in compensation for uncertainty attached to protégés’ work.

Combining the importance of mentors for the evaluation of protégés’ work with the notion of senior women getting undervalued in science, a baseline hypothesis emerges: *Women relative to men mentors negatively (or at least less positively) impact the evaluation of protégés’ work by the science community*. In a first step, we will test this baseline hypothesis. However, we cannot stop at this point. To reflect on the desirability and promise of potential countermeasures, we need to better understand why any evaluation discount arises. Hence, in a second step, we investigate the reasons for a possible gendered aspect to mentorship.

For our investigation of a possible evaluation discount experienced by protégés of women, we build on the literature investigating gender gaps in professional labor markets. This literature broadly distinguishes between *supply-side* effects and *demand-side* effects giving rise to gendered

[2] The study by Simcoe and Waguespack (2011) provided the first evidence that status advantages can affect coauthors in the context of science. Our study differs in examining the transmission of gendered evaluations from mentors to protégés, even if the mentor may not coauthor a focal publication.

outcomes (e.g., Kulis et al. 2002, Ding et al. 2013, Fernandez-Mateo and Fernandez 2016). Supply-side logics focus on women self-selecting into less advantageous positions, in turn, depressing their outcomes. In the context of science, women might choose not to compete for publication spots in top journals or to conduct research on niche topics that receive less recognition, for example. Whatever the root cause, supply-side effects may well impact mentored protégés, both directly through coauthoring with the mentor as well as indirectly by mentors imprinting a certain research agenda.

Demand-side effects, meanwhile, pertain to actions by the evaluators of women's work and how these evaluations get shaped in the prevailing social context (Reskin 2005, Fernandez-Mateo and Kaplan 2018, Abraham 2020). One possibility is that senior women's occupation of lower rungs in the science social hierarchy relative to men (Zuckerman et al. 1991) spills over and dims the esteem of their protégés as well. This may, for example, translate into protégés facing differential access to impactful research areas, despite trying, when the mentor is a woman. Another possibility is that there may be gender biased evaluations in the science community even for work that is equally impactful (Botelho and Abraham 2017, Lerchenmueller and Sorenson 2018)[3], again begetting undervaluation of work by protégés of women. Importantly, any association of mentor gender with demand-side bias[4] against protégés' work would be pernicious for two reasons. First, different to supply-side effects, the protégé (and mentor) have little-to-no influence over demand-side effects in evaluations. Second, any initial demand-side bias could lead to cumulative disadvantages in recognition beyond the mentorship period (Merton 1968, Reschke et al. 2018). Together, gendered evaluations of mentors could thus infect the evaluation of many scientists of the next generation.

To test our baseline hypothesis and to analyze supply- versus demand-side explanations, we create a granular dataset on 4,556 highly qualified postdoctoral students who received mentored early career funding from the U.S. National Institutes of Health (NIH). More specifically, we identify recipients of the prestigious Kirschstein National Research Service Award (NRSA), the so called "F32 program", chartered to support the next generation of researchers (NIH 2022)[5]. This setting offers several conceptual and empirical advantages, especially the fact that established senior scientists must formally mentor an elite cohort of early career scientists during a formative career stage. Formal mentorship then allows to empirically distinguish mentor effects from generic coauthor effects.

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[3] Gendered outcomes, like men and women differing in content published, may result from both supply- and demand-side factors. We separate these effects to the extent possible through our setting and matching design.

[4] In line with research on gendered evaluations (e.g., Botelho and Abraham 2017), we use the word "bias" to collectively refer to demand-side explanations for women-mentored work receiving fewer citations than expected conditional on its quality and content.

[5] We henceforth use the terms F32 recipient, early career scientist, and protégé synonymously.

An ideal, albeit theoretical, design for our analysis would employ a two-step random allocation. First, mentors would be randomly assigned a gender. Second, F32 recipients would be randomly allocated to women and men serving as mentors. The first step ensures that mentors do not differ on task-relevant characteristics but only on gender. Random allocation of F32 recipients mitigates concerns that protégés of different quality may be systematically matched to women or men mentors. This randomized design is for obvious reasons not feasible.

The next best empirical design satisfies two conditions. First, the mentors are observationally equivalent on pertinent dimensions and only differ in terms of gender. Second, protégés are of similar quality. To fulfill the first condition, we employ a matched sample approach using detailed information on the mentors' scientific track records. To meet the second condition, we select the F32 program as our empirical setting for its highly competitive nature. Our data support the assumption that successful contestants for the F32 grant are of homogeneous quality. We further draw on newly constructed forward citation data to assess how protégés' work may be differentially evaluated by the science community depending on their mentors' gender.

We find support for our baseline hypothesis, i.e., protégés of women relative to men mentors receive 10% fewer citations to their average publication. Adding characteristics about the protégés themselves and their actual research, like the impact factor of the publishing journal, does not materially influence the citation discount attached to women mentors (less than one percentage point). Observational differences in mentor characteristics, like historic publication and funding records, explain about 30% of the identified citation discount, underlining the importance of the formative relationship with the mentor. In all, supply-side factors could account for less than half of the identified citation discount for protégés mentored by women. Of note, accounting for the *expected citations* of a focal paper – measured by the average number of citations to all life science publications of the same year and with the same (or highly similar) content – does not explain the citation disadvantage. Protégés of women thus do not choose to publish in less attractive research areas but receive less citations for comparable work.

Shifting our attention to the demand-side, we find that protégés of women relative to men receive fewer citations especially for work with greater underpinning uncertainty yet situated in highly attractive fields of research. There is no discernable citation discount associated with mentor gender when the underlying work deals with less attractive topics. Pursuing the question further of who does not cite, accounting for the risk set of potential citers, we find that subsequent publications authored by men cite the focal research of women-mentored protégés at a 10–13% lower rate[6] than expected. Subsequent publications authored by women cite women-mentored work at a somewhat

[6] This discount afflicts the evaluation of protégés' work irrespective of the protégés' gender (see Appendix 1.1).

higher rate, too, but that benefit cannot compensate for the former discount as men still outnumber women in academic science. We furthermore show that the gendered citation discount associated with mentorship arises from science communities close to the focal research and can be dissected from a generic bias against women coauthors. In all, we interpret these findings as a substantive demand-side bias afflicting the evaluation of work by protégés of women.

Our contribution is at least twofold. We contribute to the literature on mentorship by first documenting an evaluative discount for protégés mentored by women versus men, while also distinguishing demand-side and supply-side explanations for the observed discount. Second, we forward our theoretical understanding of how collaboration dynamics affect the impact early career scientists may (or may not) unfold on scientific discourses, thereby enhancing the literature on the gender gap in science.

1.2 Mentorship in Academic Science

The importance of mentorship is undisputed and actively promoted in the science community. A recent Editorial published in Nature (2019) titled "Science Needs Mentors" may serve as a case in point. The concept of a mentor can be traced back to the story about the Trojan War in Homer's Odyssey, where Athena the wisdom goddess acted as a protector, educator, and guide of a young prince. Today, mentors in academia are considered sponsors and guides who pave the way for their protégés to enter and prosper in the academic world[7].

Mentors can fulfill several important functions to the benefit of their protégés. They provide resources in support of high-quality research, such as funding and infrastructure (Kram 1988, Scandura 1992, Allen et al. 2004). Beyond pecuniary support, mentors can endow their protégés with a better understanding of how the publication and grant application processes work (Etzkowitz et al. 2000, Preston 2004). Mentors can also introduce protégés to potential collaborators. Empirical studies have associated these functions with different measures of productivity gains for protégés, and we offer an inventory of studies in Appendix 1.2 (see Johnson (2007) for a literature review and Eby et al. (2008) for a multidisciplinary meta-analysis). Overall, results show that mentorship, as opposed to no mentorship, is positively related to, for example, number of conference presentations, research funding, and research output generally measured by number of publications (Johnson 2007, Malmgren et al. 2010). Mentors are even credited for increasing the likelihood of protégés staying in academia (Dohm and Cummings 2002, 2003, Waldinger 2010, Gaule and

[7] Following long-standing conceptualizations (e.g., Noe 1988, p. 65), we define a mentor as someone who provides guidance and support. The term "advisor" in academia usually denotes a formal relationship, like doctoral or postdoctoral advisor. As such, advisors (should) also provide guidance and support and are thus subsumed in the concept of mentorship.

Piacentini 2018), an outcome tightly coupled to productivity, but potentially also reverse causal when those who seek to persist in academia seek out mentorship. Nonetheless, there exists rich evidence that junior scholars with a mentor improve their productivity over those without a mentor.

The impact of different types of mentors, i.e., women versus men, has not been systematically analyzed. Two initial studies with informative designs (one case-based, one archival), report no material influence of mentor gender on protégé productivity per se (Pezzoni et al. 2016, Gaule and Piacentini 2018). Yet, considering the rich evidence on the differential recognition of senior women relative to men in science, mentor gender may be a rather critical factor in the evaluation of protégés' work once published.

We draw on the literature about gender gaps in professional labor markets to investigate the effect of mentor gender on the evaluation of protégés' work. This literature broadly distinguishes between *supply-side* effects and *demand-side* effects explaining gendered outcomes (e.g., Kulis et al. 2002, Ding et al. 2013, Fernandez-Mateo and Fernandez 2016). We consider differences in citations received by protégés of women versus men as focal outcome, since citations are the institutionalized metric for quantifying the science community's (cumulative) evaluation of scientific work (Merton 1988, p. 621).

1.2.1 Supply-side Explanations

The common denominator of supply-side explanations can be summarized as protégés of women offering less impactful work than protégés of men and, hence, receiving fewer citations by the science community. Literature on professional labor markets further advance differences in ability, motivation, and opportunity as determining outcomes (Bailey 1993, Jiang et al. 2012). For mentor gender to be associated with less impactful work of protégés, women relative to men mentors would have to be systematically less able scientists or less willing to mentor their protégés, or both. And even if women and men were equally able and willing to mentor protégés, women might still provide less opportunity for juniors if they guide them into less impactful research fields or imprint an according research agenda that is followed by protégés, or both.

Overall, there is little compelling evidence that men and women differ in terms of scientific ability and willingness to mentor the next generation. Although stereotypes may exist that associate scientific acumen with gender (e.g., AlShebli et al. 2020), intellectual ability has been shown to be gender neutral (Valian 2007, pp. 32-34). Women have gained the same access to the education system as men over time and a career in academic science has always required a university degree and a doctorate. Consequently, educational differences also cannot explain possible gender differences between mentors who cleared these hurdles (Weichselbaumer and Winter-Ebmer 2005) and prevailed in the up-or-out academic career. In addition, women and men mentors may differ in the way they contribute their abilities to the furthering of their protégés. Intensity or quality of supervision is hard to observe. Most informative work in this regard stems from smaller scale studies in psychology, attesting that women mentors tend to establish less power-asymmetric mentor-protégé relationships and cultivate a broader flow of information (Schwiebert et al. 1999). Men are reported to provide more career mentoring to their protégés, whereas women provide more psychosocial mentoring (Allen et al. 2004). If at all, the literature thus tends to indicate that women and men have different foci or take different roles when mentoring their protégés. But that does not mean that supervision quality is gendered. To that end, we also find no indication for potential differences in foci materially impacting protégés' productivity (Pezzoni et al. 2016, Gaule and Piacentini 2018).

Based on the literature about women in science, we may conclude that women mentors prefer to pursue different research with their protégés relative to men mentors. One of the major concerns for the evaluation of protégés is that women mentors concentrate their research in niche fields, possibly to avoid competition (Gneezy et al. 2003, Croson and Gneezy 2009). Yet these fields may be less relevant to the research community and thus attract relatively fewer citations. While the literature offers corresponding indications for women in science more generally (Leahey 2007, Leahey et al. 2010), it is unclear to what extent this holds for women mentors who have successfully climbed to the upper ranks of science. Another possibility is that women tend to work in areas that are particularly relevant to women. Koning et al. (2019), for instance, show that patents listing women inventors are more likely to focus on diseases affecting women. Since there are fewer women than men in science, the interested community would be smaller. A gender-based research focus would almost automatically lead to fewer citations. In case protégés choose to work in less demanded research areas, together with their mentors or independently, a citation discount for women- relative to men-mentored protégés is plausible.

In summary, early career researchers lack a scientific track record and are hence particularly receptive to mentors' guidance on selecting research topics as well as dependent on their mentors' support in executing it. If women and men mentors were to differ in their guidance and support such that protégés conduct research with differential promise of attracting citations, then protégés of women could conceivably receive less citations to their work.

1.2.2 Demand-side Explanations

The common denominator of demand-side explanations is the notion that equally impactful work, content that is at similar risk of attracting citations, still gets undervalued if the mentor is a woman. Demand-side effects do not present themselves readily to the observer because the underpinning dynamics entail some form of non-meritocratic evaluation, i.e., (un-)conscious bias (Fernandez-Mateo and Fernandez 2016).

Science is an inherently uncertain endeavor and uncertainty opens room for biased evaluations (Botelho and Abraham 2017). Protégés are difficult to evaluate per se. Their lack of a track record creates information asymmetries for the science community in evaluating their work. The collaboration with a mentor of certain standing can offer a critical informational cue that the science community can rely on for inferences about the underlying work. Protégés' dependency on the mentor can, however, become a mixed blessing. The gradient in the science social hierarchy is arguably largest for the mentor-protégé relationship compared to any other collaboration among scientists[8]. As such protégés stand to gain disproportionally from the certifying mentor signal when their work gets evaluated. At the same time, protégés are also most vulnerable to differences in signal strength. Although scientists eligible to serve as mentors have repeatedly documented their abilities, there exist varied indications for senior women experiencing biased evaluations of their scientific accomplishments relative to senior men (e.g., Amrein et al. 2011, Jena et al. 2015, Ma et al. 2019). There also exists literature reporting weaker gender differences in evaluations (e.g., Ceci et al. 2014, Andersen et al. 2019, Huang et al. 2020) which is, at least in part, explained by sampling differences. Looking beyond average effects, these studies still locate tangible gender differences towards the right-hand tail of the citation distribution. Such gendered evaluations of senior scientists who serve as mentors are likely to also tarnish the evaluation of protégés' work.

It is instructive to distinguish between gendered mentor effects tied to the protégé publishing with the mentor versus extending beyond direct collaborations. We first consider the case of coauthoring with the mentor. A recent study shows that early career scientists who publish with top senior scientists often have a competitive advantage over those without such coauthors in terms of getting noticed and cited (Li et al. 2019a). Recognition benefits through coauthoring with mentors, as opposed to general coauthors, could even be more pronounced as mentorship often begets long-lasting collaborations with numerous joint publications. In other words, mentorship can lead to many signals being sent about protégés' abilities. Repeat collaborations not only send more but also stronger signals of endorsement (Sorenson and Stuart 2001), dynamics that should combine to generally support the evaluation of protégés' work. As senior women are, however, likely to suffer from an evaluation discount relative to senior men, protégés of women versus men are also likely to experience a less positive boost – a negative relative effect – in the certifying signal.

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[8] Coauthors, more generally, can also experience evaluation differentials with the status signal of eminent collaborators (Simcoe and Waguespack 2011). Yet protégés are special in adding little-to-no additional signal value to a collaboration. To be clear, junior women might grow to experience bias in their own regard, but this effect theoretically distinguishes from the hypothesized mentor effect, and we show that empirically.

If gendered evaluations of mentors spill over and dim the esteem of women-mentored protégés, the evaluative discount can also transcend to independent work of protégés (Podolny 1993, Ridgeway 2001, Correll 2004, Reschke et al. 2018). Perhaps the most apparent spillover case might be, that the protégé increasingly publishes without the mentor yet continues to get associated with the mentor's certifying signal for the occasional joint publication. A related, yet more subtle explanation could be, that protégés continue to research topics without the mentor that still reflect the mentor's research agenda. Ma et al. (2020) have shown, that protégés fair best when they eventually depart from mentors' research domains. In that vein, if protégés were to become evaluated by the community under the perceived certifying signal of the mentor for the common research pursued, then an evaluative discount for women mentors may well transcend to protégés' independent work. Lastly, even if the evaluation discount were to strictly transcend through coauthoring of protégé and mentor, there is still a high likelihood that initial evaluative disadvantages for protégés of women relative to men trigger long-term effects on independent work. Research has shown that initial differences in evaluation can sustain into a self-reinforcing recognition chasm, which would put protégés of women at a cumulative disadvantage as they grow into independent researchers (Merton 1968, Lynn et al. 2009).

Finally, we conjecture four boundary conditions applying to the manifestation of demand-side effects. First, we put forth that an evaluative discount most likely materializes if the science community is aware of either the mentor's standing or associates certain esteem with the connected research agenda, both more likely applicable to communities closer (versus distant) to the focal research. Second, biased evaluations to the disadvantage of senior women and their protégés should be more pronounced among those that are less exposed to women researchers and their qualities (Beaman et al. 2009). On average, this is more likely to be the case for men rather than women scientists. Third, the room for bias is largest when uncertainty about the underlying work is amplified (Azoulay et al. 2014). In the context of science, this is particularly the case for emerging research fields (Reschke et al. 2018). Fourth, we expect demand-side effects to be accentuated where the demand for research is high, i.e., at the frontiers of science. Fields in high demand (hereafter labelled attractive fields) draw active discourses (citations), yet often exhibit fierce competition for reigning interpretations and legitimacy (Kuhn 1970, Lakatos 1976). Informational cues weigh more heavily in these environments (Reschke et al. 2018), and research has shown that senior women experience disproportionate disadvantages in such fields (Ma et al. 2019), putting protégés of women likely at a citation disadvantage relative to protégés of men.

In summary, if women and men mentors were to receive differential recognition from the science community, then protégés could receive an evaluation discount on both, collaborative work with the mentor as well as work independent from the mentor. The evaluation discount associated with mentor gender may be most material within communities close to the focal research, among men rather than women, for research that is still in its infancy and that is poised to draw citations and impact the scientific discourse.

1.3 Empirical Approach

Our empirical setting is a mentored, early career fellowship in the academic life sciences that is sponsored by the U.S. National Institutes of Health (NIH). The NIH is the largest funder of scientific research globally with an annual budget of approximately USD 40 billion. At any given time, roughly 80% of U.S. life science laboratories receive funding from the NIH (Li 2017). As part of its mission, the NIH also commits to developing the next generation of scientists. In particular, the agency administers the congressionally mandated NRSA program that invests in the capabilities of the young research workforce. The program's central funding mechanism is the so called “F32 grant”, offering up to three consecutive years of mentored research support with an average annual grant size of about USD 50,000 (e.g., NIH 2022).

The F32 grant is a very suitable setting to study the effects of formal mentorship among a cohort of highly qualified protégés. Critical for our research design is the fact that a dedicated mentor is a precondition for receiving the F32 fellowship. As part of the program, young scholars are further required to join a new research environment both in terms of content and people. The often freshly minted PhDs ought to become acquainted with new methods and research questions to broaden their scientific repertoire. The NIH therefore generally expects F32 recipients to leave their terminal degree-granting institution. The mentor then assumes responsibility from the application stage in co-devising research the early career scientist will conduct as F32 fellow. During the fellowship, the mentor guides the protégée in novel techniques for addressing research questions that often fall within, or close to, the mentor's area of expertise. Since life science research usually spans several years from inception to publication, mentors commonly collaborate with their protégés for years after the fellowship (Appendix 1.3a). Finally, life science research is resource intensive, needing laboratory personnel and equipment. Hence, the protégé's impact is also dependent on the mentor's ability to support the outlined project (NIH 2021b).

1.3.1 Data and Sample

To examine our research question, we require detailed research records of life scientists. Because no existing data set offers the needed depth of information, we merged six databases – PubMed, Clarivate’s Journal Citation Report, Scopus, genderize.io, Author-ity, and the NIH ExPorter. PubMed is the standard and most complex bibliographic reference for the life sciences. To date, the database contains 34 million scientific publications associated with over 100 million individual authorships. We parsed the PubMed XML database to obtain for each publication record, amongst other information, the publishing journal, time of publication, article content, and author names and order on the author byline. We supplemented journal impact factors (JIFs) for the journals in which the research was published from the 2018 Journal Citation Report, using unique ISSN numbers as a crosswalk. We tested bivariate correlations of various journal impact factors across the years included in our analyses and obtained correlation coefficients exceeding 0.90, indicating little temporal variance in the scaling of the metric. We assigned journals without a listed impact factor to the lowest impact category, as the Journal Citation Report requires a minimum impact threshold for inclusion in the index. We furthermore added downstream citations for all articles from Scopus by Elsevier. Scopus and PubMed data can be merged via a common unique article identifier (the PubMed ID, or PMID). Scopus records detailed information on the citing articles, including author names and positions on the byline, journals, and issue as of 1996. We supplemented this information with probabilistic gender designations of authors using the genderize.io database. This approach does not afford separating effects for individuals who consider themselves diverse, and we note that as a limitation (Appendix 1.5 holds further details). Finally, we drew on the Author-ity database to determine whether two individuals of the same (or very similar) name authoring two articles represent the same or different individuals. Author-ity uses author names, affiliations, coauthor networks, and scientific focus to disambiguate authors listed across articles (Torvik et al. 2005). Research based on an external gold standard of scientist IDs maintained by the NIH has shown that the Author-ity algorithm achieves more than 99% accuracy across, among other aspects, author productivity and gender (Lerchenmueller and Sorenson 2016). These data allow constructing detailed longitudinal research records of both mentors and protégés (see Appendix 1.6c for a visual summary).

We next drew on the NIH ExPORTER database to identify the focal mentors and protégés. Generally, mentorship is an interpersonal interaction that evades formalism and is hard to observe and trace empirically. We make use of the fact that the NIH records all funded projects with a unique grant ID in the ExPORTER. All funded scientists are obliged to acknowledge the grant ID in resulting publications, with failure to do so punishable by disqualification and potentially by federal law. NIH grant IDs in acknowledgement sections of papers have an extremely high fidelity. We mined the ExPORTER for F32 recipients and identified the publications that stem from F32 grant funding. Besides the F32 program, we exploited a long-standing norm in the authorship order of academic articles in the life sciences to identify mentors: the senior investigator receives the last author position on the article byline (e.g., Levitt 2010, Sauermann and Haeussler 2017). We took the first article with three or more authors[9] that acknowledged the F32 grant ID and determined the individual who served as the last author as the F32 recipient's mentor. This approach enabled us to identify the F32 recipient's mentor in an unusually precise way.

To probe the validity of our mentor identification, we examined coauthorship patterns of F32 recipients with their mentors for our full sample. Within the first ten years after F32 grant receipt, they coauthored five papers, on average. Within the first five years after grant receipt, the mentor even appeared as a coauthor on more than half of the F32 recipients' publications, on average (see Appendix 1.3a for further details and additional sensitivity analyses). We also conducted a manual search of a random draw of 100 mentor-protégé dyads, and we verified a connection beyond the first paper that acknowledged the F32 grant ID for over 95% of the dyads[10]. Examples for such connections include referencing the relationship in academic CVs or presentations of F32 recipients' profiles on the mentors' websites (see also Appendix 1.3b).

Starting with 4,808 F32 recipients identified via the outlined steps, we applied certain exclusion criteria in service of subsequent estimation accuracy. First, we removed 248 F32 recipients who appeared unlikely "early career stage" at the time of F32 grant receipt. This applies, for example, to F32 recipients who published more than 10 years or more than 10 papers prior to receiving the grant. Second, we removed publications where we do not expect the F32 mentorship to play a significant role. This includes papers published before F32 grant receipt, published 10 years after the F32 grant receipt, or published by more than 10 researchers. Lastly, we needed to exclude four F32 recipients whose publication data were incomplete (e.g., no information on forward citations to the focal article). The thus obtained sample comprised 58,921 journal articles published by 4,556 F32 recipients with 921 (20.2%) recipients being woman-mentored and 3,635 (79.8%) being man-mentored.

1.3.2 Research Design

To be able to answer our research question, we must make sure that mentors do not differ on task-relevant characteristics but only on gender and that early career scientists of different quality do not systematically match to men and women mentors. Since a random allocation of gender to mentors and protégés to mentors is for obvious reasons not feasible, we use our unique context and rich data to address endogeneity concerns in the best possible way.

[9] Requiring three or more coauthors increases the likelihood of senior authorship on original research because, in the life sciences, articles with less than three authors more often fall outside of original research (e.g., editorials). Our set of mentors remains stable if we relax that condition or impose additional conditions (e.g., repeat coauthoring of mentor and protégé on papers acknowledging the F32 grant).

[10] Importantly, that does not mean that there is no connection for the remaining five percent, only that there was no additional information on the internet.

We match mentors on central characteristics that are also evaluated by the NIH during the F32 grant approval process to ensure that we analyze mentors who are comparable except for their gender. To that end, we use granular data on mentors' scientific track records for the ten years preceding the focal F32 grant award. To ensure that F32 recipients are of similar quality insofar that the likelihood of better early career scientists systematically matching to a mentor of certain gender is negligible, we leverage the competitive nature of the F32 program. The F32 grant stipulates eligibility criteria that yield homogeneously qualified awardees, limiting the impact of unobservable characteristics on selection. To begin with, all applicants must be either U.S. citizens or permanent residents and hold a research relevant terminal degree (usually MD, PhD or both). The F32 application then gets reviewed by an NIH Scientific Review Group (SRG), which, in essence, are self-governed bodies of expert scientists providing review services to the individual thematic Institutes that make up the NIH. Five dimensions get evaluated by the SRGs: (1) observable characteristics of the applicant (i.e., F32 applicant's research record), (2) observable characteristics of the mentor (i.e., mentor's research record), (3) applicants' research potential (e.g., reference letters), (4) research environment during the fellowship (i.e., host institutions' research infrastructure), and (5) the proposed research (e.g., fit with mentor's expertise). The SRG ranks all dimensions from 100 (best) to 500 (worst) and sends the average score to the relevant Institute for a final decision. With a mostly meritocratic allocation of funds based on the SRG review, the set of recipients is obviously even more homogeneous in terms of quality than the broader applicant pool was to begin with. The broader applicant pool already refers to the top 60% of applications only because the Institutes usually discard the bottom 40% of applications (Heggeness et al. 2018). In other words, the pool considered for eventual funding already represents a pre-selection in a very competitive program.

Still, we consider that the final decision by the Institutes may include an unobservable component alongside the evaluation of observables. The individual Institutes may also appraise applications that are in principle worthy of funding, considering, for instance, topical priorities or aspects of workforce diversity. We are concerned that early career scientists and mentors may receive F32 funding correlated with their gender, although they may score somewhat lower on observables. Research based on administrative NIH data suggests that this "error component" varies across Institutes and time and that, on average, one out of eight F32 grants falls out of strict scoring (Heggeness et al. 2018). Consequently, our design would be unaffected by these unobservable determinants on almost 90% of the observations. Nonetheless, we incorporate F32 recipients' gender, alongside their detailed research records covering topic preferences and quality, into our matching and as control variables in our main analyses.

We used coarsened exact matching (CEM)[11] to pair publications of women-mentored F32 recipients with publications of men-mentored F32 recipients based on mentor characteristics observed at the time of grant receipt. We first coarsened the matching variables, then defined strata based on the linear combination of coarsened variables and assigned our observations relating to women and men mentors to these strata. Our matching variables comprise quartiles of mentor productivity ten years before grant receipt, quartiles for the share of these publications appearing in high-impact journals (i.e., with an impact factor exceeding 10[12]), quartiles for the number of major (i.e., R01) grants the mentor received before the F32 grant fiscal year, the gender of the F32 recipient, and five-year brackets for the fiscal year in which the F32 grant was awarded. Only treated observations, i.e., publications of F32 recipients with a woman as mentor that are assigned to a stratum with at least one publication of F32 recipients with a man as mentor (control) were kept for analysis in our matched sample. Finally, we assigned weights to these observations to ensure balance within and across strata[13], and we include these weights in our regressions.

An evaluation of mentors as well as their protégés in terms of variables relevant to the F32 grant allocation decision makes us confident that our matching approach is effective in mitigating both sorting dynamics and in analyzing comparable mentors and protégés at time of F32 grant receipt. Figure 1.1 depicts the coefficients from a probit regression estimating the likelihood of the mentor being a woman. Estimates close to zero (the dashed vertical line) indicate no influence of the variable on mentor gender. Before matching (dark blue dots), we detect three positive predictors, namely women mentors have fewer publications in high-impact journals, gender homophily in the protégé-mentor dyad, and protégés with greater pre-grant productivity more likely receive a woman as mentor. After matching (light blue dots), neither mentor characteristics, nor F32 characteristics, nor their combination jointly predict the mentor's gender (Kodde and Palm 1986). The one remaining significant predictor is the number of papers F32 recipients published before the grant. We control for this difference in pre-grant productivity, favoring women mentors, in all our analyses. Overall, almost all variables capturing F32 grant considerations are not associated with mentor gender, even before the matching, which supports our choice of research context (for more descriptive evidence see Appendix 1.4). With the matching, we mitigate any residual concerns about systematic differences in scientists' quality being correlated with mentor gender. After

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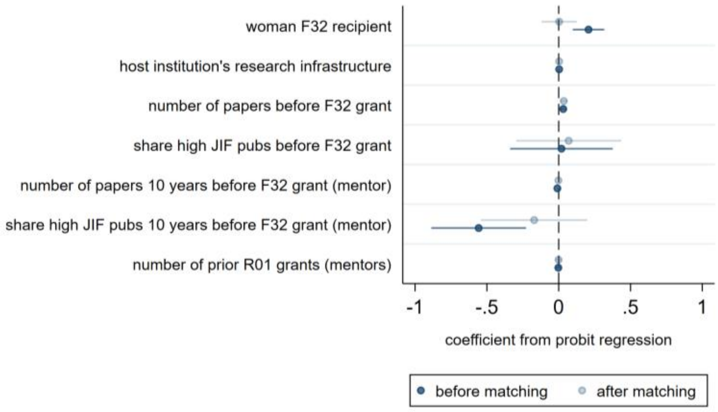
[11] Research suggests that CEM has several advantages over other techniques that also match on observable characteristics, for example, reducing model dependence (for a detailed review, see Iacus et al. (2012)). We execute matching without replacement. Our results based on CEM can be reproduced using propensity score matching as an alternative matching technique (see Appendix 1.14b).

[12] This approach captures top field as well as top general science journals (Lerchenmueller et al. 2019).

[13] For a detailed explanation of weights see King (2012); to reflect the most accurate weighting of observations, we repeat the matching exercise for our subsample analyses that draw on different sets of observations by construction. We, however, obtain consistent results without this extra effort.

matching, we retain 46,577 journal articles published by 3,852 F32 recipients with 915 (23.8%) of recipients with a woman and 2,937 (76.2%) with a man serving as mentor.

Figure 1.1 Predictors of Mentor Gender



Note: Based on probit regression with female mentor as dependent variable; 95% confidence intervals
n = 58,291 before matching and 46,577 after matching; SEs clustered by F32 recipient

To be clear, any design short of the theoretical benchmark of a two-step random allocation of gender to mentors and early career scientists to mentors of certain gender leaves room for counterfactuals. We submit that our design – matching on and controlling for mentor characteristics as well as analyzing a homogeneous set of early career scientists who joined a new research environment both in terms of content and people – allows us to estimate how equally qualified mentors of different gender affect the evaluation of the work produced by high-potential early career scientists.

Using citations as an institutionalized metric for evaluations in science, we face an additional inferential challenge. We can only readily observe realized evaluations, that is, citations that were included in reference lists of downstream papers. But to make inferences about distortions in evaluations, citations that should have been included in reference lists but were not, are at least equally important. By nature, something that did not happen is difficult to measure. To tackle this challenge, we compare *realized* to *potential* evaluations, which we conceptualize as a function of timing of publication and research content. It could, for example, be the case that research by protégés of women speaks to audiences of different size or gender composition (Koning et al. 2019). To account for this possibility, we identify sets of scholars who can reasonably be expected to consider citing a focal publication (i.e., a risk set of citers) given its content and publishing year. We use this risk set to compare actual to possible citation rates and, thereby, better adjudicate alternative supply- and demand-side explanations for citation differentials associated with mentor gender.

1.3.3 Variable Descriptions

Table 1 (displayed at the end of this section) provides definitions and descriptive statistics of the key variables for our full sample. Since our analysis is at the publication-level, we report all descriptive statistics accordingly. For a split of descriptive statistics by mentor gender please see Appendix 1.7c. We also include a correlation matrix for all variables in Appendix 1.7a, indicating that multicollinearity is not of concern.

Dependent variable. The focal dependent variable of our analysis is the number of forward citations a paper receives (*citations*). Citations serve as the institutionalized metric for the impact of academic work (Merton 1988) and play a central role in hiring, pay, and promotion decisions. Citations further serve to locate scientists' relative rank in the academic social order (Azoulay et al. 2014), which allows gauging the influence of mentors' standing on the communities' evaluation of protégés. We exploit up to date information on paper-level citation counts, adding publication year fixed effects to control for different time spans during which individual papers could accrue citations. On average, the papers published by protégés received 84 citations (min=0; max=12,928). The underlying distribution is right-skewed, directing our subsequent modelling choices.

Using detailed and newly curated information on forward citations, available since 1996, we further distinguish forward citations into stemming from articles published by men versus women and from fields close to versus distant to the focal research (see Appendix 1.9 for details on the variable construction). Forward citations mostly stem from articles with men as first or last authors and at similar rates from close versus distant fields.

Independent variable. Our main independent variable (*woman mentor*) is binary and takes on the value of one if the protégé's mentor is a woman and zero otherwise. Roughly one out of five articles (18%) in our dataset was published by protégés who are mentored by a woman.

Control variables. The control variables can be grouped into three categories, respectively capturing characteristics of the F32 grant and recipient, the mentor, and the focal research. We first control for the gender of the F32 recipients (*woman F32 recipient*, one if woman and zero otherwise). Since we match on F32 recipient gender, we do not detect gender homophily in protégé-mentor pairings in our matched dataset. We nonetheless add protégé gender to our models to account for the small fraction of F32 grants that may possibly be allocated by the Institutes based on gender equality considerations. Overall, 34% of the F32 recipients in our sample were women. Controlling for F32 recipient's gender also affords distinguishing possible gender effects associated with the protégé versus the mentor. We control for variance in the research infrastructure of the host institutions (*host institution's research infrastructure*) by including institutions' percentile ranking in terms of major NIH funding (RPG grants). The academic institutions in our sample are, on average, amongst the top 5% of this ranking. We also include a dummy variable scoring one when the F32 grant was extended (*F32 grant extension*). Grant extensions under the F32 fellowship are generally only permissive for parental leave (NIH 2018) and, besides the actual leave days, this variable would capture the broader ramifications of a family extension on a protégé's work life, potentially more relevant for women than men protégés (Thebaud 2015). Overall, about one in ten F32 grants were extended.

Although the pool of F32 recipients is homogenous by design, we still add several variables capturing the pre-F32 quality of the protégés. Controlling for any observable differences in protégés' number and quality of publications prior to receiving the F32 grant reduces the likelihood of selection influencing our estimation. On average, F32 recipients published three papers before receiving the grant (*number of papers before F32 grant*) with 7% appearing in high impact journals (*share high JIF pubs before F32 grant*). To account for emerging productivity differences of the protégés during the mentorship period, we include a count variable for the publications starting from the first publication after F32 grant receipt (*paper count since grant receipt*) and a variable indicating the number of papers published in the year before the focal paper's publication year (*papers in last year*). On average, F32 recipients publish more than 10 papers within the first 10 years of F32 grant receipt. We also use academic cohort dummies (*academic cohort)* that control for the fiscal year in which the F32 grant was awarded to account for the increasing representation of women over time. This trend should affect the likelihood of observing a woman as mentor and the perception of women in the scientific community. Fiscal years vary between 1985 and 2005, with the median year corresponding to 1995[14].

The control variables for the quality of the mentor are the same as the matching variables, i.e., the mentor's number of publications ten years prior to the F32 grant fiscal year (*number of papers 10 years before F32 grant (mentor)*), the share of these publications in high impact journals (*share high JIF pubs 10 years before F32 grant (mentor)*), and the number of prior R01 grants (*number of prior R01 grants (mentor)*). While the weights obtained from the CEM procedure ensure balance with respect to the coarsened categories of the matching variables, adding the continuous variables to the regression accounts for any residual imbalance[15]. On average, mentors had 40 publications with about 15% placed in high impact journals before serving on the F32 grant. Lending further credence to our identification approach, mentors in our matched dataset received four R01 grants, on average, before serving as a mentor on the F32 fellowship.

[14] For our subsample analyses, we use 5-year dummies to avoid model convergence issues in smaller samples.

[15] See Blackwell et al. (2009) for a detailed discussion, especially pages 537-538. Of note, because CEM strictly bounds the level of model dependence, the model specification itself is much less consequential.

Next, we account for the characteristics of the underlying research to ensure that we compare similar work, both in terms of content and quality. We include the *number of authors* and the *share of women coauthors* on the focal paper. Women-mentored F32 recipients may be more likely to coauthor with other women (Holman and Morandin 2019) and, due to potentially smaller networks of their women mentors, in smaller author teams (Woehler et al. 2021). Both could result in fewer citations to protégés' work. Author team size may also capture effective division of labor, presumably improving the odds of producing good research that attracts citations (Wuchty et al. 2007). The average article is written by five authors (solo authorships are the minimum and 10 authors the maximum). The share of women coauthors (excluding the mentor if the mentor was among the coauthors) was 28% on the average paper (min=0%; max=100%). We approximate for the quality of the underlying work via the impact factor (JIF) of the publishing journal (*journal impact factor*). The average JIF of the publications in our sample is 5.9 and varies between 0 (i.e., the journal is not listed in the Clarivate Journal Citation Report) and 70.7 (the New England Journal of Medicine). We add dummy variables for the *publication type* (e.g., article or letter, for details please see Appendix 1.7b) since some types might attract more citations than others and mentors of different gender may pursue different publishing formats. Next, we account for the presence of the mentor in the author team for the possibility that women or men are more likely to engage in direct coauthoring as mentors (*mentor among coauthor*). We also add *publication year* dummies to pick up time trends and differences in citation accrual periods across publications[16].

We furthermore include variables that account for possible and pertinent differences in the nature of the underlying scientific work. First, we seek to estimate citation differentials experienced by protégés only for research that was guided by comparable levels of expertise contributed by the mentors. To that end, we create a variable that captures the *research proximity* between the mentors' historic work and the protégés' current work, calculated as the number of MeSH (Medical Subject Headings) terms on a protégé's publication that coincide with MeSH terms appearing on the mentor's publications within ten years before mentoring the F32 recipient (for details see Appendix 1.8b). The MeSH thesaurus is a controlled and hierarchically organized vocabulary, and the terms are used for indexing articles for PubMed (NIH 2021a) . Importantly, the MeSH terms get externally assigned to articles by specially trained librarians of the National Library of Medicine, thus evading subjectivity by individual authors. Publications by protégés shared about seven MeSH terms (or 51%) of assigned keywords with historic articles of their mentors, on average.

We also create a variable for the expected impact of a given piece of research, again using the MeSH terms that get externally assigned by the National Library of Medicine (*expected citations*

[16] For our subsample analyses, we use 5-year dummies to avoid model convergence issues in smaller samples.

percentile). For each keyword that was assigned to an article published by a protégé in our sample, we determine the number of citations that keyword received across *all* articles published in the same year and indexed in PubMed. Since articles usually get assigned several keywords to accurately describe research content, we take the average number of citations associated with the keywords on the focal article published by the protégé. To norm the scaling of this variable, we rank this average relative to the corresponding distribution of all articles recorded in PubMed for the same year. This percentile ranking effectively captures the likely impact of the protégés' work, that is, the number of citations the article is expected to draw given its content (for details see Appendix 1.8a).

As the last control variable for supply-side effects, we identify the *risk set of citers* as authors working on similar content as documented in publications with the same externally assigned MeSH terms. We retrieve all first and last authors on publications, which were indexed with the same MeSH terms by the National Library of Medicine and that got published within five years to a focal publication. We then use probabilistic gender designation to determine the gender of first and last authors in the risk set of potential citers for each publication (for more details see Appendix 1.8c). We include the size of the risk set as a control variable to capture effects that may stem from women and men catering their research to audiences of different size (logged counts of gender designated authors at risk of citing the focal paper by the protégé).

*Boundary conditions. W*e use four variables to test the boundary conditions relating to the uncertainty and attractiveness of underlying research. To proxy uncertainty, we determine the median age as well as the median number of prior publications of MeSH terms relating to a focal paper (cf. Azoulay et al. 2014). For both *age of MeSH terms* and *prior publications with same MeSH terms* we create dummy variables that turn on if the focal publication's median age of MeSH terms or the median number of prior publications respectively, is lower than the median across all PubMed in the focal year. Of the publications in our sample, 70% are published in rather young fields and around 50% in fields with relatively little prior research.

To proxy attractiveness, we use the *expected citations percentile* variable introduced above as well as a second variable that captures the growth in underlying research content via the share of MeSH terms with an increasing year-on-year growth in publications (*growth in publications with same MeSH terms*). Like for the uncertainty variables, we create dummy variables that turn on if the respective values are above the median value of all publications from the same year and recorded in PubMed. Roughly 45% of publications in our sample are published in areas with relatively high growth and 85% in research areas with above median expected citations.

Table 1.1 Descriptive Statistics

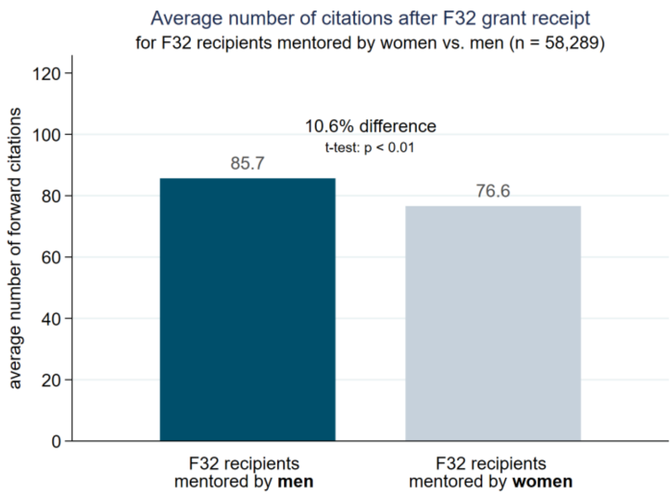
variable name	description	mean	sd	min	max
dependent variables					
citations	forward citations for a given paper	84.04	167.64	0	12,928
citations by articles from close fields'	forward citations for a given paper by articles from same journal category (excluding articles from multidisciplinary journals)	24.56	41.98	0	1,934
citations by articles from distant fields'	forward citations for a given paper by articles from different journal category (excluding articles from multidisciplinary journals)	26.90	60.16	0	4,037
citations by women first authors'	forward citations for a given paper by articles with a woman as first author	21.62	42.32	0	3,243
citations by men first authors'	forward citations for a given paper by articles with a man as first author	30.96	59.25	0	3,523
citations by women last authors'	forward citations for a given paper by articles with a woman as last author	14.35	29.41	0	2,765
citations by men last authors'	forward citations for a given paper by articles with a man as last author	39.73	74.85	0	4,369
independent variable					
woman mentor	dummy variable indicating gender of mentor: 1 if woman; 0 otherwise	0.178	-	0	1
F32 characteristics (recipient and grant)					
woman F32 recipient	dummy variable indicating gender of F32 grant receipient: 1 if woman; 0 otherwise	0.34	-	0	1
host institution's research infrastructure	percentile rank of hosting institution in terms of NIH research funding (0 lowest rank, 100 highest rank)	95.63	12.70	0	100
F32 grant extension	dummy variable indicating F32 grant extension: 1 if grant extended; 0 otherwise	0.117	-	0	1
number of papers before F32 grant	number of papers published by F32 grant recepient before F32 grant receipt	2.77	2.56	0	10
share high JIF pubs before F32 grant	share F32 recipient publications in high impact journals (JIF > 10) before F32 grant receipt	0.072	0.199	0	1
paper count since grant receipt	count variable indicating the number of publications since F32 grant receipt	11.84	12.44	1	161
papers in last year	number of papers published by F32 recipient in previous year	2.26	2.67	0	31
academic cohort''	fiscal year of the F32 grant award	1995	-	1985	2005
mentor characteristics					
number of papers 10 years before F32 grant (mentor)	number of papers mentor published within 10 year before F32 grant receipt	40.26	35.24	0	338
share high JIF pubs 10 years before F32 grant (mentor)	share of mentor publications in high impact journals (JIF > 10) 10 years before F32 grant receipt	0.148	0.151	0	1
number of prior R01 grants (mentor)	number of R01 grants issued to the mentore before F32 grant receipt	4.06	4.32	0	39
research characteristics					
number of authors	number of authors on a given paper	4.65	2.22	1	10
share of women coauthors	share of woman authors (w/o mentor and F32 recipient) on a given paper	0.279	0.335	0	1
journal impact factor	journal impact factor of a given paper	5.92	7.67	0	70.67
publication type'''	type of publication: article, article in press, book, chapter, conference paper, editoroal, erratum, letter, note, review, short survey	-	-	-	-
mentor among coauthors	dummy variable indicating whether mentor is among coauthors: 1 if mentor is coauthor; 0 otherwise	0.421	-	0	1
research proximity	number of MeSH terms on a given paper that also appeared on one of the mentor's publication from within 10 years before F32 grant receipt	6.91	4.04	0	34
publication year''	publication year of a given paper	2001	-	1985	2009
expected citations					
expected citations percentile	percentile rank based on average citations associated with assigned MeSH terms of a given paper in the same year (0 lowest rank, 100 highest rank)	74.87	23.07	1	100
risk set of citers					
number of publications in risk set (log)	natural logarithm of median number of articles with same MeSH terms as focal paper within 5 years of its publication	9.25	0.927	4.41	14.03
number of men first authorships in risk set (log)	natural logarithm of median number of articles with men first authors same MeSH terms as focal paper within 5 years of its publication	8.40	1.00	0	13.37
number of women first authorships in risk set (log)	natural logarithm of median number of articles with women last authors same MeSH terms as focal paper within 5 years of its publication	7.82	1.04	1.39	12.82
number of men last authorships in risk set (log)	natural logarithm of median number of articles with men first authors same MeSH terms as focal paper within 5 years of its publication	8.67	0.999	1.95	13.52
number of women last authorships in risk set (log)	natural logarithm of median number of articles with women last authors same MeSH terms as focal paper within 5 years of its publication	7.42	1.03	1.10	12.52
demand-side boundary conditions					
uncertainty - age of MeSH terms	dunmy variable indicating whether median age of related MeSH terms is below the average across all publications in Pubmed from the same year	0.707	0.455	0	1
uncertainty - prior publications with same MeSH terms	dunmy variable indicating whether median number of prior publications with related MeSH terms is below the average across all publications in Pubmed from same year	0.496	0.500	0	1
attractiveness - growth in publications with same MeSH terms	dunmy variable indicating whether the share of MeSH terms with a year-to-year growth in publications is above the average across all publications in Pubmed from same year	0.451	0.498	0	1
observations					58,291

detailed forward citation data available as of 1996 (n = 42,905); '' median instead of mean reported; ''' for a detailed overview on descriptive statistics for publication types see Appendix 1.7b

1.4 Results

We start by comparing the mean number of forward citations to publications of protégés mentored by women versus men (Figure 1.2). Within the first ten years after receiving the F32 grant, F32 recipients mentored by men receive 10.6% more forward citations on their average paper than F32 recipients mentored by women. In a two-tailed t-test this difference is statistically significant at the 1% level. To better understand where these differences come from, we run a series of multivariate regressions to which we hierarchically add the explanatory variables introduced in the previous section.

Figure 1.2 Descriptive Difference in Citations by Mentor Gender (before Matching)



1.4.1 Supply-side Effects

First, we examine possible supply-side effects, i.e., characteristics of protégés, their mentors, and the offered research that may influence citations. As our dependent variable is a count variable of citations and overdispersed, we estimate negative binomial regression models. An inspection of the data confirms that this model specification fits our data best (see Appendix 1.10). We report incidence rate ratios throughout (IRRs; i.e., exponentiated coefficients). These coefficients can be interpreted as percentage changes. A coefficient of one indicates no effect, coefficients above one indicate positive effects, and coefficients below one negative effects. Since an individual protégé generally (co)authored multiple publications in our sample, we cluster the standard errors in all our models at the F32 recipient level.

The estimations of supply-side effects are depicted in Table 1.2. Consistent with the descriptive evidence presented in Figure 1.2, Model 1 of Table 2 shows that a woman mentor is associated with 10% fewer citations ($p < 0.01$) accruing to protégés' publications, on average. This baseline model is estimated on the full pre-matching sample and includes only publication year dummies as controls.

Table 1.2 Supply-side Analysis

dependent variable: forward citations	NBREG	NBREG	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)	(5)	(6)
independent variables:						
woman mentor	0.902***	0.908***	0.940*	0.945**	0.947**	0.945**
	(0.028)	(0.028)	(0.032)	(0.026)	(0.026)	(0.026)
F32 characteristics (recipient and grant)						
woman F32 recipient		0.997	0.929**	0.953*	0.954*	0.955
		(0.030)	(0.034)	(0.027)	(0.027)	(0.027)
host institution's research infrastructure		1.000	0.998	0.999	0.999	0.999
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
F32 grant extension		1.032	0.974	0.986	0.980	0.975
		(0.038)	(0.047)	(0.042)	(0.042)	(0.041)
number of publications before F32 grant		1.006	1.008	1.010*	1.004	1.005
		(0.006)	(0.007)	(0.005)	(0.005)	(0.005)
share high JIF pubs before F32 grant		1.501***	1.263**	1.127*	1.125	1.115
		(0.139)	(0.123)	(0.081)	(0.082)	(0.081)
publication count since grant receipt		0.999	0.997	0.997*	0.997	0.997*
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
publications in last year		1.015**	1.014*	1.014**	1.018***	1.017***
		(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
mentor characteristics						
number of publications 10 years before F32 grant (mentor)			0.999*	0.999**	0.999**	0.999**
			(0.001)	(0.001)	(0.001)	(0.001)
share high JIF pubs 10 years before F32 grant (mentor)			1.837***	1.039	0.987	0.986
			(0.243)	(0.092)	(0.086)	(0.085)
number of prior R01 grants (mentor)			1.008	1.002	0.997	0.997
			(0.005)	(0.004)	(0.004)	(0.004)
research characteristics						
number of authors				1.049***	1.048***	1.046***
				(0.006)	(0.006)	(0.006)
share of women coauthors				0.988	0.985	0.983
				(0.030)	(0.029)	(0.029)
journal impact factor				1.058***	1.057***	1.057***
				(0.002)	(0.002)	(0.002)
mentor among coauthors				1.092***	1.069***	1.077***
				(0.028)	(0.027)	(0.027)
research proximity				1.013***	1.012***	1.010***
				(0.003)	(0.003)	(0.003)
expected citations						
1st quartile of expected citations (percentile 1-25)					base	base
2nd quartile of expected citations (percentile 26-50)					1.413***	1.381***
					(0.085)	(0.084)
3rd quartile of expected citations (percentile 51-75)					1.524***	1.513***
					(0.092)	(0.092)
4th quartile of expected citations (percentile 76-100)					1.734***	1.725***
					(0.106)	(0.106)
risk set of citers						
number of publications in risk set (log)						1.052***
						(0.011)
publication year dummies	included	included	included	included	included	included
academic cohort dummies		included	included	included	included	included
CEM weights			included	included	included	included
publication type dummies				included	included	included
constant	53.06***	48.77***	80.52***	46.97***	29.84***	19.57***
	(4.968)	(6.382)	(25.804)	(13.425)	(8.990)	(6.395)
observations	58,291	58,291	46,577	46,577	46,577	46,577

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

The second model adds the characteristics of the F32 recipients and their F32 fellowship. While protégés' placing of publications in high-impact journals prior to F32 grant receipt is positively related to the number of citations their average paper receives post F32 grant, the coefficient for women mentors remains almost unchanged (less than one percentage point). These effects are consistent with the previously described homogeneity and competitiveness of the pool of F32 recipients, irrespective of mentor gender.

The third model is based on the matched sample. Besides matching weights, we add mentor characteristics that account for any remaining variance within strata of matched mentors. Matching reduces the citation discount experienced by women-mentored protégés to 6% ($p < 0.10$). In particular, the share of the mentor's prior publications placed in high-impact journals – a possible indicator for the quality of the mentor's research agenda – appears to also influence forward citations to papers published by the protégés. The approximately one third reduction in the effect of women mentors on forward citations between the second and the third model (9% to 6%) underlines the importance of this formative relationship for the evaluation of protégés' work.

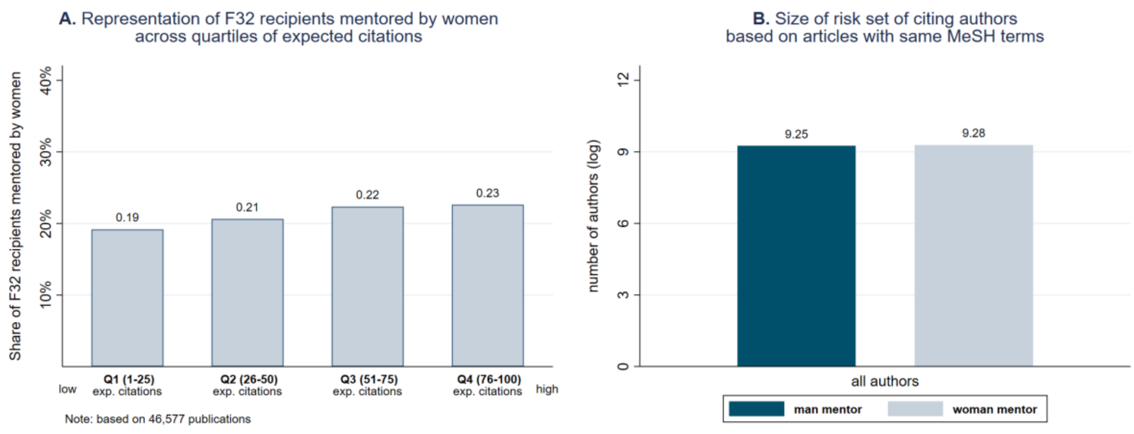
Model 4 examines the effect of key article-level features and the residual influence of women mentors on forward citations. While the woman mentor dummy itself changes marginally (0.5 percentage points), the mentor matters. Coauthoring with the mentor boosts forward citations by roughly 9%, likely due to status conferral and certification of the work. It also pays for the protégé to publish on topics proximate to the mentor's expertise, even net off the mentor coauthoring, though it confers with 1% a relatively smaller citation benefit. It is noteworthy that these mentor-related effects appear largely independent of the mentor's gender as indicated by the stable coefficient for the woman mentor dummy. Variables capturing article level quality – number of authors as a proxy for expertise breadth and the impact factor of the publishing journal – are positively related to forward citations (about 5% increase for one additional author or a one unit increase in the journal impact factor), but also do not change the citation discount associated with women mentors. In other words, the stable citation discount of 5% to 6% ($p < 0.05$) associated with women mentors appears neither related to tractable mentorship style (coauthoring and topic counselling), nor to the quality of the work being produced. Instead, the change in the coefficient on mentor's high-impact publications prior to F32 mentorship between Models 3 and 4 suggests, that mentors use their amassed expertise to spur focal publications of high quality by the protégé. Accounting for article-level features further improved the precision of our estimates. The standard error on the woman mentor dummy, for example, dropped by almost 20%.

Next, we account for the possibility that the citation discount stems from women-mentored protégés selecting into fields that draw fewer citations (Model 5). To model that content choice at a granular level, we make use of the externally assigned keywords (MeSH terms) to life science articles and control for a publication's expected citations given its content. This percentile ranking effectively captures the expected impact of the protégés' offered research relative to all life science research indexed in PubMed. Model 5 shows that there is a sizeable and monotonic return to pursuing research that is poised to attract citations. Relative to pursuing research in the bottom expected citations quartile (base category), there is roughly a 40% to 50% to 75% increase in citations as one selects topics in the second, third, and fourth quartile of the expected citation distribution, respectively. Moreover, accounting for the choice of research area does not materially impact the citation discount associated with women mentors (5%, $p < 0.05$).

Lastly, we control for the possibility that the research of women- versus men-mentored protégés caters to audiences that differ in their size. If, for example, women were to create work for women, work by protégés of women might speak to a smaller "risk set of citers". Model 6 shows that the size of an article's risk set of citers is positively related to its forwards citations. More importantly, though, adding these variables does also not change the citation discount associated with women mentors.

Figure 1.3 provides a visual explanation for the almost invariant effect of mentor gender on citations across Models 5 and 6 when accounting for expected citations and the size of the risk set related to research content offered by the protégés. Protégés of women mentors publish work that is evenly distributed across the spectrum of the expected citations distribution. If anything, the representation of women-mentored work increases slightly as we climb the expected citations distribution (Figure 1.3a). Protégés of women and men also cater to audiences of similar size (Figure 1.3b). Thus, prominent supply-side explanations, namely that women offer work that would be expected to draw less citations or cater to niches, does not feature in our data.

Figure 1.3 Representation of F32 Recipients Across Quartiles of Expected Citations and Size of the Risk Set of Citers for F32 Recipients with Men and Women as Mentors



In all, supply-side factors account for no more than 45% of the identified citation discount[17]. Before turning to the demand-side, it is important to differentiate if the identified effect of mentor gender on citations emerges solely for coauthored work (direct effect) or also transcends to independent work by the protégé (indirect effect). It is, moreover, critical to dissect a mentor gender effect on citations from a generic gender bias against senior coauthors. Thus far, we have estimated the effect of mentor gender on the evaluation of protégés' work pooling papers published with and without the mentor.

Differentiating mentor from coauthor effects. Table 1.3 shows subsample analyses assessing the direct effect of mentor gender on citations through coauthoring (Model 1) versus a transcending effect from mentor to protégé on papers published independent from the mentor (Model 2). We focus in the first model on protégé papers for which the mentor served in the last author position because the prestigious last authorship sends a clear certifying signal. Besides, there are relatively few coauthored papers where the mentor is an interior author and the set of *in lieu* last authors represents a noisy signal that is hardly interpretable in our context. Model 1 and Model 2 both produce a citation discount for protégés' work associated with mentor gender, though we caution a direct comparison of these effects across models due to differences in samples. However, the fact that mentor gender is significantly associated with citations on independent work indicates, that the identified mentor effect distinguishes from a mere coauthor effect (the mentor does not feature on the author byline of papers included in Model 2). To take the distinction of the indirect mentor gender effect versus a generic coauthor effect one step further, we add to Model 2 an explicit control for the gender of the last author on papers published without the mentor (Model 3). This specification offers a direct test of a generic bias against senior women coauthors vis-à-vis of the woman mentor effect. While the woman last author dummy shows a generic effect of 6% fewer citations, the citation discount associated with a woman mentor remains almost as is (7%).

[17] Citation discounts associated with mentor gender of 9.8% (Model 1) minus 5.6% (Model 6) yields 4.2% attributed to supply-side factors, or ~45% in relative terms (i.e., 4.2% / 9.8%).

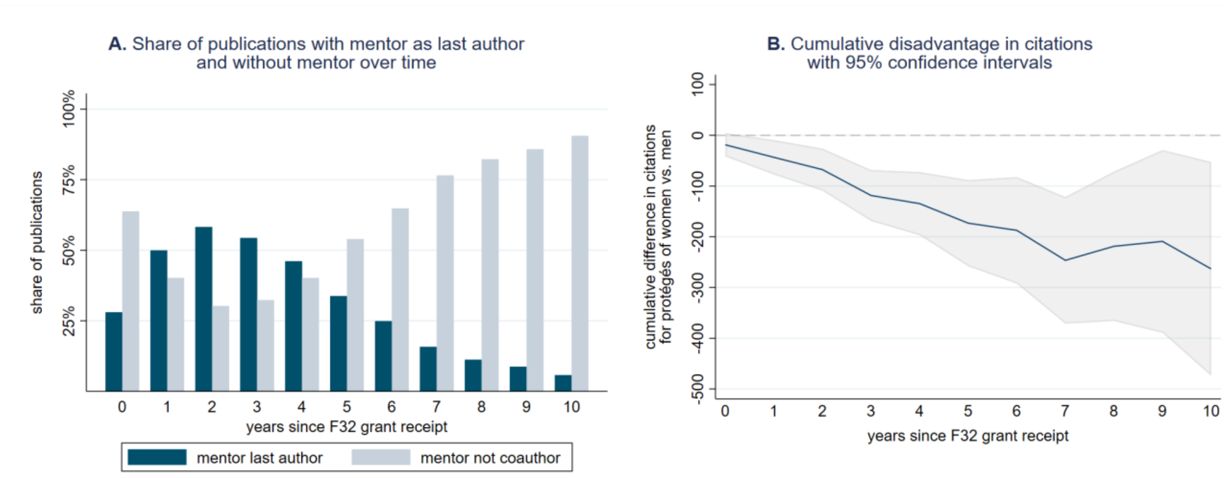
Table 1.3 Direct and Indirect Effect of Mentor Gender

	mentor last author	mentor not coauthor	
dependent variable: forward citations	NBREG	NBREG	NBREG
independent variables:	(1)	(2)	(3)
woman mentor	0.936**	0.928**	0.930*
	(0.031)	(0.035)	(0.035)
woman last author			0.942*
			(0.031)
F32 characteristics (recipient and grant)	included	included	included
mentor characteristics	included	included	included
research characteristics	included	included	included
expected citations	included	included	included
risk set of citers	included	included	included
publication year dummies	included	included	included
CEM weights	included	included	included
academic cohort dummies	included	included	included
constant	10.98***	10.86***	10.90***
	(2.736)	(2.500)	(2.519)
observations	15,286	26,300	26,300

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01;
exponentiated coefficents (IRRs) reported

To better understand the dynamics producing these direct and indirect citation discounts associated with mentor gender, we examine the temporal distribution of the underlying papers and ensuing citations. Figure 1.4a shows, that most papers coauthored with the mentor appear closer to the receipt of the mentored F32 grant, whereas independent papers become more prevalent as protégés' careers progress. Figure 1.4b documents, that the citation discount accumulates for protégés of women versus men over time. Taken together, the data in Table 1.3 and Figure 1.4 are consistent with two possibly reinforcing dynamics, namely that an evaluative discount attached to women mentors (direct effect) transcends to impair the evaluation of protégés (indirect effect), while any initial discount (direct and indirect) can combine to cumulative disadvantages in evaluation over time.

Figure 1.4 Pattern of Coauthoring with Mentor and Cumulative Disadvantage in Citations



1.4.2 Demand-side Effects

We identify demand-side effects as any remaining evaluation discount not explained by the supply-side factors. If anything, this approach likely represents a lower bound on our effect estimates since some of the supply-side factors we controlled for, like gender differences in mentor funding (Witteman et al. 2019), might already by tainted by demand-side biases.

To further contextualize the difficult-to-observe demand-side dynamics that contribute to the identified citation discount, we make use of four boundary conditions that allow us to vary the veracity with which the mentor's signal is likely received by different communities: (1) awareness of the mentor's standing, (2) exposure to women researchers, (3) uncertainty about the work, and (4) attractiveness of the field.

Awareness of the mentor's standing. Table 1.4 differentiates the extent to which mentor gender is associated with forward citations to protégés' work from scholars working in close versus distant fields of research. It stands to reason that scholars close to the focal research conducted by the mentored protégé are more readily susceptible to the informational cue in their evaluations based on their familiarity with the mentor or with the associated research agenda (or both). In support of these conjectures, we obtain varying associations of mentor gender with forward citations from close fields (Model 1) versus distant fields (Model 2). In particular, the citation discount associated with women mentors amounts to 10% if we only consider forward citations from close fields, while it remains around 5% for forward citations from distant fields.

Table 1.4 Demand-side Analysis: Citations from Close versus Distant Fields

	NBREG	NBREG
	(1)	(2)
dependent variable: forward citations	*citations by articles from* ***close fields***	*citations of articles from* ***distant fields***
independent variables		
woman mentor	0.902***	0.946*
	(0.032)	(0.030)
F32 characteristics (recipient and grant)	included	included
mentor characteristics	included	included
research characteristics	included	included
expected citations	included	included
risk set of citers	included	included
publication year dummies	included	included
CEM weights	included	included
academic cohort dummies	included	included
constant	14.23***	2.526***
	(3.389)	(0.602)
observations	31,116	31,116

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996; excluding multidisciplinary research

Exposure to women researchers: Another source of variation in communities' susceptibility to the informational cue inherent in mentors' gender may be differences in the gender composition of the communities themselves. Table 1.5 presents analyses that distinguish the effect of mentor gender by the gender of forward citers, considering first and last authors separately. Importantly, we again control for the risk set of citers, now explicitly accounting for the gender composition of the relevant audience, which allows an examination of manifested versus possible citation patterns. Models 1 and 3 show, that men, irrespective of career stage - here proxied via author position - cite the work of protégés less than one would expect when the mentor is a woman rather than a man. Conversely, senior women also cite work by women-mentored protégés (Model 4) more often than expected, while no such effect can be observed for women first authors (Model 2). Since science continues to be dominated in numbers by men, especially at more senior ranks, there exists an overall evaluation discount due to gendered citations for protégés of women versus men.

Table 1.5 Demand-side Analysis: Citations by Gender of First and Last Author

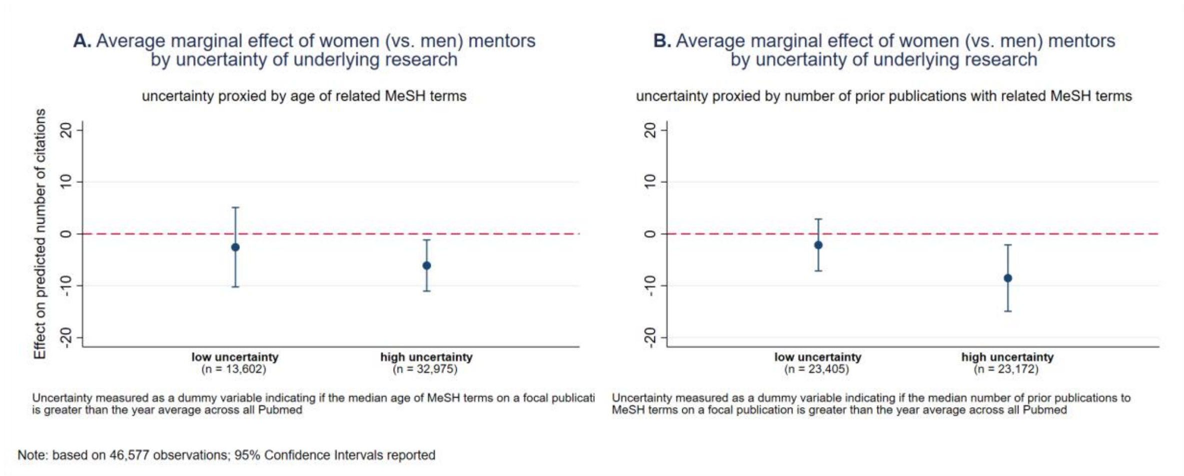
	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)
dependent variable: forward citations	*citations by* ***men first*** *authors*	*citations by* ***women first*** *authors*	*citations by* ***men last*** *authors*	*citations by* ***women last*** *authors*
independent variables				
woman mentor	0.889***	1.002	0.867***	1.121***
	(0.025)	(0.030)	(0.024)	(0.035)
risk set of citers				
number of men first authorships in risk set (log)	1.067***			
	(0.010)			
number of women first authorships in risk set (log)		1.085***		
		(0.011)		
numer of men last authorships in risk set (log)			1.059***	
			(0.010)	
number of women last authorships in risk set (log)				1.099***
				(0.012)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included	included	included
publication year dummies	included	included	included	included
CEM weights	included	included	included	included
academic cohort dummies	included	included	included	included
constant	2.443***	0.484***	2.279***	1.222
	(0.444)	(0.086)	(0.410)	(0.229)
observations	36,113	36,113	36,113	36,113

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data on forward citations available as of 1996

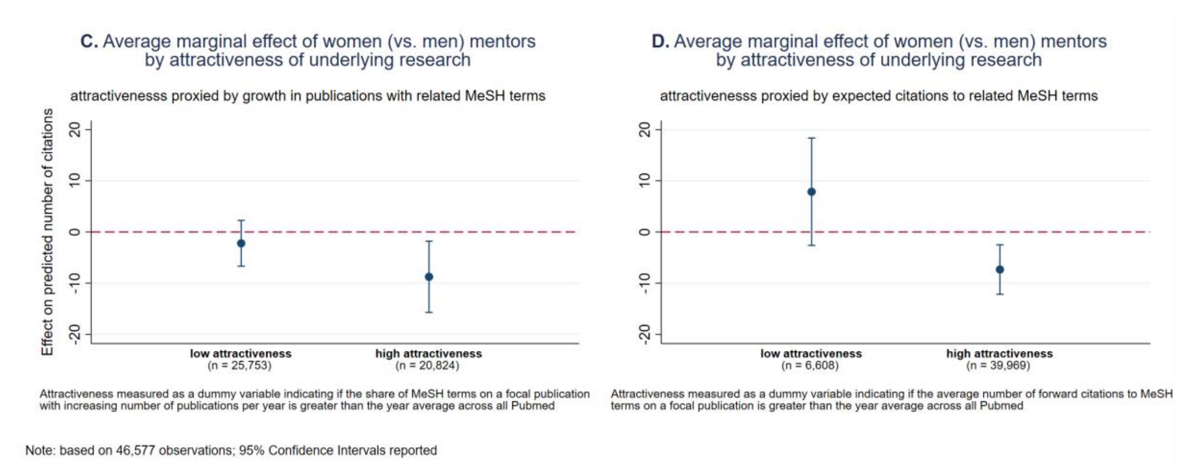
Uncertainty. We argued that susceptibility to the informational cue inherent in mentor gender should be most pronounced when the underlying work is uncertain, leaving more room for surrogates to inform evaluations. Returning to our fully saturated supply-side regression specification (Table 1.2, Model 6), we interact the woman mentor dummy with the two dummy variables that proxy uncertainty via the age and number of prior publications related to the focal research content. We then test the citation differentials associated with mentor gender resulting from these interaction models. Figure 1.5 shows that the citation discount attached to women mentors is more pronounced and statistically distinguishable from zero if the underlying research content is uncertain (Figures 1.5a and 1.5b).

Figure 1.5 Demand-side Analysis: Varying the Woman Mentor Discount with Uncertainty and Attractiveness of Underlying Research

Varying Effect of Mentor Gender with Uncertainty



Varying Effect of Mentor Gender with Attractiveness

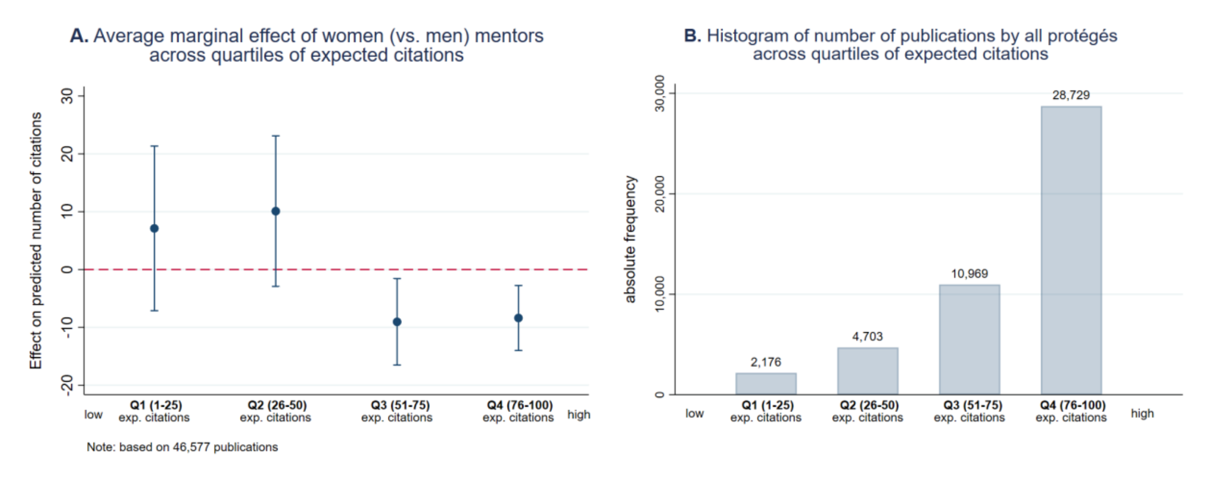


Attractiveness of the field. We further argued that demand-side effects are accentuated in attractive fields, where the demand for research is accelerating and competition is tense. Analogous to testing uncertainty as a boundary condition, we return to our fully saturated supply-side regression specification (Table 1.2, Model 6), and interact the woman mentor dummy with the two indicators for attractiveness of the field, i.e., growth and expected citations. We consistently find an evaluative discount afflicting work by protégés of women versus men when the underlying research is relatively more attractive (Figures 1.5c and 1.5d).

Considering the highly skewed returns to science, especially at its frontier, we continue by exploring the linearity of the observed citation discount for research that is expected to attract many citations. We therefore rerun the interaction model shown in Figure 1.5d with quartiles of expected citations as implemented in the supply-side analysis instead of the indicator variable. Figure 1.6a confirms that protégés mentored by women experience a citation discount on research articles that are poised to draw above median citations. The citation discount in the upper two quartiles is about 10% (8 citations less for women mentors relative to 80 citations on average) and statistically distinguishes from a null effect (red line). By contrast, we cannot discern a citation discount in the bottom two quartiles. If anything, there is a positive trend in citations for women-mentored protégés in less impactful research areas. Of note, we find similar effects if we use quintiles, deciles or a continuous specification of the expected citations variable (see Appendix 1.14g).

Importantly, the citation discount in the upper part of the expected citations distribution is unrelated to protégés' abilities, the abilities of their mentors, or the content of their research as we account for these counterfactuals. In other words, this demand-side citation discount exists net off considered supply-side effects. Figure 1.6b shows that this discount affects most of the work (approx. 85% of papers) produced by protégés.

Figure 1.6 Demand-side Analysis: Citation Discount for Women Mentors Stratified by Expected Citations and Histogram of Publications across Quartiles of Expected Citations



In summary, we first document that more than half of the observed citation discount of protégés mentored by women is driven by demand-side dynamics in our data. Testing four boundary conditions, we find support for theoretical arguments pertaining to biases in evaluations, which are inherently difficult to measure. The evaluative discount is driven by researchers close to the focal work, men rather than women, and particularly pronounced for uncertain work in attractive fields.

1.4.3 Additional Analyses and Robustness Checks

We conduct a series of additional analyses and robustness checks summarized in the Appendix. First, we probe whether the identified citation discount associated with women mentors also stratifies with the gender of the protégé. Although this is not germane to our research question, any stratification effect would inform who is most afflicted by the demand-side bias against women-mentored work. Looking at the locus of the citation discount detected in the previous analysis – protégé research poised to draw citations – we run both split sample and interaction models. We find that the citation discount associated with women mentors equally applies to both men and women F32 recipients (Appendix 1.1a). Turning to gendered forward citations, a negative gradient in the citation discount can be observed: fewer citations for women versus men mentors and fewer citations for women versus men protégés (Appendix 1.1b).

Next, we investigate how the matching in service of comparing equally qualified mentors (that only differ with respect to gender) alters the representation of mentors and their protégés in our sample relative to all F32 program participants we started with (Appendix 1.12). We run a logit regression at the level of the mentor-protégé dyad with a “final sample” dummy as dependent variable and mentor and protégé characteristics as independent variables. Women mentors are overrepresented in the final sample with a 34x higher odds of inclusion (marginalizing the relevance of the other coefficients). This pronounced oversampling of women mentors is expected given the high imbalance towards men in the mentor set and mentor gender being the treatment variable for our matching. Moreover, the most prolific mentors in our data are men who lack observationally comparable women mentors for matching. Women accounted for 12% of doctoral degrees in the biomedical sciences in the 1960s and no more than 30% in the 1980s, invariably constraining the pool of very experienced women mentors for our F32 cohorts starting in 1985 (AAUW 2015). There may also be an element of the “glass ceiling” effect in this data, whereby senior women face disadvantages in access to funding that helps penetrating the most prolific ranks in the resource intensive life sciences. Irrespective of the precise driving forces, matching out prolific and highly visible men mentors yields conservative estimates of the identified citation discount attached to women mentors in our main analysis.

Next, we rule out two alternative explanations for the observed citation discount. First, we establish that the observed effect cannot be explained by differences in self-citation behavior between men and women mentors or their protégés (Appendix 1.13a). In line with recent research (Azoulay and Lynn 2020), we find no evidence for gender differences in self-citations leading to the observed discount. Second, we address the possibility that men and women mentors refer their protégés to last authors that are more or less able to attract many citations. More specifically, we look at a subsample of articles where neither F32 recipient nor mentor are last authors and probe whether characteristics of the author who instead holds this prestigious position, such as gender or quality and quantity of prior publications, explains the observed discount for women mentors. Appendix 1.13b shows that this is not the case. In other words, the ability of men or women mentors to refer their protégés to certain coauthors does not explain the observed citation discount beyond all the research characteristics we already control for. This intuition is further supported by a descriptive comparison of these last authors' characteristics by mentor gender (Appendix 1.13c).

We conclude the additional analyses with a series of robustness checks, summarized in Appendix 1.14. First, we verify that the supply-side dynamics established in Table 1.2 also hold if we fix the time window within which publications can accrue citations. The results obtained in Appendix 1.14a, using 10- and 5-year forward citations as a dependent variable on a subset of articles for which this information is available, are very similar both in terms of effect size and significance levels to the main effects presented in Table 1.2.

In a second robustness check, we employ a different matching technique, namely propensity score matching with four nearest neighbors (mimicking the ratio obtained from the CEM approach). As shown in Appendix 1.14b, the results remain robust under this matching specification. Additional checks with a different number of nearest neighbors yield the same results and are available from the authors. In other words, the results of our main analysis are not an artifact of the employed coarsened exact matching approach.

In the third robustness check, we probe alternative model specifications to the negative binomial distribution that also account for the skewness of forward citations. Since a few publications typically attract most citations (Lotka 1926), the observed citation discount attached to women mentors might be driven by a few highly cited publications that may systematically be more often produced by men mentors and their protégés. To test for this possibility, we rerun the demand-side analysis in OLS regressions with logged citations as dependent variables. Logging the dependent variables consolidates the entire distribution and reduces the lever of extremely large values. As shown in Appendix 1.14c our results remain robust with this model specification. Of note, these alternative specifications and the obtained stable results also reflect the fact that the chosen matching procedure is fairly immune to model specification (Blackwell et al. 2009).

In three last robustness checks, we revisit some sample design choices. First, we limit the analyses to F32 recipients for whom the identified mentor appeared on all publications citing the F32 grant as a last author (Appendix 1.14d). Second, we alter the period considered relevant for the influence of mentorship from ten to five years, only including publications that appeared within five years after F32 grant receipt (Appendix 1.14e). Third, we vary the probability threshold for gender designation of citing authors (Appendix 1.14f). Again, the results of these robustness checks echo our main analyses.

1.5 Discussion and Conclusion

We started with the question whether the gender of mentors affects the evaluation of their protégés' work. To answer this question, we investigated the citation records of highly qualified postdocs with a mentored research fellowship of the NIH.

We find that mentorship is generally beneficial for the evaluation of protégés' work, indicated by an increase in citations when the mentor coauthors a paper. Nevertheless, the work of women- relative to men-mentored protégés draws 10% fewer citations on average. This citation differential is not only statistically but also economically relevant. Past research has shown, for example, that citation differentials of similar magnitude as we document here translate into one additional year expensed on tenure clocks in the life sciences (Lerchenmueller and Sorenson 2018).

We further show that the citation differential afflicts 85% of protégés' productivity, representing work that is poised to attract citations, and that supply-side factors could account for no more than 45% of the mentor gender effect on citations. Net off supply-side differences, we attribute a larger proportion of the evaluation discount to demand-side dynamics. A closer look at the boundary conditions of demand-side effects reveals that the evaluation discount from mentor to protégé is most pronounced for work with greater underpinning uncertainty yet in highly attractive fields. These discounts combine to cumulative disadvantages in evaluation. Young topics that feed nascent but dynamically growing fields appear to have the science community most susceptible to the informational cue inherent in mentor gender when evaluating protégés' work. The effect originates from men underciting women's work. In addition, we dissect the citation discount associated with women relative to men mentors clearly from a generic bias against women as senior coauthors and show that the effect of mentor gender on evaluations materializes even on papers published by the protégés without the mentors.

We make several contributions to the literature on mentoring. First, our results indicate that there is a transfer of both supply-side factors and demand-side factors from the mentor to the protégé. Transfers of demand-side biases have hitherto escaped researchers' attention in this context. Second, our results confirm that isolating demand-side mechanisms from alternative supply-side explanations is challenging (Fernandez-Mateo and Fernandez 2016). Mentors' research infrastructure, a supply-side factor, might be impacted by gender biases in access to funding, a demand-side factor, entailing a possible misclassification of the driving effect, for instance. Or we find that protégés' cumulative disadvantages in recognition are most pronounced in fields characterized by uncertainty and high attractiveness. If protégés anticipate disadvantages in these fields, they may select into more established niche fields to avoid the demand-side discount, thereby triggering a supply-side discount. To account for these interactions, we need improved theoretical frameworks that do not simply juxtapose supply-side and demand-side factors but view them in an integrated way. Third, while extant literature conceptualizes supply-side factors exclusively as choices, our findings indicate that supply-side effects for protégés at least in part stem from gender differences in mentors' observable track records prior to mentorship. In that sense, both mentor and protégé can only partially correct the underpinning penalty with decisions about supply at the time of the mentor-protégé relationship. Future work may, therefore, differentiate supply-side reasoning into aspects that can reasonably be influenced by the protagonists versus not.

Our study also sheds light on hitherto concealed dynamics of gender gaps in science. First, we complement the existing literature by offering a closer look at how gender biases transcend to collaborators (here: the protégé). The analysis of gender differences in later stages of women's careers should not only consider the current career stage, but also the past, including both current and previous collaborators whose influence on careers may vary with discipline. Second, we add to a line of research that draws our attention to career barriers that women face early (Lerchenmueller and Sorenson 2018, Sterling and Fernandez 2018, Hoisl et al. 2022), relative to women hitting "glass ceilings" when reaching more senior ranks. Due to the high importance of cumulative effects, which we know since Merton (1968), this aspect should also be deepened in future research.

We interpret citations as evaluation by the science community. However, citations are also traces of knowledge production and knowledge dissemination (Katila and Ahuja 2002, Von Wartburg et al. 2005, Verspagen 2007). Knowledge flows should ideally be objective, with the best ideas spreading and being reused. If these knowledge flows are biased in ways that favor the spread or reuse of ideas from some groups more than others, this can be problematic. This is true not only for the careers of individual scientists, but also for scientific progress in general.

As with most empirical undertakings, our study involves trade-offs and limitations. First, we cannot quantify the degree to which either the F32 recipient has been able to influence mentor allocation, or the mentor has been able to cherry pick protégés. This two-sided matching dynamic is a notorious challenge in research on tie formation (Azoulay et al. 2017), and we do not claim that our approach is immune to this challenge. But we submit that our empirical setting – protégés of homogenous caliber mentored by observationally equivalent mentors – mitigates sorting concerns to the extent possible because this two-sided matching problem becomes pronounced with quality heterogeneity in the sets of actors who seek to match. Second, we do not observe mentoring activities or quality, i.e., the extent to which the mentor puts time and resources into supervising the protégé. The fact that the mentors are reputable scientists and that the mentor is a decisive factor for a successful F32 fellowship, make us confident that the overall effort mentors dedicate to their protégés is high. We also have no grounds to surmise that mentorship effort would systematically differ by gender. Third, in analyzing the effect of mentor gender on their protégés at the publication-level, we draw inferences about a focal actor, the F32 recipient, who mostly works in team settings. We acknowledge the common attribution problem when studying individuals who work primarily in teams, such as in academia (Wuchty et al. 2007); individual's evaluations are often influenced by evaluators' perceptions of their colleagues in teams. However, the choice of individual publications as the level of analysis allows us to control for potentially confounding team characteristics such as team size and the proportion of female coauthors. Therefore, there is no reason to believe that the effects we found for the protégé are incorrect. Finally, while we can document that men undercite women-mentored work given the risk set of citers, we cannot settle if this is the result of lack of awareness about the work or due to (un)conscious bias. We do, however, offer adjudicating analyses, i.e., we show that the citation discount is pronounced in communities closer to the focal research, among men rather than women, and when the science is more uncertain yet attractive in terms of growth and expected citations.

Despite these limitations, our results allow us to phrase indicated implications for policy. We recall that the citation discount more likely emerges from communities closer (versus distant) to the focal research. Therefore, it seems advisable to review measures for increasing awareness within such communities, including on relevant conferences, within professional societies, or at the level of domain journals. Measures may include equitable representation of work in conference programs, panels, and keynotes. At the journal level, editorial coverage that highlights important contributions to the field could also consider dimensions of gender equity that extend to protégés of women. Institutions may also use increased awareness for more equitable hiring and promotion decisions. Our results imply that citations do not always accrue equitably. This should lead to reflections on how academic performance is evaluated more generally. Gender may not be the only ascribed attribute that is associated with a discount from which citation measures suffer. Furthermore, we must keep in mind that promotion of gender equity begins much earlier, usually during childhood and school years.

Besides possible measures on the institutional side, women and their protégés might also have levers at their disposal for increasing awareness. Scholars have, for example, started to examine how women can positively influence their career progress by promoting their accomplishments more actively (Bikard and Fernandez-Mateo 2018, Lerchenmueller et al. 2019, Exley and Kessler 2022). However, the suggested institutional and individual measures do not exempt individual scientists from reflecting on their citation behavior. Creating awareness of the potential benefits of such self-reflection could be an important start and can be supported by the institutions of science in frugal ways, for example, through anti-bias trainings (e.g., Kuo 2017).

The measures just listed are short- to medium-term measures. However, there are also longer-term tasks. Our results indicate that bias plays an important role. As a possible reason, role incongruity theory would suggest a perceived incongruity between personality traits or skills attributed to women (e.g., lacking ambition) and the personality demands of specific roles or positions in science (e.g., analytical thinking) (Williams and Best 1990, Ritter and Yoder 2004), leading to prejudices. The consequences of such prejudices include the formation of lower expectations about women's performance and higher expectations of failure compared with men (Heilman 1983). Such stereotypes and outdated understanding of roles must be overcome. As gender biases are deeply rooted in the culture (Correll 2004), the importance of policy intervention ought to be emphasized over reliance on bottom-up approaches.

Against this backdrop, the science community may need to reconsider the role of mentorship for developing the next generation of scientists in prevailing conditions. If prejudices against women do not get addressed, calls for women mentoring and acting as role models (e.g., Del Carpio and Guadalupe 2022) seem ambivalent. On the one hand, literature has documented the importance of women role models for influencing early-career researchers in their decision to consider careers in science, particularly young women (e.g., Ginther et al. 2020). On the other hand, pre-existing gender biases against women mentors feed forward in mentored protégés once they have embarked on the science career. Beyond individual career concerns, these circumstances also threaten scientific pluralism. If protégés of women are unduly stalled in their progress, so would be the dissemination of women’s research agendas more broadly.

The question remains to what extent our results are transferable. The highly competitive F32 program, our empirical setting, is a unique context. Yet, there is no reason to believe that our results are not generalizable to other mentor-protégé relationships. It is likely, that we would obtain higher supply-side discounts for mentor-protégé relationships, if neither the mentor nor the protégé belonged to one of the top percentiles of the respective quality distributions. Less able mentors on average have less to give and less able protégés on average can absorb less of the given. On the demand-side, the magnitude of the expected discounts is not entirely clear. On the one hand, the less able actors could be penalized even more significantly because the research community trusts them even less. On the other hand, the fact that less able actors are less known in the research community could mean that the long-term impact is smaller, because if the mentor is no longer a coauthor, the protégé will no longer be associated with the mentor.

Transferring our findings to mentor-protégé relationships outside of academia also seems possible. Consider, for example, mentor-protégé relationships in consulting. Upon joining a consulting firm, a junior consultant is assigned a mentor for a certain period, usually a partner who advises, teaches, and supports the junior consultant in advancing his or her career. The supply- and demand-side effects we identify may also apply to these or similar labor relationships (Ibarra 1992, Bohnet et al. 2016, Botelho and Abraham 2017). We leave it to future research to examine mentor-protégé relationships in other contexts as well.

In conclusion, we provide the first evidence of mentor gender affecting the evaluation of protégés' work. Since the evaluation discount for protégés of women arises early and accumulates over time, the identified dynamics feed the gender gap in science and, potentially, in other professional labor markets.

2 Knowledge Recombination in Teams with Women versus Men Stars

(This chapter is based on a paper coauthored with Mona Reber and Himani Singh)

2.1 Introduction

Substantial scholarly interest has been devoted to star knowledge workers, who disproportionately exceed their peers in terms of their contribution to organizational knowledge creation (e.g., Zucker and Darby 1996). Stars profit knowledge creation in organizations by virtue of their unique individual contributions, knowledge spillovers (e.g., Azoulay et al. 2010), and superior access to resources (e.g., Groysberg et al. 2008). The creation of knowledge relies to a large extent on the recombination of diverse existing knowledge elements (Schumpeter 1934b, Nelson and Winter 1982, Fleming 2001) and is mostly a team endeavor (Kogut and Zander 1992). The benefits of stars for the recombination of knowledge in teams, such as their creative synthesis abilities (Liu et al. 2019), are well established. However, recent evidence suggests that stars might also induce some adverse effects on knowledge recombination in teams, mainly due to increased focus on the star and development of star-centric routines (Grigoriou and Rothaermel 2014, Kehoe and Tzabbar 2015, Chen and Garg 2018, Morris et al. 2021). Considering these positive and negative effects of stars on knowledge recombination in teams, it is important to identify factors that determine the extent of both costs and benefits[18].

We identify the gender of a star as a determinant for how star knowledge workers affect knowledge recombination in teams. Much of the literature so far assumes that star effects generalize to all stars. Yet, what we know about stars does not account for differences resulting from salient star characteristics. In particular, since the majority of stars tend to be men, partly due to lower representation of women among the top ranks of many knowledge-based professions (Center for American Progress 2018, U.S. Bureau of Labor Statistics 2021), our understanding of stars' contribution to creative knowledge work may very well be restricted to men stars. However, men and women (star) knowledge workers might play remarkably different roles in team settings. We therefore seek to answer the following research question: do teams with women versus men stars recombine knowledge more broadly? We focus on the breadth of knowledge recombination, as it represents an extremely important outcome when it comes to technological and breakthrough

[18] It is not our intention to argue that certain factors lead teams with stars to produce worse recombination outcomes compared to teams with non-stars. On the contrary, we agree with prior findings that stars generally achieve superior recombination outcomes (e.g., Grigoriou and Rothaermel 2014) and expect this to generalize to teams with stars. At the baseline level, the benefits stars present for availability and integration of heterogeneous knowledge are significant and may elevate combinatory performance far above what is typically achieved by knowledge worker teams. Our data echoes this, as teams with a star predictably recombine knowledge more broadly than teams composed exclusively of non-stars.

innovation (Gruber et al. 2013). Recombination breadth captures the degree to which diverse knowledge elements are integrated and is thus crucial for creativity and innovation (Schumpeter 1934b, Nelson and Winter 1982, Fleming 2001). The emergence of radical innovations and even entirely new industries hinges on the ability to effectively merge technological and knowledge categories, as evidenced, for example, in the emergence of the optoelectronics industry from the fusion of electronic, crystal, and optics technologies (Hargadon 1998).

Whether the presence of a woman star affects the breadth of knowledge recombination more positively or negatively than the presence of a man star is not obvious. Knowledge recombination breadth can be theorized as a function of both the knowledge available to a team and the processes that allow this knowledge to be integrated. On the one hand, women are typically subject to discrimination and experience status discount compared to men (Ridgeway 1991, Ridgeway and Diekema 1992). This discount may put a woman star's entire team at a disadvantage by reducing access to networks, resources, and, consequently, knowledge available for recombination (Perry-Smith and Mannucci 2017, Liu et al. 2019). On the other hand, gender differences in the perception, characteristics, and behavior of women and men (Eagly 1987, Eagly and Karau 2002, Hsu et al. 2021) may facilitate team processes that are crucial for the successful integration of diverse knowledge components (Harvey 2014, Liu et al. 2019). We aim to investigate whether teams with a woman star recombine knowledge more or less broadly than teams with a man star.

We hypothesize that the breadth of knowledge recombination in teams should benefit more from the presence of a woman than a man star. The combination of knowledge elements across categories requires the ability to integrate diverse information, expertise and perspectives into a common creative output (Harvey 2014). The integration of these elements, which we expect to work better in teams with a woman than a man star, benefits knowledge recombination breadth (Hargadon and Bechky 2006, Liu et al. 2019), whereas the exceptionally high levels of knowledge typically available to teams with men stars can exacerbate the costs associated with the presence of stars on teams. These factors should, on the whole, benefit knowledge recombination breadth in teams with women versus men stars. We further examine teams' collaboration history as a boundary condition that impacts the relative importance of knowledge availability and integration. Specifically, we hypothesize that the positive effect of women stars on recombination breadth is more pronounced for teams that have never collaborated before, since such teams lack established systems of organizing and exchanging knowledge (Majchrzak et al. 2007, Argote et al. 2018), and thus likely find knowledge integration more challenging.

To investigate the proposed relationships, we look at US patent inventors. Inventors are highly representative of knowledge workers, since they are directly involved in the generation of new knowledge and represent a relatively homogenous group of employees engaged in creative tasks (Arrow 1972, Drucker 1999, Hoisl and Mariani 2017). Our dataset consists of patents filed by inventor teams at the US patent office in the period of 1990-2010. We follow the literature and identify star knowledge workers based on their exceptional individual inventive performance (e.g., Tzabbar and Kehoe 2014). We extract patents of teams that involved these star inventors and match teams involving a woman star to similar teams involving a man star using coarsened exact matching (CEM). Finally, we compare how broadly the teams recombine knowledge across technological boundaries in their patented inventions, using knowledge recombination breadth as our dependent variable (Gruber et al. 2013) and the team as our level of analysis. We employ several robustness checks including an instrumental variable approach and alternative dependent variables to verify our results. We find robust empirical evidence suggesting that teams with women stars combine knowledge more broadly than teams with men stars. In line with our theoretical arguments, this effect is also found to be more pronounced in teams that have never collaborated before compared to teams that have a history of working together.

Our research contributes to the theoretical understanding of the role played by stars in the creation of knowledge in teams in three ways. First, we examine how a distinct star characteristic, i.e., the star's gender, influences the extent to which teams benefit from the presence of stars. While existing research on star performers is largely built around men stars, we examine gender differences that may impact how the beneficial and adverse effects of stars documented by prior literature manifest in the creation of knowledge. Second, we attempt to resolve a contradiction emerging from the literature on status and gender roles, to theorize how gender differences between stars may impact the availability and integration of diverse knowledge in teams. Third, we extend literature on the social perspective on creativity and knowledge creation, by showing that team members' collaborations with women and men stars are likely to produce different knowledge outcomes due to differences in how team members communicate and interact with women and men stars.

2.2 Theoretical Background and Hypotheses

2.2.1 The Role of Stars in the Recombination of Knowledge in Teams

Recombination of existing knowledge and ideas is a critical part of knowledge creation in organizations, and its importance for radical innovation is indisputable (Schumpeter 1934b, Nelson and Winter 1982, Fleming 2001, Xiao et al. 2022). Knowledge recombination comprises the development of new intellectual capital by exchanging and integrating knowledge elements, for instance, in the form of concepts, artefacts, perspectives and ideas (Grant 1991, Nahapiet and Ghoshal 1998, Xiao et al. 2022). Recombining knowledge across boundaries not only increases the quality and impact of an invention (Fleming 2001, Nerkar 2003, Ferguson and Carnabuci 2017), but creative outputs that combine distant knowledge possess greater potential for competitive advantage, varied applications, and technological breakthroughs (Hargadon 1998, Nerkar 2003).

In teams, the breadth of knowledge recombination can increase both when team members possess and have access to heterogenous knowledge bases (Singh and Fleming 2010), and when team processes function in ways that facilitate the integration of such diverse knowledge through exchanges, synthesis, and cross-fertilization (Paulus and Nijstad 2003, van Knippenberg et al. 2004, De Vries et al. 2006, Baer et al. 2014). This implies that a team's capacity to recombine knowledge depends on both the overall knowledge stock available to the team, as well as the team processes that allow members to effectively integrate the available information (Faraj and Xiao 2006, Singh and Fleming 2010, Harvey 2014).

As individuals with exceptionally high performance relative to their peers and broad external visibility (Groysberg et al. 2008, Oldroyd and Morris 2012), stars exert significant influence on knowledge recombination in teams. In the following, we organize these effects based on whether they relate to the team's stock of heterogenous knowledge available (*availability of knowledge*) or to the team's capacity to successfully integrate this knowledge stock (*integration of knowledge*).

Stars increase teams' available knowledge stock in three main ways. First, they contribute their own unique and superior skills, explicit and tacit knowledge, and expertise (e.g., Zucker and Darby 1996, Lacetera et al. 2004, Rothaermel and Hess 2007). Given stars' superior productivity and impact, these are likely to be significant additions to the team. Second, due to their pronounced organizational status, reputation and social visibility, stars enjoy access to larger social networks and greater organizational resources. These resources can be used to access external knowledge that may otherwise not be readily available to teams (Oldroyd and Morris 2012, Li et al. 2020). Finally, collaborating with stars leads to positive knowledge spillover to non-star team members, which can raise the cumulative knowledge stock of the team, albeit not necessarily enhance the diversity of knowledge available (Oettl 2012, Kehoe and Tzabbar 2015).

In addition, stars impact teams' knowledge integration processes in two key ways. First, stars have been shown to play a central role in creative synthesis in teams, often by identifying and filling knowledge gaps, building consensus, and facilitating the simultaneous consideration of diverse ideas and specialized knowledge (Liu et al. 2019, Li et al. 2020). Second, stars can paradoxically also impede teams' knowledge exchange and integration, due to the development of star-centric routines and information overload brought about by their excessive social visibility and organizational status (Oldroyd and Morris 2012, Tzabbar and Vestal 2015, Chen and Garg 2018, Prato and Ferraro 2018, Li et al. 2020).

To summarize, stars are known to affect team knowledge recombination in both positive and negative ways. In the subsequent sections, we review literature on gender differences to establish that these effects may not be homogenous for men and women stars.

2.2.2 Availability of Knowledge in Teams with Women versus Men Stars

A large amount of evidence shows that, on average, women have lower status than men in comparable positions in a wide range of organizational contexts (Smith 2005, Taylor 2010, Glass and Cook 2016, Lee et al. 2022, Weck et al. 2022). Gender serves as a diffuse status characteristic that leads to perceptions of higher competence and influence for men (Ridgeway and Diekema 1992, Carli and Eagly 1999). Because gender is a highly salient characteristic in organizations (Acker 1990), status differences attributed to gender signify not only relative positioning in social hierarchies, but also access to prestige and power (Bunderson 2003, Berger et al. 2014). Extending these findings to stars, men stars are likely to enjoy higher status and visibility than comparable women stars due to gender-driven discounting of women stars' achievements. In turn, men stars' higher status may imply greater control over teams' resources and greater social prestige than comparable women stars would have (Blau 1964, Ridgeway and Erickson 2000, Anderson et al. 2001).

The gender difference in the external status of stars may affect knowledge recombination breadth by impacting teams' ability to access remote external knowledge[19]. This is because social network size and centrality as well as the capacity to undertake potentially time- and resource-intensive search processes are key determinants of the ability to obtain remote knowledge (e.g., Perry-Smith and Shalley 2003, Kneeland et al. 2020). Moreover, status is believed to be transferable, such that an actor's status "leaks to" or impacts that of her/his associates (Podolny 2005). That is, association with high status actors routinely benefits the status and organizational outcomes of low status individuals who affiliate with them (e.g., Shapiro 1983). Thus, gender differences in stars' status are likely to leak to fellow team members, such that teams with men stars may enjoy cumulatively higher status than teams with women stars, thereby further exacerbating differences in access to resources and external knowledge.

[19] Our arguments assume homogenous teams, except with respect to the star's gender. We thus assume that teams are relatively homogenous when it comes to the amount of knowledge available internally (e.g., due to team size, diversity, or experience). This is due to our interest in centering the role of a star's gender in teams' knowledge creation, given that other work has extensively focused on salient aspects of team composition, such as gender diversity and demographic fault lines (e.g., Østergaard et al. 2011, Díaz-García et al. 2013, Faems and Subramanian 2013).

2.2.3 Integration of Knowledge in Teams with Women versus Men Stars

Literature in the field of psychology documents differences between men and women in terms of perception, characteristics, and behavior. Several meta-analyses and cross-cultural comparisons indicate significant gender differences in personality traits, with women reporting higher levels of agreeableness and warmth, and men reporting higher levels of assertiveness (Costa et al. 2001, Lippa 2008, Schmitt et al. 2008, Lippa 2010). This is consistent with the gender roles literature, which demonstrates that women are routinely expected to behave in warm and communal rather than agentic ways, while the opposite is true for men (e.g., Eagly 1987, Eagly and Karau 2002, Hsu et al. 2021). Similarly, women are, on average, found to be more interpersonally sensitive, exhibit greater perspective-taking, and have more people-oriented interests than men (LePine et al. 2002, Galinsky et al. 2006, Su et al. 2009, Williams and Polman 2015). These differences have also been found to generalize to women who occupy positions of power and visibility in organizations and who have advanced up the career ladder (Eagly et al. 2003, Rosette and Tost 2010, Adams and Funk 2012, Post 2015).

Extending these differences to stars, women stars can be expected, on average, to display more interpersonal and socially oriented characteristics and behaviors than men stars. In turn, women stars' presumed display of such characteristics and behaviors may affect knowledge recombination breadth by strengthening team processes that play a major role in the integration of knowledge. Teams that undertake creative knowledge work often need to configure diverse knowledge, dissimilar expertise and potentially contradictory perspectives (Hargadon and Bechky 2006). In order to do so, they must communicate and collaborate in ways that are conducive to both the relatively uninhibited sharing of unique knowledge as well as collective sensemaking (Harvey 2014, Mannucci 2017, Liu et al. 2019). In this respect, characteristics and behaviors that indicate mutual respect, social sensitivity and interpersonal competence have been repeatedly found to facilitate knowledge integration in teams (Hargadon and Bechky 2006, Wuchty et al. 2007, Woolley et al. 2010, Grigoriou and Rothaermel 2014).

The lower status of women stars compared to men stars may also have implications for internal team knowledge processes. Status-induced hierarchical differences in teams can be detrimental to team processes as they constrain the integration of knowledge, especially of knowledge that contradicts or diverges from that of the high-status individual (Van der Vegt et al. 2010, Anthony 2018). Large status differentials in teams with stars are associated with an increasing presence of star-centrism (Bendersky and Hays 2012, Oldroyd and Morris 2012, Tzabbar and Vestal 2015, Kehoe and Bentley 2021). Due to smaller perceived status differentials between the star and the non-star team members, teams with women stars may be less constrained by the problem of star-centrism and hierarchical segregation than those with men stars, thereby avoiding excessive reliance on stars' knowledge base and facilitating the integration of diverse knowledge across the team (Hargadon and Bechky 2006, Wuchty et al. 2007, Harvey 2014).

2.2.4 Hypotheses

In the previous sections, we established that the benefits of men stars for knowledge recombination breadth in teams predominantly derive from their capacity to increase the overall knowledge available, while the benefits of women stars mainly relate to knowledge integration processes. We now consider the relative importance of both to derive whether teams with women or men stars are better when it comes to knowledge recombination breadth. In the specific context of star knowledge workers in teams, we argue that women stars' benefits for knowledge integration outweigh men stars' benefits for knowledge availability.

Since stars are a special group of knowledge workers that enact several times the productivity of others, women stars still benefit from high status, external visibility, and resources due to their star status (see Asgari et al. 2021), such that their teams can likely access greater amounts of diverse knowledge than would be the case for a more general sample of knowledge workers. Thus, teams with both women and men stars should have a relatively diverse corpus of knowledge elements available to them for recombination, though teams with men stars likely experience a comparative advantage. In turn, knowledge availability can be seen to represent the opportunity set of all possible knowledge elements available for recombination. However, in order to realize the opportunity for diverse knowledge combinations represented by knowledge availability, knowledge integration capabilities are crucial. Accordingly, team processes that facilitate knowledge integration are consistently recognized as essential for combining diverse knowledge, dissimilar expertise and potentially disparate perspectives into creative output (Hargadon and Bechky 2006, Staw 2009, Harvey 2014). In contrast, excessively increasing levels of knowledge available to teams create costs due to cognitive overload (e.g., Oldroyd and Morris 2012), as they often hinder motivation for knowledge sharing and can lead to more rigid and confirmatory knowledge processes (Kirsh 2000, Schilling et al. 2003, Kehoe and Tzabbar 2015). Ultimately, this could lead to reliance on familiar or repetitive knowledge rather than exploration of new or diverse knowledge (Uzzi and Spiro 2005, Zhou et al. 2009, Harvey 2013, Perry-Smith and Mannucci 2017). Thus, teams with high knowledge integration are likely to achieve superior recombination outcomes with moderate to high knowledge availability, compared to teams that have higher knowledge availability but are lacking in integration and are therefore unable to realize the potential for diverse combinations in the available opportunity set. We thus propose the following hypothesis.

Hypothesis 1: Teams with a woman star recombine knowledge more broadly than teams with a man star.

Prior Collaboration History as Moderator

Our main argument for the hypothesized positive effect of women stars on the recombination of knowledge rests on the assumption that women stars' benefits for integration of knowledge in teams outweigh men stars' benefits for the availability of knowledge. However, the relative importance of these underlying mechanisms can change as a function of certain boundary conditions. We now examine one such condition, namely teams' prior collaboration history. Specifically, we distinguish between teams which have never worked together and those that have a collaboration history.

Teams which have never worked together before might experience both a higher need for and more difficulty in integrating knowledge. Team members in newly formed teams typically lack established systems of organizing and exchanging knowledge, which are built through a history of interaction (Majchrzak et al. 2007, Argote et al. 2018). Hence, they are likely to find knowledge integration more challenging than teams that have collaborated before. In new teams, the role of the star as facilitator and "synthesizer" of knowledge exchanges (Liu et al. 2019) thus becomes even more important. Status differences also tend to be more pronounced in the early phases of collaboration (Bunderson 2003), potentially hindering communication and free exchange of knowledge. Therefore, the influence of knowledge integration on knowledge recombination outcomes is likely to be more pronounced for newly formed teams, compared to those with a history of collaboration. This suggests that the presence of a women star, via the knowledge integration channel, should have greater influence on knowledge recombination breadth in newly formed teams. At the same time, we do not expect that access to external knowledge is more or less important in teams without prior collaboration history as compared to teams which have worked together before. We thus propose the following moderation hypothesis:

Hypothesis 2: Prior collaboration history moderates the relationship between the gender of a star on a team and the breadth of knowledge recombined by the team, such that the positive effect of a woman star on the team's knowledge recombination breadth is stronger when the team has never worked together before (compared to teams that have collaborated before).

2.3 Methods

2.3.1 Data and Sample

We test our hypotheses in an empirical study of inventor teams and their patented inventions. We rely on patent data because it has proven useful for studying both star knowledge workers (Tzabbar and Kehoe 2014, Liu et al. 2019) and knowledge recombination breadth (Fleming 2001, Agrawal et al. 2006, Gruber et al. 2013). To build our dataset, we combine data from the USPTO, PATSTAT and genderize.io.

We first build a sample of star inventors and the patents granted to them by the United States Patent and Trademark Office (USPTO) between 1990 and 2010[20]. We use inventor data of USPTO patents provided by the PatentsView initiative (http://www.patentsview.org). We complement this data with patent information at the patent family-level recorded in PATSTAT, the worldwide patent statistical database. We use patent families to prevent double-counting and to better estimate patent-based measures of a single invention, particularly knowledge recombination breadth[21] (cf., Martínez 2011). We then infer the likely gender of the inventors from their forenames using the genderize.io database (https://genderize.io/). Because name-based gender designation is particularly challenging for certain countries and ethnicities, we conduct additional checks relying on US census data[22] as well as independent raters. We exclude names and countries (e.g., China), for which gender designation is not reliable[23]. Finally, we match inventor teams with women stars to inventor teams with men stars to account for the gender imbalance in patenting and differences in inventor teams (Ding et al. 2006, Sugimoto et al. 2015). In the subsequent sections, we explain each of the abovementioned steps in depth, first elucidating how we identify women and men star inventors and then giving an overview of the matching approach employed.

Identifying star inventors. Following the definition of stars, we identify star inventors based on their exceptional relative performance. To do so, we create a panel dataset covering the universe of inventors who have ever filed a patent at the USPTO and measure their inventive performance at different points in time. In a first step, we rely on the inventor disambiguation provided by the PatentsView initiative to identify unique inventors. The disambiguation is based on an algorithm outlined in Li et al. (2014) and allows for a robust identification of individual inventors of granted US patents since 1976 (Melero et al. 2020). In a second step, we link more than two million unique inventors to over seven million patents. Next, we identify star inventors based on the quantity and impact of their cumulative inventions, i.e., inventor performance, following the approach proposed by Tzabbar and Kehoe (2014). We calculate inventor performance as the product of two factors. The first is the number of patents ($InvPat_{ij}$) for which inventor i applied by year t, divided by the

[20] We rely on granted patents since the USPTO started recording patent applications only in 2001. Additionally, more than 97% of patent applications filed by the inventor teams in our sample as of 2001 were granted. This is not surprising given that we look at teams with star inventors.

[21] A patent family represents the entire set of patents and applications filed across different countries protecting a single invention. In this article, when we refer to “patent”, we are referring to the simple DOCDB patent family.

[22] Open source dataset, available here: https://github.com/rflynn/pro-file/tree/master/data (accessed on August 24, 2022)

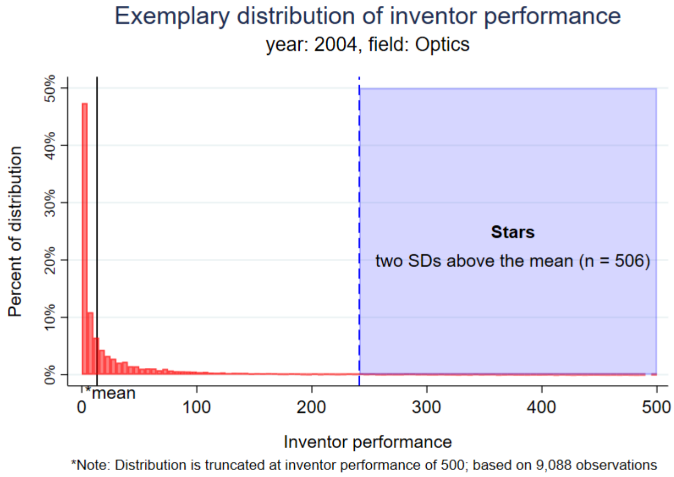
[23] The gender designation procedure is outlined in detail in Appendix 2.1.

years since the inventor's first patent filing (*IndTenure*$_{it}$). This is multiplied by the second factor, the sum of forward citations to all patents filed by inventor *i* by year *t* (*ForwardCite*$_{ijt}$) discounted by the years since the patents were granted (*YearsSincePatGrant*$_{ijt}$):

$$InvPerformance = \left[\left(\frac{InvPat_{it}}{IndTenure_{it}}\right)\right] \times \sum \left(\frac{ForwardCite_{ijt}}{YearsSincePatGrant_{ijt}}\right)$$

We update this inventor performance measure on a yearly basis once an inventor has entered the dataset through a first patent filing. We determine an inventor's main industry based on the technology field (Schmoch 2008) in which an inventor *i* has filed most of his or her patents by year *t*. This implies that the inventor's main industry may vary over time. As stars are conceptualized relative to their peers, it is important to define and adapt the peer group in case stars switch between fields. As exemplified in Figure 2.1, we follow prior research (Tzabbar and Kehoe 2014) and consider every inventor with an inventor performance score of more than two standard deviations above the mean for a given year in a given industry as a star inventor.

Figure 2.1 Exemplary Identification of Star Inventors



Altogether, we identify 91,762 star-inventor-years in the sample. These star-inventor-years can be attributed to less than one percent of inventors who ever filed a patent at the USPTO. Yet, they are responsible for more than 20% of all patents filed between 1990 and 2010. This underlines the disproportionate contribution of star inventors and lends credence to our star identification procedure.

Since we are interested in the difference in knowledge recombination breadth of inventor teams with one woman versus one man star, we further limit the sample to patents filed by exactly one star inventor and at least one non-star coinventor. We exclude all private inventions, i.e., patents filed without an organization, as we aim to investigate team processes in organizational settings.

For the observations retained in the sample, we derive the gender of the star based on the procedure described in Appendix 2.1 and only keep stars for whom we can reliably disambiguate gender. Following the outlined steps leaves us with approximately 55,000 teams that filed patents with roughly 7,000 distinct star inventors. Of these teams, 951 involved one of 189 women star inventors.

Matching teams with women stars to teams with men stars. Even though the proportion of women stars has steadily increased over the years (see also USPTO 2019), women stars continue to be substantially underrepresented among star inventors. As summarized in Appendix 2.2, women make up 2.64% of star inventors (from 1990-2010), with the highest shares in the fields of biotechnology (9.64%) and basic material chemistry (7.05%), i.e., fields which tend to have higher rates of woman participation in general. Besides these differences in the representation of women versus men stars across fields and time, a comparison of the distribution of key covariates (see Appendix 2.3) suggests that there are other differences between the teams they work in. To account for these differences and the imbalance between men and women star inventors, we employ a matching approach.

Using coarsened exact matching (CEM), inventor teams with a woman star are matched to inventor teams with a man star (Iacus et al. 2011, Iacus et al. 2012). The CEM technique ensures balance along a set of covariates between the treatment group, i.e., inventor teams with a woman star, and the control group, i.e., inventor teams with a man star[24]. The CEM algorithm involves four steps (Blackwell et al. 2009). First, a set of covariates is selected and coarsened into meaningful categories. Next, treated- and non-treated observations are sorted into strata based on their values along the coarsened matching variables, or alternatively, on their exact original values (exact matching). Third, observations assigned to strata that do not have at least one treatment and one control observation are pruned. Lastly, weights are calculated and assigned to each observation to maintain balance within and across strata[25]. These weights are used in all later analyses.

We match our data at the team level along the following variables: *patent filing year* (21 years), *patent WIPO field* (35 fields), and *share of women inventors* (two categories: share above or below the median in the same year and field). By doing so, we obtain 26,793 matched patents of which 951 (3.6%) were filed by inventor teams with a woman star. As illustrated in Appendix 2.3, the matching technique not only yields balance on the matching variables, but also on other key covariates, including team size, team inventive performance, team patenting experience, extent of

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[24] For a recent application of CEM matching to inventors and patent data, see also Le Gallo and Plunket (2020).

[25] A detailed explanation of CEM weights was published by Gary King in 2012 and can be accessed here (accessed on August 24, 2022).

prior collaboration, technological team diversity, and regional team diversity[26]. None of the means of these variables statistically differ between inventor teams with women stars and men stars after matching. To underline the comparability of teams with women and men stars, Table 2.1 presents a probit model, with having a woman star in the inventor team (i.e., being treated) as the dependent variable, and team characteristics as independent variables. Before matching, the share of women inventors and regional team diversity are statistically significant predictors of teams with women stars, while none of the variables are significant after matching. We are, thus, confident that the sample of 26,793 patents filed by 5,017 different star inventors is balanced and allows for a thorough analysis of our hypotheses.

Table 2.1 Predictors of Teams with Women Stars before and after Matching

	before matching	after matching
dependent variable: woman star inventor	Model 1	Model 2
team size	1.015	1.000
	(0.013)	(0.013)
share of women inventors	1.803***	1.069
	(0.161)	(0.095)
team inventive performance	1.001	1.000
	(0.001)	(0.001)
team patenting experience (years)	1.006	1.002
	(0.006)	(0.007)
team patenting experience (patents)	0.993	0.998
	(0.006)	(0.006)
extent of prior collaboration	1.046	1.087
	(0.063)	(0.072)
technological team diversity	1.027	1.008
	(0.042)	(0.046)
regional team diversity	0.908*	0.922
	(0.051)	(0.051)
main patenting field dummies (28 fields)	yes	yes
patent filing year dummies (21 year)	yes	yes
constant	0.0367***	0.162***
	(0.011)	(0.062)
observations	53,292	26,793

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; standard errors clustered by star inventors in brackets; coefficients reported as inverse rate ratios (IRRs); 1,167 observations were dropped in Model 1.1 because the star's gender is perfectly predicted by his field (only applied to men).

2.3.2 Variable Descriptions

Dependent variable. The dependent variable in our analysis is *knowledge recombination breadth*. We operationalize this variable as per Gruber et al. (2013). The measure is an adapted

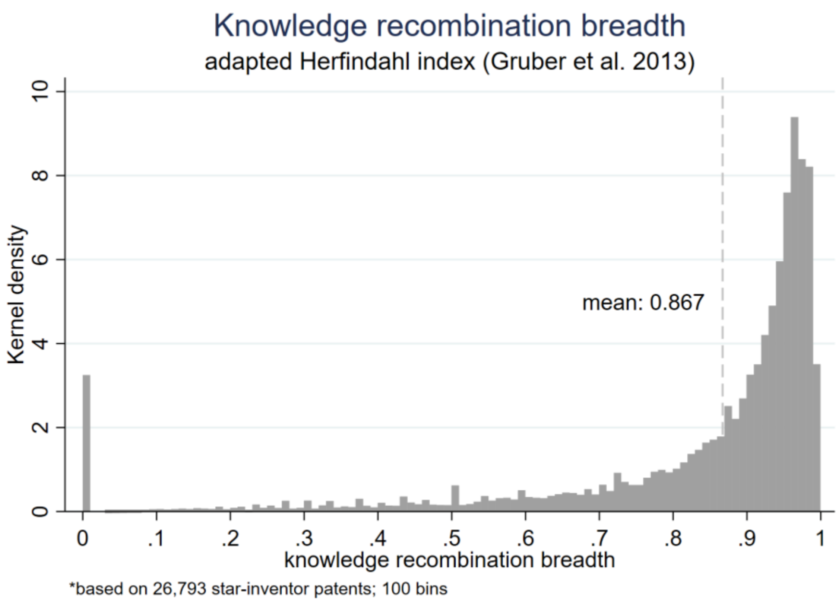
[26] We achieve similar results by matching on additional covariates and adopt the approach described above as it represents the most parsimonious approach to achieving covariate balance for our data.

Herfindahl index, which captures the distribution of a focal patent's backward citations across different technological domains. Technological domains are represented by four-digit International Patent Classification (IPC) subclasses. The IPC system emerged as a result of the Strasbourg Agreement in 1971 and helps patent authorities around the globe to group patents in technology classes and retrieve prior art when examining patent applications[27]. A patent filed at the USPTO cites J prior patents. The referenced patents are assigned to K different technological domains (IPC subclasses). The share of a specific technology domain in one referenced patent is captured in s_{jk}. The cumulative number of references to technological domains by all cited patents is captured in S. Based on these parameters, *knowledge recombination breadth* is calculated as follows:

$$\bar{B}_{JK} = 1 - \sum_{k=1}^{K} \left(\frac{\sum_{j=1}^{J} s_{jk}}{S} \right)^2$$

Knowledge recombination breadth is bound between one and zero and increases when a patent references a larger number of distinct technological domains. It decreases when it references the same technological domain multiple times (Ferguson and Carnabuci 2017). A distribution of the variable is depicted in the histogram in Figure 2.2. The average knowledge recombination breadth in our sample is 0.867, with a standard deviation of 0.195. Many patents report a knowledge recombination breadth of zero because they only reference patents from one technological domain. Running our analyses on a subsample where these patents are excluded does not change our results.

Figure 2.2 Distribution of Knowledge Recombination Breadth



[27] https://www.wipo.int/treaties/en/classification/strasbourg/ (accessed on August 24, 2022).

Independent variables. Our main independent variable is an indicator for *woman star inventor*. The variable takes the value of one when a patent was filed by an inventor team with a woman star and zero when it was filed by an inventor team with a man star. As we excluded patents with multiple stars and patents without any gender-designated star, these categories are mutually exclusive. In our matched sample, approximately 3.6% percent of the patents were filed by inventor teams with a woman star.

Our moderator variable is an indicator for *no prior collaboration experience*. This variable takes the value of one if the extent of prior collaboration is zero, such that none of the team members have worked together on a team before.

Control variables. Several controls are applied at the team, star, and patent level that are likely to influence knowledge recombination breadth.

Team-level controls. At the team level, we control for *team size* since larger teams tend to have a broader knowledge stock to draw from for knowledge recombination. *Team size* is measured by the number of inventors appearing on a patent. We control for the *share of women inventors*, i.e., the share of women non-star team members of all non-star team members for whom we were able to designate the gender. We control for *team inventive performance*, measured as the average non-star team members' inventor performance as of the year prior to the focal patent's filing date. This is the same measure we used to identify star inventors and encompasses the quantity and impact of the inventors' prior patents. Next, we control for *team patenting experience* by looking at both the average number of years and the average number of patents since the non-star team members' first patent filing. Having more experienced team members will likely increase a team's knowledge stock. To account for the possibility that team members already know each other, which might enhance the extent to which they share knowledge, we further control for the *extent of prior collaboration*. This is measured as the share of non-star team members who have previously filed a patent with at least one other team member on the focal patent (cf. moderator variable above). While patenting experience and team size may account for the size of a team's knowledge stock, we control for the diversity of a team's knowledge stock via *technological team diversity* and *regional team diversity*. *Technological team diversity* captures the number of distinct WIPO fields (Schmoch 2008) the non-star team members have filed most of their patents in. *Regional team diversity*, on the other hand, is a count of the different countries the team members come from.

Star-level controls. At the level of the star, we employ four control variables. Since the star inventors in our sample are already pre-selected according to their exceptional relative performance, they can all be assumed to bring an exceptional set of skills and abilities to the team. To still account for differences in this right tail of the inventor performance distribution, we control for *star inventive* *performance*, which reflects the impact and quantity of the star inventor's prior patenting activity. We further control for *star patenting experience (years)* and *star patenting experience (patents)* to account for the time spent inventing and the number of patents previously filed, presumably increasing stars' individual knowledge stocks. Next, we control for *star technological diversity*, which counts the number of different WIPO fields (Schmoch, 2008) the star inventor has previously patented in. Lastly, we add *country dummies* for the country of the star inventor based on the location that was recorded in the patent application process.[28]

Patent-level controls. Finally, we also control for patent characteristics. The *number of patent claims* controls for the scope of the invention that is protected by the patent. The broader the scope of a patent, the more likely it combines different bodies of knowledge. The *size of the patent family* controls for the different patent applications that belong to the same simple DOCDB family. The size of the patent family can be an indicator for the invention's value as patent families also cover patent applications for the same invention with patent offices other than the USPTO. Given the costs associated with patenting, applications will only be filed in multiple jurisdictions if deemed worthy. The *number of backward citations* captures the number of references a patent makes to other patents and accounts for the fact that our dependent variable knowledge recombination breadth and the precision of its measure increase with more backward citations (Gruber et al. 2013). The *number of patent applicants* controls for the number of distinct applicants, who appear on the patent filing and are not listed as inventors. As we excluded private patents from the sample, the applicants are firms or organizations. We employ *patent filing year dummies* to account for time trends in the data, such as more knowledge being recombined in recent years and increased woman patenting activity. Lastly, we use 131 *technology class dummies* based on the 3-digit IPC subclasses a focal patent has been assigned to. These dummy variables control for heterogeneity in patenting behavior across technological fields.

Table 2.2 lists summary statistics and descriptions for each of the presented variables. Table 2.3 further presents bivariate correlations. Correlations between the independent variables are relatively low, indicating that collinearity should not be a concern.

[28] This information comes from PatentsView as the detailed locations of inventors and patent-owning entities are recorded when a patent is granted: see https://datatool.patentsview.org/#viz/locations (last accessed on August 24, 2022).

Table 2.2 Descriptive Statistics

variable name	variable description	mean	sd	min	max
dependent variable					
knowledge recombination breadth	adapted Herfindahl index at IPC4-level (Gruber et al. 2013)	0.867	0.195	0	0.999
independent variable					
woman star inventor	dummy variable indicating the gender of the star; 1 if woman, 0 otherwise	0.035	-	0	1
control variables at the team level					
team size	number of inventors at the DOCDB patent family level	4.321	2.477	2	34
share of women inventors	share of women non-star team members	0.172	0.308	0	1
team inventive performance'	average inventive performance (Tzabbar & Kehoe 2014) of all non-star team members as of previous year	16.737	44.608	0	1686
team patenting experience (years)'	average number of years since the first patent of all non-star team members	7.222	5.171	0	35
team patenting experience (patents)'	average number of prior patents of all non-star team members	5.390	6.579	0	117
extent of prior collaboration	share of team members who have previously co-patented with at least one other team member	0.697	0.367	0	1
technological team diversity	number of distinct WIPO fields (Schmoch 2008) non-star team members filed most of their prior patents in	1.714	0.845	1	7
regional team diversity	number of distinct countries the team members come from	1.187	0.485	1	6
control variables at the star inventor level					
star inventive performance'	inventive performance of star inventor (Tzabbar & Kehoe 2014) as of previous year	480.761	1365.795	5.376	48200.375
star patenting experience (years)'	number of years since the first patent filing of the star inventor	16.627	7.039	2	35
star patenting experience (patents)'	number of prior patents of the star inventor	43.215	33.910	2	1492
star technological diversity'	number of different WIPO fields (Schmoch 2008) the inventor has previously patented in	7.647	4.463	1	35
country dummies	32 dummy variables for the country the star inventor comes from	-	-	-	-
control variables at the patent family level					
number of patent claims'	average number of claims of all publications within the DOCDB patent family	19.577	12.427	0	296
size of patent family'	number of distinct patent applications within DOCDB patent family	6.313	6.887	1	427
number of backward citations'	number of backward citations to distinct patents	36.049	61.778	1	4839
number of patent applicants	number of different applicants listed within the DOCDB patent family	1.174	0.574	1	14
patent filing year''	earliest filing year of any of the patent applications within the DOCDB patent family	2006	-	1990	2010
technology class dummies	131 dummy variables for the technology classes (3-digit IPC) a patent is assigned to	-	-	-	-
observations					**26,793**

'variable standardized by its standard deviation in all later analyses to ease interpretability; ''median instead of mean reported

Table 2.3 Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
(1) knoweldge recombination breadth	1																		
(2) woman star inventor	0.024	1																	
(3) team size	0.097	-0.003	1																
(4) share of women inventors	0.042	0.007	0.071	1															
(5) team inventive performance	-0.078	0.006	-0.048	-0.059	1														
(6) team patenting experience (years)	0.004	0.004	-0.015	-0.145	0.241	1													
(7) team patenting experience (patents)	-0.061	0.003	-0.049	-0.116	0.668	0.631	1												
(8) extent of prior collaboration	-0.001	0.013	0.028	-0.052	0.138	0.220	0.234	1											
(9) technological team diversity	0.172	0.000	0.283	0.015	-0.047	0.031	-0.031	-0.169	1										
(10) regional team diversity	0.053	-0.015	0.282	0.029	-0.034	-0.039	-0.055	-0.035	0.036	1									
(11) star inventive performance	-0.060	-0.029	-0.059	0.025	0.252	0.023	0.113	0.026	-0.034	-0.019	1								
(12) star patenting experience (years)	0.048	-0.118	0.028	0.011	-0.029	0.126	0.062	-0.021	0.092	0.009	-0.043	1							
(13) star patenting experience (patents)	-0.067	-0.086	-0.057	0.007	0.151	0.089	0.194	0.045	-0.005	-0.008	0.529	0.426	1						
(14) star technological diversity	0.106	-0.068	-0.067	0.005	0.027	0.027	0.030	-0.048	0.286	-0.046	0.121	0.384	0.289	1					
(15) number of patent claims	0.034	0.003	0.017	-0.013	0.014	-0.010	0.004	0.033	0.026	-0.025	0.034	-0.035	-0.030	0.039	1				
(16) size of patent family	0.170	-0.003	0.240	0.025	-0.071	-0.001	-0.066	-0.022	0.025	0.133	-0.083	0.055	-0.084	-0.090	-0.023	1			
(17) number of backward citations	0.083	-0.015	0.077	-0.027	0.021	0.010	-0.028	0.054	0.016	-0.004	0.038	-0.018	-0.040	0.041	0.089	0.121	1		
(18) number of patent applicants	0.064	-0.012	0.120	0.032	-0.030	-0.023	-0.058	-0.029	0.037	0.127	-0.017	-0.011	-0.026	-0.035	-0.019	0.196	0.086	1	
(19) patent filing year	-0.014	0.000	0.057	0.024	0.188	0.158	0.145	0.024	0.019	0.067	0.161	0.134	0.130	0.066	-0.037	-0.022	0.134	-0.104	1
Observations	26,793																		

note: correlations with |r| > 0.015 are significant at $p < 0.01$

2.4 Results

To test our first hypothesis, we run multivariate linear regression models and estimate how broadly teams with women stars recombine knowledge compared to teams with men stars. Table 2.4 presents five linear regression models testing the hypothesis that teams with women stars recombine knowledge more broadly than teams with men stars. In Model 1 we start with the main independent variable woman star inventor, without including any controls, and observe a positive and statistically significant relationship with knowledge recombination breadth (β = 0.060, $p <$ 0.01). We then subsequently add the weights obtained from the CEM matching that ensure a balanced sample between patents filed by inventor teams with men stars and patents filed by inventor teams with women stars (Model 2), the team-level controls (Model 3), the star-level controls (Model 4) and patent-level controls (Model 5).

Across these model specifications, we see a positive and statistically significant relationship ($p < 0.01$) between having a woman star on the team and knowledge recombination breadth, on average. Importantly, the effect size decreases from 0.060 to 0.025 when moving from the first to the second model, indicating that our matching achieves the goal of improving balance in the sample and that it is important to control for inherent team differences. The effect size remains robust as more controls are added, with only a slight decrease to 0.023 in the final model that includes all controls. At the same time, the model's explanatory power increases with the inclusion of the control variables, resulting in an adjusted R-square of 0.228 in the final model.

To illustrate the magnitude of the effect, we benchmark the coefficient of woman star inventor against other coefficients in the model. Adding one additional member to the team, for example, is associated with an increase in knowledge recombination breadth by 0.003 on average, holding everything else constant. We can extend this comparison to variables, which we normalize by their standard deviation to ease interpretability (as indicated in Table 2.2). An increase in a stars' technological diversity by one standard deviation, for example, is related to an increase by 0.018 in knowledge recombination breadth, on average. Similar effect sizes can be observed for one standard deviation changes in star inventive performance and prior collaboration. Only for technological team diversity we find a slightly larger point estimate of 0.027. Altogether, we interpret the results summarized in Table 2.4 as support for our hypothesis and as an indication for a meaningful and relevant effect.

Table 2.4 Linear Regression of Knowledge Recombination Breadth on Woman Star

dependent variable: knowledge recombination breadth	Model	Model 2	Model 3	Model 4	Model 5
woman star inventor	0.060***	0.025**	0.025**	0.027***	0.023***
	(0.010)	(0.010)	(0.010)	(0.009)	(0.007)
team size			0.003**	0.003***	-0.001
			(0.001)	(0.001)	(0.001)
share of women inventors			0.022*	0.025**	0.014
			(0.013)	(0.011)	(0.009)
team inventive performance			-0.009**	-0.008*	-0.005
			(0.004)	(0.005)	(0.004)
team patenting experience (years)			0.008**	0.007**	0.002
			(0.004)	(0.004)	(0.003)
team patenting experience (patents)			-0.010*	-0.006	-0.000
			(0.005)	(0.005)	(0.004)
extent of prior collaboration			0.020***	0.022***	0.014***
			(0.006)	(0.006)	(0.005)
technological team diversity			0.037***	0.031***	0.027***
			(0.003)	(0.003)	(0.003)
regional team diversity			0.014***	0.014**	0.007
			(0.005)	(0.006)	(0.004)
star inventive performance				0.002	0.002
				(0.004)	(0.004)
star patenting experience (years)				0.008**	0.000
				(0.004)	(0.003)
star patenting experience (patents)				-0.019***	-0.013***
				(0.005)	(0.004)
star technological diversity				0.017***	0.018***
				(0.004)	(0.003)
country dummies				yes	yes
number of patent claims					0.006***
					(0.002)
size of patent family					0.002
					(0.002)
number of backward citations					0.010***
					(0.003)
number of patent applicants					0.001
					(0.002)
patent filing year dummies					yes
technology class dummies					yes
CEM weights		yes	yes	yes	yes
constant	0.831***	0.866***	0.756***	0.623***	0.567***
	(0.004)	(0.004)	(0.011)	(0.016)	(0.029)
observations	26,793	26,793	26,793	26,793	26,793
adjusted R-squared	0.002	0.001	0.042	0.070	0.228

note: * p < 0.1, ** p < 0.05, *** p < 0.01; standard errors clustered by star inventors in brackets

We test hypothesis 2 by interacting the dummy variable for *no prior collaboration experience* (i.e., if the extent of prior collaboration is zero, such that none of the team members have worked together on a team before) with the woman star variable in the regression. As shown in Model 1 of Table 2.5, the main effect of not having collaborated before is negative. In line with our arguments, the interaction of woman star and no prior collaboration is positive and significant (β = 0.035; $p < 0.01$). This indicates that the effect of a woman star on the team's knowledge recombination is more positive when the team has never worked together before. We obtain similar results for the interaction when using *no prior collaboration with the star inventor* as an alternative variable, taking the value one if the star has never worked together with any of the non-star team members, as shown in Model 2. Thus, we find empirical support both of our hypotheses.

Table 2.5 Linear Regression of Knowledge Recombination Breadth on Woman Star - Moderated by Prior Collaboration History

dependent variable: knowledge recombination breadth	Model 1	Model 2
woman star inventor	0.017**	0.017**
	(0.008)	(0.008)
woman star inventor x no prior collaboration	0.035***	
	(0.012)	
no prior collaboration	-0.013**	
	(0.005)	
woman star inventor x no prior collaboration with star inventor		0.028**
		(0.012)
no prior collaboration with star inventor		-0.009*
		(0.005)
controls at the team level	yes	yes
controls at the star inventor level	yes	yes
controls at the patent family level	yes	yes
constant	0.580***	0.578***
	(0.029)	(0.029)
observations	26,793	26,793
adjusted R-squared	0.228	0.228

note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; standard errors clustered by star inventors in brackets

Robustness Checks and Additional Analyses

We test the robustness of our findings and refute alternative explanations in a series of post-hoc analyses. First, we discuss and address concerns regarding endogeneity and sample selection bias. We then show that our results are robust to using alternative specifications of the dependent variable and an alternative estimation strategy.

Endogeneity. A central concern that may threaten the validity of our findings is that team composition and project choice are not random. In other words, the presence of women stars may not be exogeneous with regard to team or project characteristics, which may bias the OLS regression estimates (Wooldridge 2002). Despite our rich set of control variables, the examined relationship between the presence of a woman star and team knowledge recombination may be biased by endogeneity from two main sources. First, reverse causality might occur as anticipated outcomes may affect the likelihood that women stars are assigned to specific types of teams or projects. If women stars were, for instance, assigned to teams that are *better* at recombining knowledge, we would obtain biased coefficients in the OLS regression. Second, omitted variables may influence both the independent and the dependent variable, since through the matching and controls we only ensure that there are no differences on observables between teams with women and men stars. Teams or projects with women stars may, however, differ from those with men stars on unobserved factors that could also relate to knowledge recombination. For instance, one possibility could be that teams with women stars work on broader, more interdisciplinary topics with higher potential for knowledge recombination, and this may not fully be captured by our team- and patent-level controls such as technological team diversity.

To mitigate these concerns, we use an instrumental variable (IV) regression as a robustness check. We use the *share of women inventors per industry, year and country/state*[29] as an instrument. A valid instrument needs to be relevant, i.e., correlated with the endogenous variable (woman star), and exogenous, i.e., not correlated with the dependent variable (knowledge recombination breadth) or the error term capturing unobserved factors in ways other than though the endogenous variable (Wooldridge 2002). The share of women inventors per industry, year and country/state can be considered relevant because the likelihood of having a woman star on a team is determined by the pool of active women inventors in the peer group (same year, industry and country/state). A higher share of women inventors in the peer group increases the likelihood of one of them becoming a star and working on a patent in that industry, year, and country/state. The relevance of the instrument is also validated by our data as the instrument exhibits a positive correlation with the endogenous variable woman star (correlation = 0.072, $p < 0.01$). Conditional on the controls, especially those for team characteristics including the share of women on the team, exogeneity is given, as the share of women in the peer group is theoretically unrelated to the focal team's knowledge recombination other than through the focal woman star.

First- and second-stage results of the IV regression are shown in Table 2.6. First-stage IV results (dependent variable: woman star) indicate that the instrument coefficient is highly significant and positive ($\beta = 0.275$; $p < 0.001$). The Cragg–Donald Wald F-statistic takes the value of 205.34 and thus rejects the null hypothesis of weak model identification (i.e., that the instrument explains only a small part of the variance in the endogenous regressor), indicating sufficiently strong instruments (Bound et al. 1995, Staiger and Stock 1997)[30].

[29] For the United States, we use the share per industry, year, and U.S. federal state. This information also comes from the inventor location retrieved from PatentsView.

[30] Post-estimation tests also reject the null hypothesis that the model was under-identified (Kleibergen–Paap rk LM statistic = 19.39, $\chi 2$ p-value = 0.000) or overidentified (Sargan–Hansen J-statistics = 0.000), with the latter indicating that the model was exactly identified.

Table 2.6 2SLS IV Regression of Knowledge Recombination Breadth on Woman Star

	first stage - 2SLS IV Model 1	second stage - 2SLS IV Model 2
variables	***DV: woman star***	***DV: knowledge recombination breadth***
share of women inventors per industry, year and country/state	0.275***	
	(0.062)	
woman star inventor		0.596***
		(0.217)
team size	-0.001	-0.001
	(0.001)	(0.001)
share of women inventors	0.001	0.014
	(0.008)	(0.011)
team inventive performance	0.001	-0.001
	(0.003)	(0.004)
team patenting experience (years)	0.002	0.000
	(0.003)	(0.004)
team patenting experience (patents)	0.000	-0.006
	(0.003)	(0.005)
extent of prior collaboration	0.006	0.013**
	(0.005)	(0.006)
technological team diversity	0.005*	0.029***
	(0.003)	(0.004)
regional team diversity	-0.003	0.004
	(0.004)	(0.005)
star inventive performance	-0.003	0.009*
	(0.002)	(0.005)
star patenting experience (years)	-0.020***	0.006
	(0.004)	(0.006)
star patenting experience (patents)	-0.007***	-0.011**
	(0.002)	(0.005)
star technological diversity	-0.002	0.024***
	(0.003)	(0.004)
region dummies	yes	yes
number of patent claims	0.000	0.008***
	(0.003)	(0.002)
size of patent family	-0.000	0.013***
	(0.003)	(0.003)
number of backward citations	-0.005**	0.017***
	(0.002)	(0.005)
number of patent applicants	-0.005*	0.010***
	(0.003)	(0.003)
patent filing year dummies	yes	yes
main class dummies	yes	yes
CEM weights	yes	yes
constant	0.061**	0.719***
	(0.026)	(0.038)
under-identification test (Kleibergen–Paap rk LM statistic)		19.39
$\chi 2(1)$P-value		0.000
weak identification test (Cragg–Donald Wald F statistic)		205.34
observations	26,793	26,793

note: * p < 0.1, ** p < 0.05, *** p < 0.01; standard errors clustered by star inventors in brackets

Second-stage results corroborate the baseline results from Table 2.4, as the coefficient of woman star is positive and significant ($\beta = 0.596$; $p < 0.01$). The size of the coefficient in the second stage of the instrumental variable regression is larger than in the OLS regression. This change in the coefficient size can be attributed to the use of a continuous instrumental variable to instrument a binary endogenous variable. As the instrumented variable represents the probability of having a woman star (not a dummy), the interpretation of the coefficient size has changed (Wooldridge 2002). Overall, the IV regression confirms our main results.

Sample selection bias. Employing a matching technique increases the balance between treatment and control units in the later analyses but might also introduce bias by focusing on a very special set of observations. In our analysis, we use approximately 27,000 (49%) of about 55,000 patents which would theoretically qualify for the analysis. Even one step earlier, in the gender designation process, we lose roughly 15% of observations because the stars' gender cannot be determined accurately (see Appendix 2.1). To address potential concerns that our final sample is not representative, we estimate a probit model that predicts an inventor team's likelihood to end up in the final sample based on its characteristics. Model 1 in Appendix 2.4 shows that the inventor teams we analyze are, on average, smaller with a lower share of women inventors but a higher level of inventive performance as compared to inventor teams which are not included. While there is no difference in terms of star characteristics between these teams, the related patents tend to have more claims, more backward citations and more applicants, on average. Most of these differences are small and can be explained by the employed matching approach which, by construction, changed the composition of patents in the sample. For example, many older patents and patents from fields with only men stars could not be matched. To ensure that our findings are generalizable, we rerun the analysis on the full sample for which the gender of the star is available. As shown in Models 1a (H1) and 1b (H2) in Appendix 2.5, which summarizes the robustness checks for both hypotheses, the findings remain stable. We are, thus, confident that sample selection bias introduced via the matching approach is not an issue and that our findings generalize to the broader population of inventor teams. We also obtain similar results with different numbers of categories and thresholds used for coarsening the matching variables in the CEM procedure.

Alternative estimation strategy. Our dependent variable knowledge recombination breadth is bound between 0 and 1. We choose weighted OLS in our main analyses because it makes the interpretation of the results simple and straightforward. Yet, to investigate possible issues of model dependence, we also run a Tobit model censored at 0 and 1 (Tobin 1958). As shown in Models 2a (H1) and 2b (H2) in Appendix 2.5, our results remain robust.

Alternative variable specification. Our dependent variable measures the diversity of technology classes reported in a patent's backward citations. The reliability of this approach hinges on the assumption that backward citations qualify as an objective indicator for an invention's knowledge recombination breadth. As opposed to the patent examination process at the European Patent Office (EPO), the patent application process at the USPTO allows not only examiners but also applicants to reference prior knowledge. Specified in the duty of disclosure, patent applicants are required to disclose all information known to the individual. If individuals fail to cite a reference, they put their patent's validity at risk (Kuhn et al. 2020). Thus, in theory, all applicants have the same incentive to cite prior work when applying for a patent. Still, one may argue that personal characteristics, such as willingness to take risks or time and resources available for searching prior patents, influence the referencing process.

To rule out this alternative explanation, we create a second measure of knowledge recombination breadth, which excludes all backward citations made by the applicants themselves (on average, 40% of all citations). As shown in the Models 3a (H1) and 3b (H2) of Appendix 2.5, our results remain stable when using this adapted measure of knowledge recombination breadth. We are, therefore, confident that our results are not driven by different referencing behavior between inventor teams with women and men stars.

2.5 Discussion and Conclusion

The aim of our study is to investigate differences in knowledge recombination breadth between teams including a woman star versus a man star. Extending prior research, we characterize potential differences between men and women stars that may lead to differences in the recombination of knowledge in the teams they are a part of. Drawing from literature on status and psychological differences regarding the perception, characteristics, and behavior of women and men, we elucidate how gender differences between stars translate into differences in the breadth of knowledge recombination in teams.

We view knowledge recombination breadth as a function of the amount of knowledge available for recombination as well as of teams' knowledge integration processes. Specifically, we argue that men stars enhance teams' access to external knowledge due to their greater status in organizations, while women stars demonstrate behaviors and characteristics which facilitate knowledge integration processes in teams. We also theorize that teams' benefits from superior knowledge integration outweigh those associated with accessing external knowledge. Our empirical analysis of inventor teams with women and men star inventors provides support for the hypothesis that teams with women stars recombine knowledge more broadly than teams with men stars.

Further, this effect is also found to be more pronounced in teams that have never collaborated before compared to teams that have a history of working together.

2.5.1 Theoretical Implications

Our research extends knowledge on the role of women star performers in knowledge-intensive activities and contributes to current research debates in three main ways. First, we contribute to the star literature (Zucker et al. 1998, Lacetera et al. 2004, Rothaermel and Hess 2007, Groysberg et al. 2008), where our knowledge to date is largely built around men stars. In particular, prior work has established both benefits and costs of stars' presence on teams. Complementing this existing research, which indicates the organizational value of stars in knowledge work is contingent upon their collaborations with others (Oettl 2012, Grigoriou and Rothaermel 2014, Kehoe and Tzabbar 2015, Chen and Garg 2018), we highlight the importance of considering the star's individual characteristics. Here, our findings indicate that the gender of the star matters and that women and men stars play different roles in teams, leading to systematic differences in knowledge outcomes.

Second, we attempt to address a contradiction emerging from literatures on gender differences related to status and gender differences related to psychological perceptions, characteristics, and behaviors. We disentangle the relevance of increasing available knowledge as raw material for recombination in teams, and the processes that ultimately allow this diverse material to be integrated into creative output (Hargadon and Bechky 2006, Harvey 2014, Liu et al. 2019). Here, our findings suggest not only that stars can differentially impact these two determinants, but that the relative importance of knowledge integration processes is a key driver of teams' knowledge recombination outcomes.

Finally, our findings also contribute to the social perspective on team creativity and knowledge creation, which considers the importance of interaction and collaboration within teams as a central determinant of breakthrough creativity (Perry-Smith and Shalley 2003). By arguing that teams interact and communicate with women and men stars in varied ways, our findings suggest that non-star team members' collaboration with women and men stars does not yield identical knowledge outcomes. We, thus, contribute to the literature that examines the role and functioning of team social processes as key determinants of knowledge recombination (e.g., Harvey 2014, Mannucci 2017, Li et al. 2020).

2.5.2 Practical Implications

Our findings are also of high practical relevance. First, our findings imply that a special emphasis on identifying and advancing the progress and special skills of women knowledge workers may be fruitful for organizations and society. Our study shows that the characteristics and behaviors displayed by women stars, on average, present advantages for teams' knowledge recombination outcomes. By better understanding where these differences come from, organizations can leverage the untapped potential of women who are largely underrepresented among star knowledge workers.

Second, consistent with prior work (Tzabbar and Kehoe 2014, Kehoe and Tzabbar 2015, Chen and Garg 2018), our findings emphasize that stars represent a double-edged sword for organizations in that they can both facilitate and hinder different aspects of knowledge recombination. Our study draws particular attention to stars' gender. To fully utilize the potential of stars in teams, organizations should strive to balance the benefits that men versus women stars represent against their potential limitations. For example, knowledge recombination in teams with men stars may benefit from systematic measures designed to enhance the integration of knowledge (Li et al. 2020). Managers may improve knowledge recombination breadth in such teams by encouraging stars to more frequently display behaviors that express interpersonal sensitivity and approachability.

Third, our findings suggest that organizations should pay particular attention to the knowledge bases of non-star team members as sources of new and unique ideas. Prior work has highlighted the danger of overreliance on stars' knowledge bases in teams (Tzabbar and Kehoe 2014, Kehoe and Tzabbar 2015, Chen and Garg 2018). Our findings suggest that, especially when the team includes a man star, special emphasis should be placed on exploring and integrating the unique knowledge bases of all team members, since novel ideas and diverse knowledge may not otherwise be exchanged and integrated in such teams to the same extent as in teams with women stars.

2.5.3 Limitations and Directions for Future Research

As with most empirical undertakings, our study comes with limitations that provide opportunities for future research. First, the usual concern with using patent data is that only patented inventions can be observed and not projects that failed. Since failed patents are not captured by our dependent variable, a systematic difference in the failing rate between teams with women and men stars could be problematic but seems unlikely given our focus on highly successful inventors.

Although we use a matching approach to minimize differences in team composition, include several star-related controls in our analyses, and provide an instrumental variable analysis, our data do not offer a random treatment allocation which would allow us to uncover causal relationships. Therefore, the potential to infer causality from our study is constrained by the data and design, and future research may aim to confirm our findings using data from random or quasi-random designs.

The measures we used to identify stars and to capture knowledge recombination breadth have some limitations. While being in line with prior literature, finding a cut-off point beyond which the performance of an individual qualifies for stardom is always arbitrary. Also, while we consider our choice of the measure for knowledge recombination breadth justified based on prior literature, this is not the sole way of measuring the breadth or diversity of knowledge recombined, nor is the combination of technological classes in patents itself the only way to proxy knowledge categories integrated in creative outputs. Therefore, it is important that future work replicates our results in different contexts, using different creative outputs and strategies for identifying stars knowledge workers.

We further discuss various potential differences regarding the perception, characteristics, and behavior of men and women stars and provide some tentative evidence on potential mechanisms. Our main goal is to manifest the observed differences in outcomes by running a large-scale analysis across industries, years and geographical areas. However, our data do not allow us to fully disentangle the mechanisms that may lead to the observed difference in knowledge recombination breadth. Future research may aim at closely examining the underlying mechanisms to better understand the dynamics and differences between teams with women and men stars, potentially by conducting qualitative studies at the micro-level or laboratory experiments.

To designate the gender of star inventors, we rely on their first names. Common problems in the gender designation of Asian names force us to exclude Asian inventors from the sample (see Appendix 2.1 for details). The generalizability of our findings is therefore limited to non-Asian inventors, which at the same time opens the door for future research to investigate how cultural norms and different gender roles across countries might influence processes and outcomes in teams with women versus men star knowledge workers.

Finally, it would be insightful to identify additional contingencies, such as situational factors (e.g., time pressure) or network characteristics (e.g., centrality of stars in knowledge networks) that influence whether teams with women or men stars perform better. Getting closer to these contextual forces may advance our general understanding of team dynamics with stars and the role of star characteristics including but not limited to the star’s gender.

3 Make No Mistake – Performance of Extreme Precision Tasks under Pressure and the Role of Gender

3.1 Introduction

Researchers in psychology, organizational behavior, and behavioral economics generally agreed that task performance decreases under pressure (e.g., Beilock and Carr 2001, Ariely et al. 2009). This is because pressure, i.e., any factor or combination of factors that augments the importance of performing well on a given occasion (Baumeister 1984), detracts individuals, induces them to avoid risk and to focus more on performing the task than the actual outcome (Kimble and Perlmuter 1970, Baumeister and Showers 1986, Beilock and DeCaro 2007). Distraction, risk-aversion, and de-automatization can lead to “choking”, i.e., individuals performing below their optimum (Baumeister 1984). This is particularly the case for individuals who react strongly to stress situations, something that applies, on average, more to women than men (e.g., Mayor 2015, Cai et al. 2019, Cahlikova et al. 2020).

More recently, however, empirical studies have delivered mixed results regarding the relationship between pressure and performance (e.g., Gardner 2012, Shurchkov 2012, Cahlíková et al. 2020). As a possible explanation for the mixed evidence, it has been suggested that pressure can be harmful for performance when appraised as a threat but beneficial when appraised as a challenge (e.g., Uziel 2007, Otten 2009, Mitchell et al. 2019). Besides complexities related to the appraisal of pressure, it is also likely that the very characteristics of the task itself matter, as the performance of some tasks seems to generally increase (decrease) under pressure, independent of appraisal. To that end, scholars have separately investigated performance effects for tasks that differ in terms of cognitive and physical demands (e.g., Ariely et al. 2009, González-Díaz et al. 2012, Shurchkov 2012). Yet, examining the pressure-performance link for these demands in isolation neglects intricacies arising from interdependencies between cognitive and physical activation.

Bringing these different strands of explanation closer together, I consider *extreme precision tasks*, i.e., tasks that are cognitively demanding *and* performed under “extreme” states of physical activation. I argue that tasks of this nature benefit from a more conscious and risk-averse execution. Hence, the effects of pressure that are generally considered detrimental to task performance may actually be performance-enhancing for such tasks. Examples of extreme precision tasks include surgery in emergency medicine, gunfire in law enforcement, or firefighting[31]. When performing such tasks, individuals must balance attention between physical and cognitive demands (Kahneman 1973, Lambourne and Tomporowski 2010). Pressure can help shifting attention to cognitive

[31] The limited understanding of the pressure-performance link under conditions of simultaneous cognitive and physical demand may, at least in part, be explained by these settings being difficult to examine empirically.

processes by activating additional cognitive resources and distracting from physical demands. This attention shift may allow for a conscious adaptation in behavior, which can be conducive to the successful execution of such tasks.

Beyond considering the nature of the task as influencing the pressure-performance relationship, I also consider a salient difference in who is performing the task. It has been suggested that women's performance suffers in competitive settings under pressure more than men's (Gneezy et al. 2003, Jurajda and Münich 2011, Ors et al. 2013). It is further suggested that this is because women are more sensitive to pressure as a stressor (Stroud et al. 2002, Chen and Qu 2021) and because women are more likely to appraise pressure as a threat rather than a challenge (Cahlikova et al. 2020). However, if the nature of the task induces a positive influence of pressure on performance, as is conceivable for extreme precision tasks, this should put women at an advantage relative to men. Accordingly, I consider gender as a central contingency factor that should moderate the effect of pressure on performance of extreme precision tasks.

In sum, I aim to answer the following two research questions: (1) How does pressure influence the performance of extreme precision tasks? and (2) Are there gender differences in performance of extreme precision tasks under pressure? Answering these questions does not only advance our understanding of how the influence of pressure on performance varies with task characteristics but also contributes to the growing and partially contradicting literature on how men and women perform differently under pressure (e.g., Shurchkov 2012). This is important because in fast-paced environments, organizations and their members increasingly find themselves in high-pressure situations (Bourgeois III and Eisenhardt 1988, Eisenhardt 1989, Sull and Eisenhardt 2012). Additionally, in globalized value chains, even small local human error can have global impact. This was, for example, vividly demonstrated by the 2021 Suez Canal obstruction of the "Ever Given" container ship[32], which likely grounded due to the captain not performing at the required level in a precision task under pressure[33].

To answer the two research questions, I use arguments from attentional control theory (Eysenck et al. 2007, Eysenck and Derakshan 2011), suggesting that the effect of pressure on performance depends on (a) the extent to which pressure distracts from the actual task (*inhibition function*) and (b) on the person's ability to adapt his or her behavior to the high-pressure situation (*shifting function*). In extreme precision tasks, physical and cognitive processes compete for attention (Tomporowski 2003). Adding pressure as a stressor can shift attention towards cognitive

[32] https://www.economist.com/the-economist-explains/2021/03/26/why-the-suez-canal-and-other-choke-points-face-growing-pressure, last accessed 23.08.2022

[33] https://www.theguardian.com/environment/2021/apr/03/wind-or-worse-was-pilot-error-to-blame-for-the-suez-blockage, last accessed 23.08.2022

processes, which might allow for the activation of additional (mental) resources and an adaptation in behavior. When adapting their behavior under pressure, individuals will likely try to avoid risk and pay more attention to the conscious execution of the task (Cahlíková and Cingl 2017), which may well benefit performance in extreme precision tasks (Vickers 2011). This might put women, who are on average more sensitive to pressure than men, at a relative advantage as women might be distracted more easily (*inhibition function*), such that they can adapt their response strategy (*shifting function*) in a way that it benefits performance.

The empirical context of this analysis is biathlon, an Olympic winter sport that combines rifle shooting with cross-country skiing. To answer the research question, I analyze the shooting performance of professional biathlon athletes. Shooting in biathlon is a cognitively demanding task (Coleman 1980), which takes place under great physical activation in between several laps of cross-country skiing. Hence, biathlon shooting can be considered archetypical of an extreme precision task (Vickers and Williams 2007). Additionally, the fact that biathlon is an Olympic sport allows for the comparison of performance in regular (World Cup) races versus performance in situations of high pressure, i.e., at the Olympics. The Olympics take place only once every four years and represent the career highlight of any professional (biathlon) athlete. The importance to perform well at the Olympics is much higher than at any other race, a contingency verified in interviews with professional athletes and coaches. The setting further allows to vary the intensity with which athletes are likely experiencing pressure, for example, by identifying those that have a realistic chance of winning a medal (high pressure) and those that stand little chance (low pressure). Furthermore, the availability of detailed performance data over a long time period and different race formats allow an indirect analysis of the underlying mechanisms - the inhibition and shifting function. Finally, men and women biathlon athletes perform the same task, which permits the investigation of performance differences under pressure within and across gender.

Analyzing a longitudinal dataset that tracks 391 professional athletes, 197 women and 194 men, from 1994 to 2018, I find that, on average, shooting performance does not differ at Olympic versus non-Olympic races, contrary to the hypothesis that pressure generally increases performance of extreme precision tasks. In line with attentional control theory, this could either imply that negative effects of distraction and positive effects of behavioral adaptation cancel each other out or that the Olympics were not perceived as a stressor. When looking at gender differences, I find that the latter account is more likely than the former. Women, who are considered more sensitive to pressure than men, and thus more likely to perceive the Olympics as a stressor, show the expected performance improvement and miss fewer shots at Olympic races than at non-Olympic races. This effect is driven by women athletes who have a realistic chance of winning an Olympic medal and are thus even more likely to experience a lot of pressure during Olympic races. For men, no differences in performance are observed at Olympic versus non-Olympic races, likely because they do not perceive an Olympic race as particularly more stressful than a non-Olympic race. This corresponds to the idea that men are generally less sensitive to pressure and less distracted by it (Lazarus and Folkman 1984, Cahlíková et al. 2020). It also explains why there was no significant effect in the full sample, pooling women and men.

I further show that the positive effect of pressure on performance that was found for women applies to race formats where athletes start sequentially and do not directly compete against each other on the race track. According to the conducted expert interviews, athletes have more time to think about the special circumstances in these races, making distraction by pressure more likely (*inhibition function*). Finally, I find suggestive evidence that the observed effects are due to women taking less risk (*shifting function*) by shooting more slowly at Olympic as compared to non-Olympic races.

By studying the effect of pressure on performance of extreme precision tasks and related gender differences, this study contributes to the literature in two ways. First, it advances our understanding of how task characteristics shape the relationship between pressure and performance by showing that extreme precision tasks, which are physically and cognitively demanding, may profit from pressure through ways that have previously been considered detrimental to performance (Mitchell et al. 2019). This adds a new explanation for the mixed empirical evidence in the related psychology, organizational behavior, and behavioral economics literature, which has primarily looked at cognitive and physical tasks in isolation (e.g., Gimmig et al. 2006, Ariely et al. 2009, DeCaro et al. 2011, Cahlíková et al. 2020). Second, this study contributes to the literature on gender differences in competitive settings. It provides a framework and supporting empirical evidence that allow to reconcile the seemingly contradicting evidence on gender differences in performance under pressure (e.g., Shurchkov 2012, Cohen-Zada et al. 2017, Cai et al. 2019). At the same time, it highlights that, contrary to the dominant narrative, there are high pressure situations in which women can improve their performance more than men.

3.2 Performance Under Pressure

Pressure is defined as any factor or combination of factors that increases the perceived importance of performing well on a specific task (Baumeister 1984). Pressure can come from various sources, such as performing in front of an audience (e.g., Butler and Baumeister 1998, Wallace et al. 2005), or facing intense competition (e.g., Jurajda and Münich 2011). One of the most prominent sources of pressure, which is also the focal source of pressure in this study, comes from the expected consequences associated with performing well on a task (Ariely et al. 2009). As the stakes, that is the potential gains associated with performing well, increase, so does the importance of performing well (*pressure*). For example, taking the last penalty in the Soccer World Cup final leads to more pressure than taking a penalty in a friendly match during the season break. Similarly, performing a life-saving surgery on a human patient is associated with more pressure than practicing the same surgery on a corpse during medical training.

Originally, scholars have proposed that individuals "choke" under pressure, i.e. they perform below their optimum when much is at stake (Baumeister 1984, Beilock and Carr 2001). In line with this proposition, there are many studies that found performance to decrease when it is particularly important to perform well (e.g., Ehrenberg and Bognanno 1990, Ariely et al. 2009, Bradler et al. 2019, Schlosser et al. 2019). However, more recently, scholars have also found no or even positive effects of pressure on performance (e.g., Oudejans and Pijpers 2009, Gardner 2012, Shurchkov 2012, Jane 2022). As a potential explanation, it has been proposed that individuals who appraise pressure as a challenge can improve performance under pressure while those who experience it as a threat suffer from performance losses (Mitchell et al. 2019). This is because challenge appraisals may lead to additional motivation to invest effort in the task (Eisenberger and Aselage 2009) while threat appraisals may lead to dysfunctional behavior (cf., Mitchell et al. 2019). However, this line of reasoning fails to explain performance differences under pressure in tasks that are immune to (additional) motivational effects (Yerkes and Dodson 1908, González-Díaz et al. 2012) or that experience no change or even increases in performance under pressure despite it being perceived as a threat (Masters 1992, Calvo and Carreiras 1993).

Attentional control theory adds a contingency view to the pressure-performance relationship. In particular, it suggests that as a source of anxiety[34], pressure influences attention and thereby performance via two main ways[35], the *inhibition* and *shifting* functions of the central executive (Miyake et al. 2000, Oudejans et al. 2011). The inhibition function controls the extent to which individuals are distracted by task-irrelevant stimuli (Miyake et al. 2000, p. 57, Eysenck et al. 2007, p. 338). The inhibition function is impaired if the pressure stimulus is very salient and appraised as a threat rather than a challenge (Lazarus and Folkman 1984). In that sense, attentional control theory is in line with the proposition by Mitchell et al. (2019) that pressure appraised as a threat is more distracting than pressure appraised as a challenge.

However, it deviates from this logic, by allowing for the shifting function to adapt behavior in ways that compensate for the performance losses induced through distraction. The shifting

[34] Anxiety is considered to have both a cognitive component (worry) and an arousal component (alertness/ activation). Anxious people are considered to "devote cognitive capacity to worrying about their performance" (Humphreys and Revelle 1984, p. 175).

[35] The theory also proposes *updating* as a third executive function that is, however, related the memory system and not to attentional control (Eysenck et al. 2007). It is therefore not considered relevant for the relationship between pressure and performance.

function facilitates an individual's ability to adapt his or her behavior to changing task requirements by redirecting attention (Miyake et al. 2000, Derakshan and Eysenck 2009, p. 171). Typically, anxiety leads to behavior that is more risk-averse, self-focused, and less efficient (Liao and Masters 2002, Derakshan and Eysenck 2009)[36]. This is because under anxiety, people tend to focus more on losses rather than gains, and those who fear losses are expected to display a disproportionate avoidance of risk in situations where much is at stake (Kahneman 1973, Kahneman and Tversky 1979, Lazarus and Folkman 1984, Folkman et al. 1986, Sitkin and Weingart 1995).

Overall, the effect of pressure on performance therefore depends on the availability of additional resources that allow for an appropriate adaptation of behavior and on whether the focal task profits from a risk-averse and conscious execution. If both of these requirements are met, an appropriate compensation strategy can make up for the performance losses stemming from anxiety occupying a person's attentional capacity.

3.2.1 Extreme Precision Tasks and Pressure

Tasks that might profit from an adaptation of behavior under pressure are extreme precision tasks, such as, for example, complex surgeries in emergency medicine or bomb disposal in military. These tasks require vigilance while being physically extremely activated. Hence, they need to be performed at a maximum level of attention to cognitive processes while coping with physical arousal and fatigue.

When performing extreme precision tasks, the stimulus-driven and the goal-oriented attentional systems are constantly interacting with each other (Pashler et al. 2001). The goal-oriented system is governed by goals, expectations, and knowledge (top-down) and the stimulus-driven system is influenced by sensations and salient stimuli (bottom-up). The responsibility for coordinating between these two attentional systems lies with the part of the working memory known as the central executive (Corbetta and Shulman 2002). When performing extreme precision tasks, physiological arousal and physical sensations (bottom-up) must be balanced against the attainment of higher order goals and the execution of previously learned routines and knowledge (top-down) (Vickers and Williams 2007). For example, the surgeon needs to balance attention to physical demands, e.g., tiredness and back pain (bottom-up), and cognitive demands, e.g., performing a medical procedure (top-down).

If the importance of performing an extreme precision task well increases and individuals perceive this performance pressure as a stressor, the balance between the two systems is disrupted,

[36] In some instances, it has even been shown that compensation strategies can incorporate unethical behavior (Robertson and Rymon 2001) such as cheating (Mitchell et al. 2019).

mainly via pressure occupying the stimulus-driven system (Derakshan and Eysenck 2009, p. 170). By occupying the stimulus-driven system, pressure can lead to distraction of attention away from physical sensations or stimuli, such as pain or fatigue (Asmussen and Mazin 1978, Bear et al. 2020). The extent to which this happens depends on the inhibition function and on the perceived salience of the pressure stimulus. If there is distraction and attentional imbalance, additional cognitive effort allows for the redistribution of attention and adaptation of behavior. Typically, this implies an increased self-focus, and an avoidance of risk (Kahneman 1973, Folkman et al. 1986, Sitkin and Pablo 1992).

Prior research has established that performance in extreme precision tasks improves with narrowed attentional focus and risk avoidance, such as fixation of long duration and cautious rather than rapid and dynamic movements (Vickers 2011). For example, it has been shown that policemen who stay calm and follow the goal-oriented attention system are the ones who shoot best under anxiety (Nieuwenhuys and Oudejans 2011). If pressure shifts attentional resources to the goal-oriented system and if behavior is adapted via the shifting function, the performance losses suffered by distraction might be compensated. In extreme precision tasks, it is likely that the overall effect of pressure on performance is even positive, i.e., performance improves relative to a situation with low pressure (Vickers and Williams 2007, p. 392). This is because pressure can help to shift attentional capacity away from physical demands to cognitive processes, which are more important for performing well. Consider, for example, a first responder for medical emergencies, who has to run to the site of a car accident before performing a precise medical procedure. Under pressure, e.g., in a real instead of a training situation, it might be easier for the first responder to focus on the extreme precision task instead of the physical activation induced by the physical exercise. In summary, this leads to the following hypothesis:

Hypothesis 1: Performance of extreme precision tasks increases under pressure.

3.2.2 Gender as a Contingency Factor

Besides task characteristics, individual perceptions of pressure have been shown to serve as a contingency factor for how pressure influences performance (e.g., Uziel 2007). Building on the first hypothesis, it is likely that the strength of the positive effect of pressure on performance in the context of extreme precision tasks varies with individual characteristics that are related to a person's general sensitivity to pressure. In that vein, prior research suggests that men and women differ in the extent to which they perceive pressure as a negative stressor in competitive settings. In a large scale survey, Matud (2004) found that, on average, women suffer more stress than men and that they are emotionally more distracted by it. Women tend to show a greater bias towards negative cues (Hankin and Abramson 2001) and appraise stressful situations more often as threat than men

(Chen and Qu 2021). Women were also shown to be more sensitive to higher stakes (Azmat et al. 2016)[37]. Returning to the attentional control theory, this suggests that, on average, women and men differ in their inhibition functions such that women are distracted by pressure more easily than men.

In line with this proposition, a laboratory experiment, in which psychological pressure was manipulated, showed that women perceived pressure as more threatening than men (Cahlíková et al. 2020), possibly because within the experiment women had to perform a mathematical task, which is considered as stereotypically "male" (Schmader et al. 2008). Such differences in reactions to "male" versus "female" tasks have also been shown in other contexts (e.g., Günther et al. 2010). Shurchkov (2012), for example, showed that women perform worse in high pressure math-based tournaments but increase their performance on a verbal task in a competitive environment. Interestingly, the performance increase of women in the verbal task was associated with women using extra time to reduce mistakes while men performing the same task used the extra time to increase the quantity of their responses. This suggests that men and women also differ in their response strategies to pressure, i.e., their shifting function.

Indications of gender differences in shifting, i.e., the ability to adapt behavior in response to pressure, have also been proposed by Cohen-Zada et al. (2017). In professional tennis, they find that women make fewer mistakes under pressure than men, which, in line with a similar study in professional tennis, could be because women play less aggressively, i.e., take less risk, when pressure increases (González-Díaz et al. 2012). Additionally, it is possible that gender differences in overconfidence influence both the likelihood of being distracted by pressure (*inhibition*) and a person's compensation strategy (*shifting*). Overconfident individuals may experience pressure as less threatening, thus less distracting. At the same time, overconfidence may lead individuals to adapt their behavior to pressure-inducing circumstances in a more risk-seeking manner, with confidence in own abilities. Since it has been established that, on average, men are more overconfident than women (e.g., Barber and Odean 2001, Correll 2001), this behavior is expected to be gendered, as well.

In summary, there is rich evidence that women and men respond differently to pressure. Women are expected to generally perceive pressure as more threatening than men and therefore tend to be distracted more easily (*inhibition function*). On average, women also tend to adapt their behavior in a more conservative and risk averse way in high pressure situations (*shifting function*).

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[37] There is also biological evidence for gender differences in response to pressure, mostly related to cortisol, the "stress hormone". It has been shown that men produce more cortisol than women in stressful situations (Kirschbaum et al. 1993, Stroud et al. 2002, Kudielka et al. 2009). Elevated cortisol levels are in turn associated with riskier decision-making (Putman et al. 2010) and reductions in complex cognitive process (Putman and Roelofs 2011).

In the context of extreme precision tasks, which profit from risk-averse and conscious execution, it is therefore likely that women experience a stronger performance increase under pressure than men, which leads to the second hypothesis:

Hypothesis 2: The increase in performance of extreme precision tasks under pressure is stronger for women than for men.

3.3 Methods

3.3.1 Empirical Setting

To empirically investigate the influence of pressure on performance of extreme precision tasks and related gender differences, I analyze the shooting performance of professional biathlon athletes. Biathlon is an Olympic winter sport that combines cross-country skiing with rifle shooting (IBU 2022). Cave paintings found in Norway suggest that the idea behind biathlon exists for more than 5,000 years, originally with men hunting their prey on skis with bow and arrow (Mellinger 2017). In the 18th century, biathlon was widely spread as a military sport in Northern Europe, training soldiers how to shoot well and ski fast. The first biathlon club was founded in Norway in 1861. In 1960, biathlon was added to the Winter Olympics program for men but it was not until 1992 that also women's biathlon became Olympic. Since 1993, the Sport is governed by the International Biathlon Union (IBU) (Britannica 2022).

A biathlon race consists of several laps of cross-country skiing, in between which athletes need to perform a shooting round. Biathlon shooting is a task with both immense physical and cognitive demands that resembles extreme precision tasks such as those encountered in "military, fire-fighting, police work, emergency medicine and many other areas" (Vickers and Williams 2007). Athletes' final rank in a competition is determined by the amount of time athletes need from start to finish. The number of laps and their distance vary by discipline and gender. There are four single disciplines that are relevant for this study[38]: Sprint, Mass Start, Individual, and Pursuit. All athletes compete in each of these disciplines, i.e., there is no specialization. In the Sprint discipline, women run a total distance of 7.5 km and men a total distance of 10 km, divided into three laps of equal length. Between the first and the second lap and the second and the third lap, both men and women complete a series of five shots on five targets in a shooting range. In all other disciplines, athletes need to run a longer distance, complete five laps, and perform four rounds of shooting.

[38] There are also disciplines that are performed in a team setting such as relay, mixed relay, and single mixed relay. The influence of pressure on performance in team settings may differ from individual settings and is beyond the scope of this study. Nonetheless, how same- and mixed-gender teams differ in their perceptions and responses to pressure might be an interesting question to explore in future research.

There are two shooting positions, prone and standing. In prone shooting, athletes lie down on a shooting mat and aim for a circular target with a diameter of 4.5cm that is 50m away. In standing shooting, athletes stand on the shooting mat and aim for a circular target with a diameter of 11.5cm in 50m distance. All competitions have an equal number of prone and standing shootings and the first shooting in any discipline is always prone. For every missed shot, athletes are penalized, either by being required to run a penalty loop of 150m (Sprint, Mass Start, Pursuit) or by having added one extra minute per missed shot to their overall time (Individual). Both penalties have severe consequences for the athlete's final outcome, as the final ranks are usually separated by only a couple of seconds. For example, at the Olympics 2018, the Austrian athlete Julian Eberhard missed the bronze medal in the Sprint competition by less than a second and German athlete Simon Schempp even lost the gold medal in the Mass Start competition to Martin Fourcade from France by less than a tenth of a second.

Biathlon is an ideal setting to answer the research questions because (1) biathlon shooting is an extreme precision task, (2) athletes can adapt their shooting behavior in response to changing task demands, (3) biathlon shooting allows for the comparison of situations with high and low pressure, and (4) men and women can perform this task equally well. I will briefly review each of these assumptions in the following and provide supporting qualitative evidence from six semi-structured expert interviews, which I conducted with professional biathlon athletes and coaches (three men and three women). Detailed transcripts of the original interviews that were held in German are provided in Appendix 3.9, but all information that is relevant for this study is discussed in the main text.

Biathlon shooting as an extreme precision task. Shooting in biathlon is an extreme precision task that is both cognitively and physically demanding. When arriving at the shooting range, athletes' heart rate is usually around 85-87% of its maximum (Hoffman and Street 1992). At the firing line, athletes are trained to reduce their heart rates to below 70% of its maximum. Once on the mat, the athletes need to suppress their body's physical demands and focus on cognitive processes. A narrowed attention and high self-consciousness are conducive to the athlete's ability to aim and pulling the trigger. The main determinants of shooting performance are "stability of hold, aiming accuracy, cleanliness of triggering, and timing of triggering" (Köykkä et al. 2022, p. 421), which are extremely difficult to achieve, especially in a situation of high physical activation[39]. In particular, the gaze control, a moment of stable aiming before pulling the trigger, is challenging yet important for performance (Vickers and Williams 2007). In addition, athletes need to consider

[39] The author of this study tried a round of five shots on large targets (11.5cm), with the targets being 25m away, in an indoor shooting range (no wind), in prone position, and without any physical exercise - he missed four out of five shots.

environmental factors such as wind and snowfall, which influence both vision and the bullets' trajectory. Using this information, athletes can adjust the visor of their weapon during the race.

The interview partners have further stated that shooting performance is mostly dependent on cognitive processes given the high task complexity. When asked about the main drivers of shooting performance, Andrea Henkel, who has won four Olympic medals in her career, replied with one word: "head" (see Appendix 3.9c). Simon Schempp, who has won three Olympic medals, added that shooting in biathlon is such a complex task that you could write a book on all of its determinants (see Appendix 3.9d). He also stressed that physical constitution on the day of the race plays an important role and that athletes need to pay attention to their bodies' signals when entering the shooting range. This implies that while shooting is a task that is mainly driven my cognitive processes, it is also subject to complex interdependencies between the body and the mind.

Adaptation of behavior during biathlon shooting. When asked about strategies athletes can use to adapt their shooting to changing task demands, the experts mentioned the importance of calming down and reducing speed. Simon Schempp said that shooting fast means taking more risk and that a conscious and slow shooting will make it more likely to hit all targets (see Appendix 3.9d). Marion Wiesensarter, an active German athlete, explained that in situations in which she experiences a lot of pressure, she engages in relaxation exercises to refocus (see Appendix 3.9e). Juliane Frühwirth, a German junior athlete, mentioned that she would sometimes count in her head as she enters the shooting range to increase attentional focus (Appendix 3.9f).

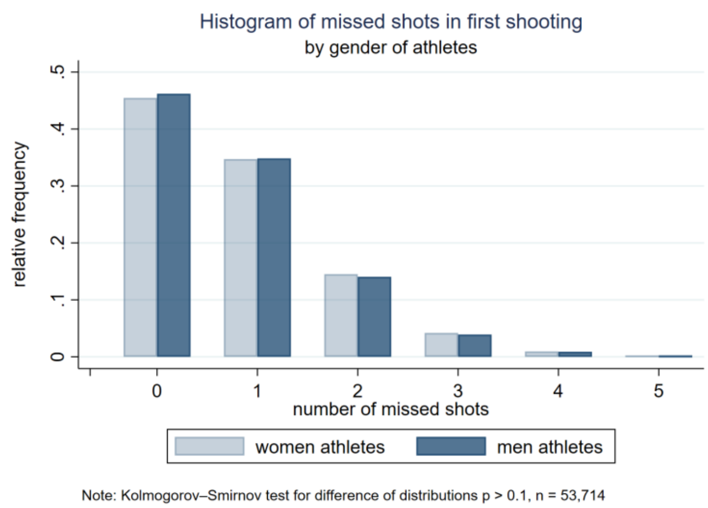
However, taking a lot of time at the shooting range is not the proverbial silver bullet. Fritz Fischer pointed out that there is also the possibility of shooting "too slowly", meaning that athletes try to do it too perfectly and then also miss targets (see Appendix 3.9a). Since final ranks in the competitions are a function of the total race time, there is also a natural incentive to shoot fast rather than slowly. However, it was pointed out by several experts that it is always better to take a couple of seconds more at the shooting range than to miss a shot. In summary, these statements show that athletes can adjust their shooting behavior to changing circumstances, in particular, by slowing down when experiencing a lot of pressure.

Pressure in biathlon shooting. In line with the definition of pressure, I consider the Olympics an occasion in biathlon where the importance of performing well is very high. The Olympics take place once every four years and offer athletes a unique opportunity to write their names in the sport's history books. For many athletes, this creates stress (cf., Gould et al. 1999, Olusoga et al. 2012). Next to the Olympics, the IBU organizes regular World Cup races, usually starting in late November and finishing in late March, and in the non-Olympic seasons, World Championships towards the end of the season. Because of the frequency with which these races occur and the status they hold in the biathlon community, the amount of pressure at these races cannot be compared to the Olympics. To put it in the words of Fritz Fischer, winner of a gold medal at the 1992 Olympics and long-time coach of the German national team: "The Olympics stand above everything"[40].

All interview partners have emphasized that the stakes at the Olympics are higher than at any other race, even if they try to approach all races in the same way. For example, Benedikt Doll, an active German athlete who has won two Olympic bronze medals, described an Olympic race as a unique opportunity, for which there is no second chance. In a World Cup race, on the other hand, athletes sometimes think that if it does not work out today, it will work out tomorrow (see Appendix 3.9b). This not only underlines the high stakes at the Olympics, but it also hints at the pressure being appraised as a threat, i.e., there is no second chance if you mess it up. Fritz Fischer further pointed out that Olympic races are more extensively covered by media, which has monetary implications for the athletes (see Appendix 3.9a). Olympic champions become national heroes and are often offered sponsoring deals that go well beyond the usual financial renumerations in biathlon. Again, this increases the stakes and pressure to perform well at Olympic races.

Gender differences in biathlon shooting. Finally, biathlon shooting is a task that men and women can perform equally well, allowing for a comparison of performance within and across gender. As an example, Figure 3.1 shows that there is no statistically significant difference in the distribution of missed shots between men and women across more than 50,000 prone shooting rounds.

Figure 3.1 Shooting Performance in First Shooting Round by Athlete Gender



[40] Traslated by the author, for the transcript of the original interview in Germany, please see Appendix 9a.

3.3.2 Data and Sample

I constructed a longitudinal dataset at the athlete-shooting-level, using detailed data on competitions, venues, and athletes shared by the IBU and its data provider *siwidata*. The available data includes all professional biathlon races between the 1994/1995 and 2018/2019 season, covering six Winter Olympics (Nagano 1998, Salt Lake City 2002, Turin 2006, Vancouver 2010, Sochi 2014, and Pyeonchgang 2018). The sample is limited to the four single disciplines of biathlon: Individual, Mass Start, Pursuit, and Sprint. While Individual and Sprint have been Olympic disciplines for the entire sample period, Pursuit was added in 2002 and Mass Start in 2006. Women and men compete in separate races that are usually held at the same place and often even on the same day.

To ensure comparability within and across athletes, I limit the analysis to the first shooting round in each race. The first shooting round is always performed in the prone position and allows for the cleanest analysis of shooting performance under pressure. Performance in any later shooting round is noisy because of within race dynamics and potential spillover effects from earlier to later shooting rounds that cannot be disentangled. For example, the interview partners have repeatedly mentioned that feedback about earlier shooting rounds, which is provided by coaches and staff at the race track, influences their performance at later shooting rounds (Appendix 3.9). Additionally, in some disciplines the first shooting round is followed by a standing shooting while in others by a second round of prone shooting, making later shooting rounds difficult to compare across disciplines.

I employ a several criteria for an athlete to be included in the final sample in service of estimation accuracy. First, I remove any athlete who has never competed at the Olympics to ensure that all athletes under investigation have at least one observation in the high-pressure condition. Next, I only consider athletes who have achieved at least one top ten result throughout their career and who have participated in at least ten professional races during the sample period. These criteria ensure that I study competitive athletes and exclude athletes from smaller nations who get the chance to participate at the Olympics because of lower entry hurdles than for World Cup races. Several interview partners have pointed out that the Olympics allow for every nation to have a maximum of four starters at a race, which limits top nations with more than four highly competitive athletes, but benefits smaller nations that can invite second tier athletes to complete their squads. It is likely that these less competitive athletes do not experience the Olympics as a situation of high pressure.

Applying these steps, I end up with a sample of 391 athletes, 194 men and 197 women, and 599 races for each gender. Out of these 599 races for both men and women, 95 were Individual, 96

Mass Start, 175 Pursuit, and 233 Sprint races. There are 21 Olympic races for both men and women (6 Individual, 6 Sprint, 5 Pursuit, 4 Mass Starts) in the sample.

I use these observations to create a panel dataset at the athlete-shooting-level. Since I only consider the first shooting of each race, this is equivalent to the athlete-race-level. The panel is unbalanced as not every panel member is observed in every period. On average, each of the 391 athletes under investigation is observed 136 times. The minimum observations per athlete is 14, the maximum is 464 (Ole Einar Bjørndalen). The 391 athletes come from 32 different countries, with Germany (9%), France (8%), Russia (7.5%), and Ukraine (6%) being represented most prominently.

3.3.3 Variable Descriptions

All variables used in the regression models are summarized in Table 3.1 and described below. A detailed correlation table is provided in Appendix 3.1.

Dependent variable. The main dependent variable is the number of shots an athlete misses in the first shooting round of a focal race. Since the shooting round consists of five shots for five targets, the variable *missed shots* is bound between 0 and 5, with lower values indicating a better performance. On average, athletes in the sample miss 0.8 shots.

To test compensation strategies, i.e., adaptation in behavior under pressure, I use a second dependent variable in the later analysis. This variable, *shooting time*, captures the number of seconds that pass between the athlete starting the shooting by lying down on the shooting mat and him or her leaving the mat again. The shooting time is hand-stopped and available as of the 2001/ 2002 season. Because of likely measurement errors, extreme values (e.g., 5 or 200 seconds) have been adjusted to the 1st and 99th percentile, 22 and 52 seconds respectively, but results stay consistent when removing these erroneous observations from the sample. The first shooting round lasts, on average, 32.8 seconds.

Independent variable. The main independent variable is a dummy variable *Olympics*, which turns on when the focal shooting round is part of an Olympic race. Four percent of all shooting rounds in the sample were Olympic, underlining its unique and special character.

Control variables. With the longitudinal data structure, I employ athlete fixed effects to account for any time-invariant athlete characteristics such as talent or stable personality traits. These individual fixed effects also absorb the direct effect of gender but I use a *woman athlete* dummy variable to test interaction effects in the full sample, exploiting between person variance, and to split the sample. About half (47%) of all shooting rounds in the sample were performed by women athletes.

Table 3.1 Descriptive Statistics

variable name	description	mean	sd	min	max
dependent variables					
missed shots	number of missed shots in the first shooting round of a biathlon race	0.80	0.91	0	5
shooting time'	time (seconds) needed for the first shooting at the focal race, hand-stopped from arrival to departure from shooting mat	32.88	5.44	22	52
independent variable					
olympics	dummy variable indicating whether the focal shooting was part of an olympic race: 1 if olympic; 0 otherwise	0.04	0.18	0	1
athlete characteristics					
woman athlete	dummy variable indicating gender of athlete: 1 if woman; 0 otherwise	0.47	0.50	0	1
favorite	dummy variable indicating whether athlete is considered a favorite in a given race: 1 if among top 15 of current world cup standing; 0 otherwise	0.27	0.44	0	1
current world cup rank	current World cup rank of focal athlete	43.73	41.01	1	215
average rank in last five races	focal athlete's average finishing rank at the last five races	30.85	17.25	1	110
starting number	focal athlete's starting number at the focal race	36.29	26.19	1	136
average missed shots in first shooting of last five races	focal athlete's average number of missed shots in the first shootings of the last five races	0.80	0.49	0	5
average shooting time in first shooting of last five races	focal athlete's average shooting time in the first shootings of the last five races	32.94	4.18	19.6	66.12
number of professional races in career	focal athlete's number of prior professional races (including focal race)	98.67	70.91	2	477
number of olympic races in career	focal athlete's number of prior olympic races in his or her career (including focal race)	3.31	3.05	0	19
number of prior world cup races within the same season	number of prior world cup races within the same season (including focal race)	12.30	7.37	1	27
prior olympic medal in career	dummy variable indicating whether focal athlete has already won an olympic medal in his or her career: 1 if yes; 0 otherwise	0.11	0.31	0	1
age at race	focal athlete's age in years at focal race	27.82	4.16	16	48
number of races at same event	number of races at the same even the focal athlete has started in (including focal race)	1.66	0.75	1	4
days since last race	number of days since last professional rate (replaced to 14 when more than 14 days)	5.51	4.91	1	14
fast first lap'	dummy variable indicating whether the relative speed on the first skiing lap is above the focal athlete's season average	0.50	0.50	0	1
home race	dummy variable indicating whether focal shooting was in the athlete's country: 1 if in athlete's country, 0 otherwise	0.06	0.24	0	1
number of team members in same race	number of focal athlete's team members within the same race (including focal athlete)	4.10	1.65	1	10
race characteristics					
average missed shots in first shooting across all starters	average number of missed shots in the first shooting across all starters of the focal race	0.88	0.23	0	1.967
discipline: mass start	dummy variable indicating the discipline of the focal race: 1 if mass start; 0 otherwise	0.10	0.29	0	1
discipline: pursuit	dummy variable indicating the discipline of the focal race: 1 if pursuit; 0 otherwise	0.27	0.45	0	1
discipline: sprint	dummy variable indicating the discipline of the focal race: 1 if sprint; 0 otherwise	0.45	0.50	0	1
disicpline: individual	dummy variable indicating the discipline of the focal race: 1 if individual; 0 otherwise	0.18	0.38	0	1
world championship	dummy variable indicating whether focal race is a world championhsip race: 1 if yes; 0 otherwise	0.12	0.32	0	1
season dummies''	dummy variables indicating the season within which the focal race took place	2007/2008	-	-	-
observations					53,714

' detailed information on shooting and course time available as of the 2001/ 2002 season; '' median instead of mean reported

Complementing the individual fixed effects, I further control for a number of time varying characteristics at the athlete level, which broadly fall into four categories: momentum, experience, fatigue, and social facilitation.

Momentum describes the tendency of athletes who have recently performed well to also perform well on the next occasion, for example, because of increased self-confidence or being in good physical condition (Adler 1981). At the same time, good prior performance may increase the amount of pressure athletes experience because they set themselves higher goals or face higher expectations from coaches, family, and fans. To account for these dynamics, I create a dummy variable *favorite* that turns on when the focal athlete is among the top 15 athletes according to the World Cup standing before the start of the focal race. On average, 27% of the shooting rounds in the sample, were performed by "favorites". In addition to using this dummy variable as a control variable, I use it to test interaction effects with the Olympics dummy as it can serve as a proxy for the intensity with which athletes are experiencing the Olympics as pressure. Those who compete for podium might experience more pressure than those who do not. Descriptive data corroborates that favorite athletes have a more realistic chance of winning a medal (reaching podium) than non-favorite athletes. The odds of reaching the podium are more than eight times higher for favorite as compared to non-favorite athletes, i.e., 17.7% of favorite athletes make the podium vs. 2.1% of non-favorite athletes.

Next to the favorite dummy, I control for the focal athlete's exact rank in the current World Cup standing (*current world cup rank*) to pick up residual variance beyond the favorite dummy variable at a more fine-grained level. If the focal race is the first race of the season, this variable takes on the focal athlete's final rank of the previous World Cup season. Since injuries at the beginning of a season may lead athletes who have recently performed well to still be ranked low in the World Cup, I also control for the focal athlete's average rank in the last five races (*average rank in five last races*) as well as an athlete's *starting number*. In the Individual and Sprint disciplines, the starting number proxies not only an athlete's current performance level but also the amount of information athletes might have about the specific race conditions. In both disciplines, athletes start sequentially within gaps of 30 seconds in a semi-random order and those who start later can learn about daily conditions from earlier starters. At the same time, those who start early have a smaller break between their race and their shooting practice and tend to have better snow conditions, which is why most athletes prefer to start early rather than late (Appendix 3.9).

Next, I control for the average number of shots the focal athlete missed in his or her first shooting in the five previous races (*average missed shoots in first shooting of last five races*). Again, momentum is an important determinant of confidence and performance, in particular for shooting, as was pointed out by several interview partners (Appendix 3.9). I create the same variable for the shooting time (*average shooting time in first shooting of last five races*).

Another important determinant of performance under pressure is experience (Landman et al. 2016). Athletes, who have already competed in many professional races might learn how to cope with pressure (e.g., Vine and Wilson 2010). Accordingly, I control for both the *number of professional races* and the *number of Olympic races* an athlete has competed in prior to the focal race. On average, athletes have competed in 98 professional races, three of which were Olympic. To also account for more recent experience and potential career breaks, I also add the *number of world cup races from the same season* as a control variable.

Not only the amount but also the kind of experience can matter. In particular, athletes who have already won an Olympic medal at an earlier point in their career, might perceive less pressure at an Olympic race than those who have not won an Olympic medal yet. I use the variable *prior Olympic medal in career* to better understand the effects of pressure on performance in subsample analyses.

The next block of control variables accounts for the level of fatigue with which athletes start a race. Fatigue can be both physical and mental and may affect performance under pressure (Vickers and Williams 2007). As athletes might need a longer time to regenerate as they get older, I control for the focal athlete's age at the race (*age at race*). The youngest athlete starting a race in the sample is 16 years old (Magdalena Gwizdon) and the eldest is 48 years old (Ilmars Bricis). On average, athletes are 28 years old when starting a race.

Another variable that accounts for fatigue, is the *number of races at the same event*. The biathlon season is organized in World Cup, World Championship, and Olympic events which combine a series of races at the same place, usually held within one or two weeks. It is possible that fatigue increases with the number of races that have already been held at the same event. Since disciplines are usually held in a similar order across events, this variable is highly correlated with the discipline dummies (see Appendix 3.1 for the correlation table). I will therefore use this variable as a control only when splitting the sample by discipline. In all other models, I instead control for the number of days that have passed since the athlete's last professional race (*days since last race*). This variable is capped at 14 days to avoid an inflation of the variable across seasons. The last variable that captures fatigue accounts for the focal athlete's speed in the first skiing lap. Similar to shooting time, this information is hand-stopped and available as of 2001. Because skiing time is dependent on a lot of conditions such as the discipline, the distance, the course elevation or snow conditions, the variable has been transformed into a dummy variable *fast first lap*. This variable turns on if the athlete's lap time in the first skiing lap relative to his or her overall skiing time in the same race is below the season average for the same discipline. I use this control variable when analyzing the athletes' compensation strategy under pressure.

Finally, I employ two control variables at the athlete level that account for social facilitation. Social facilitation describes the tendency of people to increase effort as a result of the presence of others (Zajonc 1965). It was found to be correlated with both performance and pressure and should therefore be controlled for (e.g., Bond and Titus 1983, Harb-Wu and Krumer 2019). The first related variable, *home race,* is a dummy variable that turns on if the focal race takes place in the athlete's home country. This is the case for 6% of all shootings. Lastly, the *number of team members in the same race* accounts for the fact that with many athletes from the same nation starting at a race, a single athlete may be more motivated to perform well, an experience that was shared during the expert interviews (e.g., interview with Andrea Henkel, Appendix 3.9c). On average, there are four athletes from the same nation competing in the same race.

In addition to the athlete-level controls, I employ several control variables at the race level. *Average missed shots in first shooting across all starters* accounts for race conditions that likely affect all starters' performance. If there is, for example, a lot of wind on the day of the race, then it is also more likely that shots are being missed.

Next, I control for the different disciplines using dummy variables. In some disciplines, like Sprint or Individual, the shooting performance is more important for the overall race outcome than in others (e.g., Luchsinger et al. 2020). Additionally, the length of the race and whether athletes start at the same time or sequentially differs by discipline. These differences could also affect how pressure influences shooting performance.

Furthermore, I employ a dummy variable that turns on if the focal race is a World Championship race. World Championship races take place towards the end of every non-Olympic season. Besides collecting World Cup points at the World Championship races, athletes are also competing for medals. However, interview partners have indicated that World Cup victories are usually considered more prestigious than World Championships, while neither of the two can be compared to the Olympics (Appendix 3.9).

Finally, I employ season dummies to control for any remaining time trends, such as the biathlon sport having become more professional and more popular over the last years. The increasing media attention might affect how much pressure is perceived by the athletes but an improved training infrastructure might also help athletes to better handle it. Altogether, there are 25 seasons included in the sample.

3.4 Results

To formally test the first hypothesis that the performance of extreme precision tasks improves with pressure, I make use of the panel data structure and estimate fixed effects regression models with clustered standard errors at the athlete level. Since the main dependent variable of interest is the number of missed shots, a count variable, I estimate Poisson models using the xtpoisson command in Stata. If not stated otherwise, coefficients are reported as incidence rate ratios (exponentiated coefficients) that can be interpreted as percentage changes in the dependent variable induced by a one unit change in the independent variable. A coefficient of one implies no effect, an effect below one a negative and an effect above one a positive effect.

Model 1 in Table 3.2 shows a baseline model that includes all observations in the sample. The main independent variable of interest is the Olympics dummy that serves as a proxy for high-pressure situations. Given the data structure, the dummy variable captures within-person variance in the shooting performance of athletes at Olympic versus non-Olympic races. As the Olympics dummy does not distinguish from a null effect in Model 1, there is no statistically significant difference in shooting performance at Olympic versus non-Olympic races across all athletes in the sample. However, it is possible that not all athletes who start at the Olympics perceive it as a situation of high pressure.

Model 2 therefore tests an interaction effect between the Olympics dummy and the favorite dummy, but also for favorite athletes there is no statistically significant performance increase at Olympic races. Even though the interaction term is below one, implying that they miss fewer shots, it does not differ from a null effect in a statistically significant way ($p > 0.1$).

Model 3 extends the logic that some athletes might perceive the Olympics as a greater source of pressure than others, by further differentiating the favorite athletes in those that have already won an Olympic medal during their career and those that have not. It is expected that those without an Olympic medal experience more pressure. However, also this analysis does not show that those who likely experience a lot of pressure at the Olympics perform better than those who do not. In summary, there is no evidence supporting the first hypothesis that performance of extreme precision tasks generally increases under pressure.

Table 3.2 Effect of Olympics on Shooting Performance

	ALL	ALL	FAVORITE
	(1)	(2)	(3)
dependent variable: number of missed shots	POISSON	POISSON	POISSON
independent variables			
olympics	0.995	1.015	
	(0.030)	(0.033)	
favorite	1.023	1.025	
	(0.018)	(0.018)	
olympics x favorite		0.912	
		(0.071)	
olympics x never won olympic medal in career			0.917
			(0.076)
olympics x already won olympic medal in career			0.811
			(0.108)
not olympics x already won olympic medal in career			0.918
			(0.059)
not olympics	base	base	base
controls at the athlete level			
current world cup rank	1.000	1.000	1.002
	(0.000)	(0.000)	(0.003)
average rank in last five races	1.002***	1.002***	0.998
	(0.001)	(0.001)	(0.002)
starting number	1.000	1.000	1.000
	(0.000)	(0.000)	(0.001)
average missed shots in first shooting of last five races	1.060***	1.060***	1.015
	(0.013)	(0.013)	(0.030)
number of professional races in career	1.000	1.000	1.000
	(0.000)	(0.000)	(0.002)
number of olympic races in career	1.002	1.002	1.024*
	(0.006)	(0.006)	(0.014)
number of prior world cup races within the same season	1.002*	1.002*	1.000
	(0.001)	(0.001)	(0.003)
age at race	0.978	0.978	1.016
	(0.018)	(0.018)	(0.038)
days since last race	1.001	1.001	1.001
	(0.001)	(0.001)	(0.003)
home race	1.045**	1.044**	1.065*
	(0.021)	(0.021)	(0.037)
number of team members in same race	1.006	1.006	1.020*
	(0.005)	(0.005)	(0.010)
athlete fixed effects	included	included	included
controls at the race level			
average missed shorts in first shooting across all starters	2.797***	2.797***	3.170***
	(0.068)	(0.068)	(0.143)
discipline: mass start	1.207***	1.206***	1.326***
	(0.029)	(0.029)	(0.064)
disicpline: pursuit	1.117***	1.117***	1.178***
	(0.021)	(0.021)	(0.050)
discipline: sprint	0.988	0.988	0.985
	(0.013)	(0.013)	(0.032)
discipline: individual	Base	Base	Base
world championship race	0.987	0.987	1.021
	(0.015)	(0.015)	(0.037)
season dummies	included	included	included
observations (athlete-shooting-level)	53,714	53,714	14,342
athletes	391	391	259

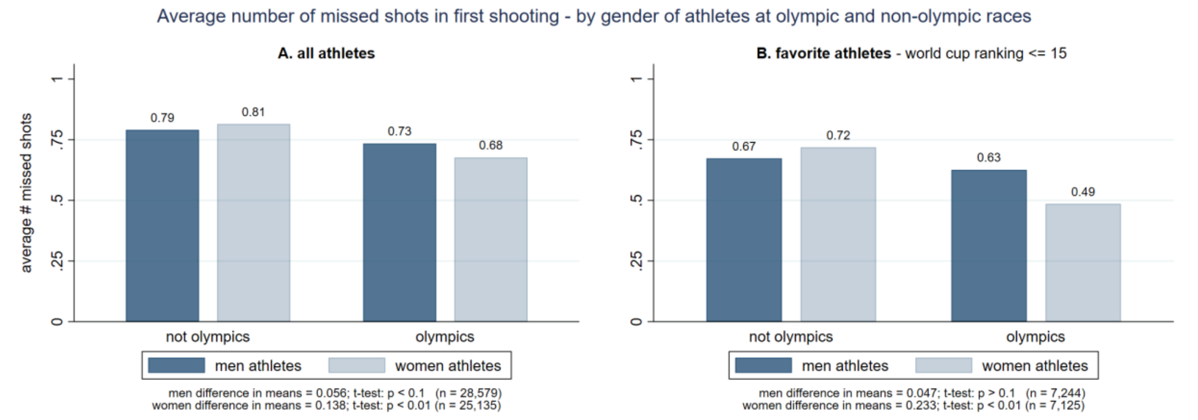
standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

Apart from these main effects, the control variables mostly behave as expected. For example, athletes shoot significantly worse, i.e., miss more shots, when they rank low in the current world cup standing or when they have missed many shots in previous races, stressing the important role of momentum. Interestingly, athletes shoot significantly more mistakes when they compete in a home race. This is in line with prior research, that found evidence for social facilitation in biathlon competitions (Harb-Wu and Krumer 2019). With respect to the race-level controls, the average number of shots missed by all starters are a strong predictor of the focal athlete's shooting performance, underlining the importance of controlling for general race conditions. It is also noteworthy that athletes shoot significantly more mistakes (10-12%) at Pursuit and Mass Start races, where they compete directly against each other rather than in sequential order. In general, favorite athletes (Models 3 and Models 4) seem to be less sensitive to momentum and external factors, as fewer control variables have a statistically significant effect on their shooting performance.

Gender as a Contingency Factor

Despite no evidence in support of the first hypothesis, it is still possible that women and men perform an extreme precision task differently under pressure. Figure 3.2 provides descriptive cross-sectional evidence that, indeed, the performance improvements at Olympic relative to non-Olympic races in biathlon shooting are stronger for women than for men. Panel A shows that, on average, women miss 0.81 shots at non-Olympic races and 0.68 shots at the Olympics. A two-sample t-test indicates that this difference in means is statistically significant ($p < 0.01$). Men also improve their shooting performance at Olympic vs. non-Olympic races but to a lesser extent (0.79 vs. 0.73, $p < 0.1$). Looking at favorite athletes only (Panel B), the performance differences even get larger for women, while for men they get smaller and are no longer statistically significant ($p > 0.1$).

Figure 3.2 Shooting Performance at Olympic vs. non-Olympic Races – by Gender



Note: based on 53,714 shooting rounds, 14,369 by favorite and 39,345 by non-favorite athletes; including 197 women and 194 men athletes between 1994-2018

Table 3.3 explores these gender difference in multivariate panel regressions to formally test the second hypothesis. Model 1 shows an interaction term of the Olympics dummy variable with a dummy variable for women athletes in the full sample. Because of the individual fixed effects, the direct effect of athlete gender is not estimated and the interaction term is based on cross-person variance. The statistically significant interaction term of 0.908 ($p < 0.1$) implies that women's shooting performance at Olympic races improves more than men's, i.e., they shoot relatively fewer mistakes. This is a first indication for gender differences in shooting performance at Olympic vs. non-Olympic races.

To investigate whether these cross-person effects are also significant within person, Models 2 and 3 split the sample by athlete gender. Model 2 is limited to women athletes whereas Model 3 is limited to men athletes only. While the directions of the coefficients for the Olympics dummies are in line with Model 1, i.e., below one for women athletes and above one for men, they do not differ from a null effect in a statistically significant fashion in either subsample. With respect to the control variables, there are, however, some interesting differences between men and women. For example, while men still shoot significantly more mistakes at home races, there is no indication for social facilitation induced by home races among women. Furthermore, women miss more shots when they race with more athletes from the same team, while men shoot significantly better as they get older and have participated in fewer races within the same season.

Model 4 and Model 5 test for interaction effects of the Olympics dummy with the favorite dummy, again to identify the effect for women and men athletes that are expected to perceive the Olympics as a high-pressure situation. Model 4 limits the sample to women and Model 5 to men athletes. There is a strong and statistically significant interaction term for favorite athletes and the Olympics dummy for women ($p < 0.05$) but not for men ($p > 0.1$). Women athletes who start an Olympic race with a realistic chance of winning a medal miss, on average, 22.5% fewer shots than in a non-Olympic race, holding everything else constant. At the same time, there is no difference for men favorite athletes at the Olympics, if anything they shoot slightly worse in an Olympic race. For both men and women non-favorite athletes, the direct effect of the Olympics stays insignificant, implying that non-favorite athletes neither shoot worse nor better at an Olympic race, potentially because they do not experience it as a distracting stressor.

Table 3.3 Effect of Olympics on Shooting Performance - by Gender

	ALL	WOMEN	MEN	WOMEN	MEN
	(1)	(2)	(3)	(4)	(5)
dependent variable: number of missed shots	POISSON	POISSON	POISSON	POISSON	POISSON
independent variables					
olympics	1.042	0.945	1.041	0.998	1.029
	(0.043)	(0.040)	(0.044)	(0.046)	(0.048)
olympics x woman athlete	0.908*				
	(0.051)				
favorite	1.023	1.001	1.039	1.007	1.038
	(0.018)	(0.024)	(0.027)	(0.024)	(0.026)
olympics x favorite				0.775**	1.050
				(0.079)	(0.111)
controls at the athlete level					
current world cup rank	1.000	1.000	1.000	1.001	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average rank in last five races	1.002***	1.002***	1.002***	1.002***	1.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
starting number	1.000	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average missed shots in first shooting of last five races	1.060***	1.071***	1.043**	1.071***	1.043**
	(0.013)	(0.018)	(0.018)	(0.018)	(0.018)
number of professional races in career	1.000	1.002***	0.999*	1.002***	0.999*
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
number of olympic races in career	1.002	1.002	1.003	1.002	1.003
	(0.006)	(0.009)	(0.008)	(0.009)	(0.008)
number of prior world cup races within the same season	1.002*	0.999	1.005***	0.999	1.005***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
age at race	0.978	1.011	0.949**	1.011	0.949**
	(0.018)	(0.027)	(0.023)	(0.027)	(0.023)
days since last race	1.001	1.001	1.001	1.001	1.001
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
home race	1.044**	0.997	1.088***	0.996	1.089***
	(0.021)	(0.030)	(0.028)	(0.030)	(0.028)
number of team members in same race	1.006	1.014**	0.998	1.013*	0.998
	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)
athlete fixed effects	included	included	included	included	included
controls at the race level					
average missed shorts in first shooting across all starters	2.797***	2.787***	2.898***	2.786***	2.898***
	(0.068)	(0.096)	(0.103)	(0.096)	(0.103)
discipline: mass start	1.207***	1.195***	1.224***	1.194***	1.224***
	(0.029)	(0.040)	(0.041)	(0.040)	(0.041)
disicpline: pursuit	1.117***	1.127***	1.106***	1.126***	1.106***
	(0.021)	(0.029)	(0.031)	(0.029)	(0.031)
discipline: sprint	0.988	0.988	0.984	0.989	0.984
	(0.013)	(0.019)	(0.019)	(0.019)	(0.019)
discipline: individual	Base	Base	Base	Base	Base
world championship race	0.987	1.018	0.957**	1.018	0.957**
	(0.015)	(0.022)	(0.020)	(0.022)	(0.020)
season dummies	included	included	included	included	included
observations (athlete-shooting-level)	53,714	25,135	28,579	25,135	28,579
athletes	391	197	194	197	194

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

To further explore effects of pressure on shooting performance by gender, Table 3.4 continues to investigate underlying dynamics in the sample of favorite men and women athletes. Even among favorite athletes the perception of the Olympics might change once they have been successful and already won an Olympic medal. Analog to Model 3 of Table 3.2, I split the Olympics dummy into two cases, (1) starting at the Olympics and already having won an Olympic medal during the career and (2) starting at the Olympics and not having won an Olympic medal yet[41]. Model 1 is limited to women favorite athletes and shows that they only shoot significantly better (23% fewer mistakes) when they have not yet won an Olympic medal, i.e., when the pressure is expected to be particularly high. Once they have already won an Olympic medal in their career, their shooting performance no longer differs from the base case. For men, there is no statistically significant effect for either of the two cases. These results indicate that women and men perform an extreme precision task very differently under pressure, with women performing best when pressure is high and men showing no change in performance.

Table 3.4 Varying the Amount of Pressure

	FAVORITE WOMEN	FAVORITE MEN
dependent variable: number of missed shots	(1) POISSON	(2) POISSON
independent variables:		
olympics x never won olympic medal in career	0.756**	1.068
	(0.090)	(0.114)
olympics x already won olympic medal in career	0.822	0.836
	(0.149)	(0.154)
not olympics x already won olympic medal in career	0.956	0.910
	(0.093)	(0.062)
not olympics	base	base
controls at the athlete level	included	included
controls at the race level	included	included
season dummies	included	included
observations (athlete-race level)	7,112	7,230
athletes	136	123

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

Underlying Mechanisms – Inhibition and Shifting Functions

Having established that women favorite athletes perform an extreme precision task under pressure better than men, I further test mechanistic explanations. The attentional control theory

[41] I also include a dummy for not being at the Olympics and already having won an Olympic medal during the career. The base case is not being at the Olympics and never having won an Olympic medal.

proposes two main channels, the inhibition and the shifting function. Gender differences in preferences and behavior leave room for men and women to differ along both functions. In the following, I will offer indirect tests in an attempt to tease these mechanisms apart. I focus on the athletes that were shown to be most sensitive to pressure at the Olympics, i.e., favorite athletes with realistic chances of winning an Olympic medal.

First, I look at the inhibition function, which controls the locus of attention and the likelihood of an athlete being distracted by pressure. It was hypothesized that women are more distracted by pressure than men because they are more sensitive to pressure as a negative stressor. To empirically study the extent to which distraction matters, I split the sample by disciplines. In the Individual and Sprint disciplines, athletes start sequentially and race against the clock. Because in these two disciplines athletes are racing their own race, they have more attentional capacity available to worry about themselves and their own performance. This is different to Mass Start and Pursuit, where athletes directly race against each other. Here they need to not only worry about themselves but also about their direct competitors.

The expert interviews confirmed that athletes are easily distracted by pressure in Sprint and Individual competitions, when there is little distraction from other sources. Juliane Frühwirth mentioned explicitly that in the Sprint and Individuals disciplines there is more time for "distracting thoughts" (Appendix 3.9f). Asked about gender differences, two other women athletes, Andrea Henkel (Appendix 3.9c) and Marion Wiesensarter (Appendix 3.9e), further suggested that women generally think and worry more than men, implying that the inhibition function may be a mechanistic explanation for the observed gender differences.

If the inhibition function did not contribute to the observed gender differences in performance under pressure, we would expect to see gender differences in shooting performance in all four disciplines to the same extent. But if men and women differed in their sensitivity to pressure as a distracting stressor, then we would expect these differences to be particularly pronounced in the Sprint and Individual competitions, where athletes are distracted more easily. Table 3.5 shows that this is the case[42]. In Sprint and Individual competition (Model 1), the interaction effect between the Olympics and the woman athlete dummy is highly significant and large in magnitude. On average, women favorite athletes improve their performance at Olympic Sprint and Individual competitions by 23% fewer shots missed (37% - 14%) than men. For Mass Start and Pursuit competitions, we do not find statistically significant gender differences in performance under pressure (Model 2).

[42] This analysis is limited to races after 1998, the beginning of the first Olympic cycle with Mass Start being Olympic. Models include an additional control variable for the sequence of races at a focal event since Sprint competitions are often the first ones being held and by nature take place prior to the Pursuit race. In Pursuit races, athletes start with the time differences with which they have finished the preceding Sprint race.

Consistent effects are observed when only looking at within-person effects (Model 3-6). Women athletes shoot significantly better at Olympic Sprint and Individual competitions than at non-Olympic competitions in these two disciplines. On average, they miss almost 30% fewer shots ($p < 0.01$).

Table 3.5 Varying Distraction – Inhibition Function

	FAVORITE	FAVORITE	FAVORITE	FAVORITE	FAVORITE	FAVORITE
	ALL	ALL	WOMEN	MEN	WOMEN	MEN
	Sprint & Individual	Mass Start & Pursuit	Sprint & Individual	Sprint & Individual	Mass Start & Pursuit	Mass Start & Pursuit
	(1)	(2)	(3)	(4)	(5)	(6)
dependent variable: number of missed shots	POISSON	POISSON	POISSON	POISSON	POISSON	POISSON
independent variables:						
olympics	1.145	0.975	0.735**	1.099	0.890	0.935
	(0.151)	(0.115)	(0.098)	(0.161)	(0.143)	(0.113)
olympics x woman athlete	0.628***	0.849				
	(0.106)	(0.161)				
controls at the athlete level	included	included	included	included	included	included
controls at the race level	included	included	included	included	included	included
season dummies	included	included	included	included	included	included
observations (athlete-shooting-level)	6,937	6,697	3,414	3,523	3,325	3,372
athletes	216	212	113	103	111	101

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; limited to races as of season 1998/1999

I continue to explore whether women and men also differ in their shifting function, i.e., in how they adapt their behavior in high pressure situations. To do so, I use the shooting time as a new dependent variable and estimate fixed-effects linear regression models using ordinary least squares (OLS)[43]. Since shooting time serves as a proxy for the level of risk athletes take at the shooting range, it is expected that women shoot more slowly in high pressure situations than men, i.e., take less risk. In addition to the control variables included in Table 3.2, I now add control variables that are relevant to the new dependent variable. First, I control for an athlete's average shooting time in previous races (*average shooting time in first shooting of last five races*), an adopted measure for momentum. Second, I control for the athlete's relative speed in the first lap, since very fast skiing might increase the time an athlete needs at the shooting rage in order to bring down his or her heart rate (*fast first lap*). Last, I control for the number of missed shots using dummy variables[44], because athletes tend to pause their shooting routine when missing a target and because I am interested in the behavioral adaptation net of performance[45].

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[43] Due to data availability this analysis is limited to professional race taking place after 2001.

[44] Dummy variables are used because the effect of missed shots on shooting time may be non-linear but the effects stay robust to including the number of missed shots as a continuous variable (p-values even get smaller).

[45] It would also be interesting to check the mediating effect of risk-taking on performance via shooting time. However, testing a mediation model would require more granular data such as the time to first shot. The aggregated time is noisy because on the, one hand, it influences shooting performance (e.g., via risk-taking) but, on the other hand, it is also influenced by performance (e.g., via readjustment after missing shot).

As shown in Model 1 of Table 3.6, women favorite athletes take significantly more time when shooting at the Olympics than men, on average and holding everything else constant, around 0.7 seconds (please note that coefficients are no longer exponentiated). Models 2 and 3 split the sample again by the gender of favorite athletes and look at the behavioral adaptation within person. Women athletes shoot almost one second more slowly at an Olympic than at a non-Olympic race. For men, we do not observe any statistically significant difference.

Table 3.6 Adaptation of Behavior – Shifting Function

	FAVORITE ALL	FAVORITE WOMEN	FAVORITE MEN
	(1)	(2)	(3)
dependent variable: shooting time in first shooting	OLS	OLS	OLS
independent variables:			
olympics	-0.00117	0.837*	-0.0411
	(0.284)	(0.430)	(0.329)
olympics x woman athlete	0.729*		
	(0.434)		
controls at the athlete level	included	included	included
controls at the race level	included	included	included
shooting time specific controls			
average shooting time in first shooting of last five races	0.205***	0.173***	0.212***
	(0.027)	(0.038)	(0.035)
fast first lap	0.175*	-0.0696	0.423***
	(0.095)	(0.134)	(0.120)
0 missed shots	base	base	base
1 missed shot	0.785***	0.923***	0.660***
	(0.093)	(0.124)	(0.130)
2 missed shots	2.178***	2.434***	1.947***
	(0.188)	(0.263)	(0.243)
3 missed shot	3.938***	4.748***	3.134***
	(0.392)	(0.619)	(0.470)
4 missed shots	6.384***	7.378***	5.602***
	(1.019)	(1.409)	(1.413)
5 missed shots	8.341***	9.217**	7.763***
	(1.765)	(4.084)	(1.689)
season dummies	included	included	included
constant	24.80***	27.23***	22.01***
	(2.993)	(4.203)	(4.364)
observations (athlete-race level)	10,371	5,104	5,267
athletes	242	125	117

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01;
exponentiated coefficents (IRRs) reported

It is important to note that the observed differences in shooting time are net of performance, i.e., holding the number of missed shots constant. In other words, at the Olympics, women need more time to get to the same performance levels than at non-Olympic races. This has two important implications. First, it shows that women's performance efficiency decreases under pressure.

Second, it shows that women adapt their behavior when faced with pressure such that they shoot more slowly, which likely explains their overall performance improvements.

In summary, the results have shown that women and men biathlon athletes differ in their performance under pressure. Women athletes shoot fewer mistakes at Olympic than at non-Olympic races. These differences are driven by athletes that are expected to experience a lot of pressure because they have realistic chances of winning a medal and have not yet won one. The effects are strongest in disciplines where pressure is likely to be more distracting and driven by women taking less risk, i.e., more time, at the shooting range, suggesting gender differences in both the inhibition and the shifting function. There are no performance differences and no differences in behavior for men athletes at Olympic versus non-Olympic races.

Robustness Checks and Additional Analyses

To establish the reliability of the results that women perform better at Olympic than at non-Olympic races while there is no change in performance for men, I conduct a series of robustness checks. First, I revisit the definition of favorite athletes, for whom performance differences were detected. While in the main analysis I considered athletes, who are ranked within the top 15 of the current World Cup standing as a favorite, I rerun the main analysis with stricter (top 10) and more lenient (top 20) thresholds, obtaining consistent results (Appendix 3.2). Effect sizes tend to be larger for the stricter threshold, which underscores the intuition that pressure affects those who have a serious chance of winning a medal more strongly. Moreover, an interaction term between the Olympics dummy and the continuous specification of a focal athlete's current World Cup rank also produces consistent results.

Second, I test whether the results are sensitive to excluding star performers from the analysis (Appendix 3.3). Star athletes might behave differently under pressure than non-star athletes (Jane 2022). I define any athlete who has won more than ten professional biathlon races in his or her career as a star. When excluding these 18 women and 11 men star athletes from the analysis, the effects remain consistent, i.e., women favorite athletes shoot significantly better at Olympic vs. non-Olympic races while no such differences can be observed for men.

Third, I rerun the main models with different model specifications (Appendix 3.4). I test whether the main results hold when running an OLS model instead of a Poisson model and find consistent results. Additionally, I create a dummy variable that turns on if the focal athlete does not miss any shots and run linear probability as well as logit models with the *no mistakes* dummy as a dependent variable. Again, the results remain robust.

Fourth, I test the sensitivity of the results to excluding individual Olympic seasons, to probe whether the observed effects are driven by data anomalies or single events. To do so, I run six separate models, always excluding one of the six Olympic seasons from the sample (Appendix 3.5). While effect sizes between models vary, they all reproduce the main finding that women favorite athletes miss fewer shots at Olympic versus non-Olympic races, while no such differences are observed for men.

Fifth, I limit the analysis to Olympic seasons and exclude seasons that take place in the three years between an Olympic event, to test whether the observed performance differences are driven by the entire season being Olympic rather than just the focal race. Appendix 3.6 shows that this is not the case – even within Olympic seasons women favorite athletes perform better at Olympic versus non-Olympic races while no such performance differences are found for men.

Sixth, I address the concern that the observed gender differences are due to a lower performance density in women's as compared to men's biathlon. I therefore compare the number of distinct athletes on the podium for both men and women across an entire Olympic season. Appendix 3.7 shows that the performance density, hence the number of distinct athletes on a podium during a season, is very similar for men and women. This applies to both Olympic and at non-Olympic races and suggests that at least among the sport's elite, i.e., those competing for podium, there are no systematic differences in performance density across gender. Also note, that the gender differences were found for favorite athletes, where performance density can be expected to be generally higher. Additionally, all model specifications control for innate talent via athlete fixed effects. Taken together, it is unlikely that performance density explains the observed gender differences.

Finally, I establish that the main results also hold on the full sample (Appendix 3.8) by testing a three-way-interaction between the Olympics dummy, the woman athlete dummy and the dummy for favorite athlete. Again, this analysis corroborates the main results.

3.5 Discussion and Conclusion

The goal of this study was to investigate whether performance of extreme precision tasks increases under pressure and whether this effect differs by gender. Deriving arguments from attentional control theory (Eysenck et al. 2007), it was hypothesized that pressure distracts attention (inhibition function) but that performance losses induced by distraction can be compensated by an adaptation in behavior (shifting function). For extreme precision tasks, it was expected that this adaptation in behavior, which typically leads to a more a conscious and risk averse task execution, results in an overall increase in performance (Hypothesis 1). The performance increase under pressure was expected to be larger for women than men, since women are considered more sensitive to pressure (Hypothesis 2).

In a large-scale study of 391 professional biathlon athletes and more than 50,000 shooting rounds, the first hypothesis was not supported. However, when analyzing gender differences, it was found that women increase their performance under pressure, whereas no performance differences were observed for men. An indirect test of the underlying mechanisms – varying the room for distraction and looking at patterns in behavioral adaptation – suggested that the effects are driven by both the inhibition and shifting function, i.e., the distracting nature of pressure as a stressor seems to allow for a more risk-averse task execution.

Even though Hypothesis 1 was not supported, the finding that men do not change their performance in extreme precision tasks under pressure still deviates from the dominant logic in the literature of individuals "choking" under pressure (Baumeister 1984, DeCaro et al. 2011). The fact that men's performance does not change when performing extreme precision tasks under pressure indicates that the high physical and cognitive demands of such tasks make it less likely for pressure to occupy a person's attention. When performing such tasks, the bottom-up attentional system, which would be occupied by pressure if perceived as a stressor, is already attending to the physical demands of the task itself. This reduces a person's receptiveness to pressure as a stressor. There are two observations in the data that support this interpretation. First, men do not show any changes in shooting time at Olympic as compared to non-Olympic races, which supports the idea that they do not shift behavior. Second, as men's overall performance does not decrease at Olympic races despite no adaptation in behavior, it is likely that they are not distracted by additional pressure. Hence, attentional control theory would suggest that pressure does not enter their attentional system as a stressing stimulus. If pressure inhibited attentional focus and distracted from the task without being compensated, one would have expected shooting performance to decrease. Therefore, even the lack of support for Hypothesis 1 can be attributed to task characteristics, in particular to tasks being both cognitively and physically demanding, like extreme precision tasks.

The effects that were found for women are also in line with attentional control theory's predictions. Women adapt their behavior under pressure by shooting more slowly, which overcompensates the performance losses induced by distraction. Additionally, the effect of pressure on women's performance was found to be particularly strong in biathlon disciplines with a lot of room for distraction (inhibition function), and compensated by taking more time at the shooting range, i.e., adapting behavior (shifting function). Finally, the observed performance increases are driven by athletes with realistic chances of winning a medal who had not yet won one. These athletes are expected to experience a lot of pressure at the Olympics, as they have high internal and external expectations to perform well.

The study also shows that the effect of pressure on performance is a double-edge sword (Gardner 2012). On the on hand, pressure boosts women's performance effectiveness, i.e., they shoot fewer mistakes, but on the other hand, women experience a reduction in performance efficiency, i.e., they need more time. These distinct effects for efficiency and effectiveness imply that a task's performance dimensions are additional important task characteristic to consider when evaluating the effect of pressure on performance. If, for example, tasks need to be executed in the fastest possible way, then losses in efficiency may weigh more heavily. But if the quality of the task is more important, than the focus should lie on effectiveness. In interviews, biathlon experts mentioned that it is usually better to shoot a couple of seconds more slowly and to not miss a shot than to take the risk of missing a shot and running a penalty lap that costs energy and approximately 30 seconds of extra time.

The tradeoff between efficiency and effectiveness also highlights that the implication of this study should neither be to only have women perform extreme precision tasks under pressure, or even worse, to increase pressure when women perform such tasks in order to boost performance. A constant exposure to pressure can impair mental health (Beiter et al. 2015) and reduce sensitivity to such situations (Nieuwenhuys and Oudejans 2011), both with negative implications for performance in the longer term. Additionally, the positive effect of pressure on performance effectiveness for women came at the cost of a loss in efficiency, while men experienced no change in either of the two performance dimensions. If anything, this hints at complementary rather than substitution effects, which likely materialize best in gender diverse teams and organizations.

By introducing the role of task characteristics as an additional explanation for why pressure does not always lead to "choking", I add a new perspective to well established literature on the pressure-performance relationship (Baumeister 1984, DeCaro et al. 2011). Existing explanations have so far primarily focused on the perception of pressure rather than the effect of response strategies on task performance (e.g., Mitchell et al. 2019). This study highlights that tasks that benefit from narrowed attention, conscious and cautious execution, and that value effectiveness over efficiency, might be performed better under pressure, even if pressure enters the attentional system as a stressor.

By further highlighting that gender differences in sensitivity to pressure can lead to women performing certain tasks more effectively than men, this study also contributes to the literature on gender differences in competitive settings (e.g., Gneezy et al. 2003, Niederle and Vesterlund 2011). Based on the premise that women perform worse under pressure than men, this literature has argued that women try to avoid high pressure situations (Niederle and Vesterlund 2007). In line with more recent empirical evidence (e.g., Shurchkov 2012, Cohen-Zada et al. 2017), this study identifies a context in which women perform (relatively) better under pressure than men. Paradoxically, this is because of the same reasons that have been used to argue the contrary.

The theoretical framework provided in this study and derived from attentional control theory further allows the integration of other observed differences in men’s and women’s responses to pressure. For example, it has been shown that, under pressure, women tend to perform better on stereotypically “female” tasks and worse on tasks commonly characterized as “male” (e.g., Günther et al. 2010, Cahlíková et al. 2020). In line with attentional control theory, this could be because pressure on stereotypically male tasks may be more distracting (inhibition function) and because it might be more difficult for women to develop an effective response strategy when performing such tasks under pressure (shifting function). This is because both the appraisal of a cue as a threat versus a challenge and the availability of a response strategy, likely depend on prior experiences and exposure, which for stereotypically male tasks is expected to be lower for women than men.

Despite this study’s focus on professional athletes in a sport setting, the findings might hold broader implications for organizations and strategic management. Unconventional empirical settings can often serve as a magnifying glass for (organizational) behavior (Bamberger and Pratt 2010) and sports has become a popular empirical setting to inform management research (Fonti et al. 2022). In the context of this study, it could be possible to draw parallels between biathlon athletes and other highly competitive individuals who perform similarly demanding tasks, like the upper echelons of an organization (Hambrick and Mason 1984). Similar to biathlon athletes, upper echelons follow a highly competitive career path along which they repeatedly face situations of extreme pressure, such as assessment centers, job interviews, or at later stages press conferences and shareholder meetings. Given the amount and the complexity of their work, their tasks can also become both cognitively and physically demanding e.g., due to long working hours, travel time, or the lack of sleep. Similar to a biathlon athlete at the shooting range, in situations where it matters most, they must make no mistakes. Considering these parallels, the present study could, for example, inform the question of how CEOs take decisions when they themselves or their organizations are under pressure and how these decisions differ by gender. Related literature has, for example, shown that anxious CEOs reduce both their personal and their organizational risk-taking (Mannor et al. 2016), a tendency that is in line with attentional control theory.

In addition to biathlon as an empirical context, the specificities of extreme precision tasks may be used to infer implications for the effect of pressure on task performance in organizational settings. The main arguments for why extreme precision tasks may profit from pressure via inhibition and shifting are that potential performance losses induced by distraction can be overcompensated by a conscious and risk-averse execution. It is likely that also other tasks meet these criteria. Consider, for example, writing the contract for a billion-dollar merger or filing a legal court case in a murder trial. Such tasks require precision and thoroughness, particularly when a lot is at stake and those performing the tasks are under a lot of pressure.

Reversing this intuition, the findings of this study might also shed light on instances when task performance decreases under pressure. If, for example, a task comes with time constraints, like competitive entry exams at schools (Jurajda and Münich 2011, Cai et al. 2019), the distracting nature of pressure cannot be compensated via readjusting attention and behavior because the possibility to adapt is limited. In the same vein, if task performance is negatively correlated with risk-aversion, a more conservative compensation strategy might have detrimental rather than beneficial effects on performance under pressure. This likely applies, for example, to winner-take-all competitions (Cason et al. 2010), where best and not average performance is rewarded.

Limitations

As with most empirical studies, there are certain limitations as to what this study can and cannot conclusively inform. While the empirical analysis provides strong evidence that men and women biathlon athletes perform differently at the Olympics, the underlying mechanisms cannot be directly observed. Expert interviews verify the underpinning assumptions such as the Olympics being a situation of high pressure but the interviews may be subject to social desirability bias and are temporally distant to the actual races that were analyzed. While this large-scale study allows to observe behavioral adaptation and performance changes in response to pressure in the field, it comes at the cost of not being able to directly observe perceptions and reactions to pressure as a stressor, and the hypothesized inhibition and shifting functions. In light of the rich experimental evidence from the laboratory that supports the importance of these functions (for a review please see Eysenck and Derakshan 2011), it is likely that they contribute to the observed gender differences in performance under pressure, but their relative weights in shaping the performance differential cannot be disentangled. Verifying the relative importance of the inhibition and shifting functions, must therefore be left to future research.

Another important feature of the data is that biathlon athletes represent a highly selected sample of men and women, to which gender differences observed in the general population may apply to a lesser extent. On their paths to becoming professional, biathlon athletes have mastered many situations of extreme pressure, filtering out those that cannot handle it, and preparing those that “survive” for a start at the Olympics. This repeated exposure to pressure might affect how much professional athletes are distracted by it and how well they can adapt. Professional athletes also work with mental coaches that help them cope with high pressure situations. For the findings of this study, this training and selection has two important implications. With respect to the inhibition function, a professional biathlon athlete is expected to be less distracted by pressure than a lay person. With respect to the shifting function, a professional biathlon athlete is likely better able to employ an appropriate response strategy under pressure. Since both arguments apply equally to men and women, this should make the sample more homogenous. Men and women biathlon athletes go through the same training and often even share the same coach. This implies that the gender differences in performance under pressure found in this study likely represent a lower bound.

With respect to endogeneity, the empirical study is, if anything, vulnerable to omitted variables, i.e., factors that correlate both with the gender of the athlete, the shooting being performed at an Olympic race, and shooting performance. Since the participation in Olympic races is not random, the possibility of unobserved factors explaining the observed performance differences cannot be ruled out with certainty. Nonetheless, the longitudinal data structure, the athlete fixed effects, the extensive set of control variables derived from both literature and expert interviews, as well as the robustness checks mitigate concerns to the extent feasible.

Future Research

Beyond avenues for future research that follow from the limitations, this study's theoretical implications also point to open questions that could be interesting to investigate. For example, this study suggests that a certain level of sensitivity to pressure may be beneficial. However, it may be possible that a person's experiences and exposure to pressure shape their inhibition and shifting functions over time such that a person becomes less sensitive. Future research could look at temporal dynamics and investigate the extent to which both functions can be "trained" and how this training influences performance. If, for example, the inhibition function would over time become more resistant to pressure and no longer allow for any distraction, this could have negative consequences for the performance of extreme precision tasks under pressure, since distraction allows for the adaptation of behavior.

Related to gender differences, future research could advance our understanding of how gendered perceptions and experiences shape inhibition and shifting, for example by comparing women from different cultural backgrounds. In particular, a focus on the societal roles of women and gendered role expectations (Eagly 1987), might affect women's sensitivity to pressure and how easy it is for them to develop an effective compensation strategy.

Another path for future research could be to consider the competitive and organizational structure within which a task is performed. Prior research has, for example, shown that women perform worse when they are competing against men instead of women (Gneezy et al. 2003). It would be interesting to study whether women and men perform extreme precision tasks under pressure differently in mixed-gender versus single-gender competitions. It is not only possible that depending on the competitive structure, pressure is perceived as more or less distracting, but also that an individual's response strategy varies depending on who the competitor is. In a similar fashion, future research could shift the investigation to the team level (c.f., Apesteguia et al. 2012) and, for example, test whether gender differences in performance under pressure lead to conflict in mixed-gender versus single-gender teams.

As this study has shown, the relationship between pressure and performance is complex and a better understanding of the underlying mechanisms and how individual and task characteristics feed into them is needed. By shedding the light on tasks that might profit from pressure using attentional control theory, this study seeks to add a new perspective and provide a framework that stimulates further research helping individuals, organizations, and societies to deliver the best they can when it matters most.

General Conclusion

Gender differences influence innovation outcomes and performance in competitive settings. Women and men top performers react differently to pressure (Chapter 3) and foster different knowledge recombination processes in teams (Chapter 2). At the same time, women's own as well as their collaborators' contributions receive lower evaluations than men's (Chapter 1). Taken together, this dissertation documents women's important contributions to innovation and scientific progress as well as their potential for contribution under different competitive conditions. Concurrently, the evaluation of women's contributions may be discounted by communities and society at large, leading to suboptimal outcomes.

With the focus on who gets a task done in the most effective or efficient way, women's and men's human capital are often regarded as substitutes. In contrast, this thesis suggests that they could also be seen as complements in certain contexts. By acknowledging women's and men's unique direct contributions as well as the synergies that arise from how gender shapes social processes, fostering gender diversity can contribute to organizational success and innovation. For example, teams that work in extreme settings can profit from both men and women team members, as their response strategies when put under pressure is different. While women increase performance effectiveness, men are able to maintain performance efficiency, two important yet complementary strategies (Chapter 3). Similarly, organizations in innovative industries might profit from women top performers in innovation projects that require broad and diverse knowledge recombination, but men top performers when more narrow and specialized knowledge recombination is required (Chapter 2). Neither of the two knowledge recombination outcomes is generally better or worse. Teams and organizations that can do both likely enjoy a competitive advantage.

To harness this complementarity in human capital, it is important to increase the representation of women in competitive settings. To date, women remain highly underrepresented in these settings. For example, of all inventors who filed an international patent application at the World Intellectual Property Organization (WIPO) in 2020, 16.5% were women[46]. Of all CEO positions at U.S. S&P 500 firms in January 2022, only 6.4% were held by women[47]. Measures that aim at increasing the number of women in competitive settings are targeted at both supply- and demand-side factors. For example, there are programs that expose girls to men-dominated jobs during their childhood, which can affect their preferences for entering such jobs later on in their lives (supply-side) (Bell et al. 2019). At the same time, there are initiatives that aim at reducing

[46] https://www.wipo.int/women-and-ip/en/news/2021/news0002.html

[47] https://www.catalyst.org/research/women-ceos-of-the-sp-500/

demand-side barriers, like the double-bind peer review process in some science disciplines or anti-discrimination trainings.

However, to sustainably reduce the gender gap in competitive settings, structures and cultures likely need to change such that women's and men's contributions are valued to the same extent. Gendered evaluations that disadvantage women relative to men can start a vicious circle that discourages women from even contributing in the first place. For example, if women's academic achievements in the sciences are not recognized, they face difficulty in obtaining funding. In the next round, this will make it harder for them to produce work of good quality because they need resources to do so (Merton 1968). By design, the work produced under these constraints will receive even less recognition and lower evaluations. Paradoxically, outsiders causally attribute the lower quality of work to gender rather than the lack of funding, i.e., the constraints women face. The more rounds this process prevails, the worse it gets – not only for focal actors but also their collaborators (Chapter 1). Constantly being exposed to these double standards (Foschi 1996, 2000) can ultimately lead to women adapting their preferences, possibly to reduce cognitive dissonance (Festinger 1957), and ultimately exiting competitive settings. Breaking this vicious circle starts with unbiased evaluations.

This thesis showcases the persistence of such gendered evaluations but also aims to highlight that breaking this circle and realizing the complementary but mostly untapped potential of women top performers is worth it. Future research may follow this path and quantify the economic benefits arising from women's and men's complementary human capital (Sorenson and Dahl 2016). These benefits may be found at the individual level, e.g., stable household income and employment, at the organizational level, e.g., as a source for competitive advantage and organizational resilience, and at the societal level, e.g., as a driver of economic growth and technological progress. Quantifying foregone benefits can increase society's and organizations' incentives to harness the additional value that could be created through men's and women's complementing human capital. At the same time, it can serve as an objective foundation for a fair and just evaluation on the demand-side. Ultimately, this might make it more attractive for women to enter these settings, such that they may adapt their preferences on the supply-side.

Appendix

A1. Appendix to Chapter 1

Appendix 1.1: Mentor-Protégé Pairings

a) Interaction Effects of Mentor and F32 Recipient Gender

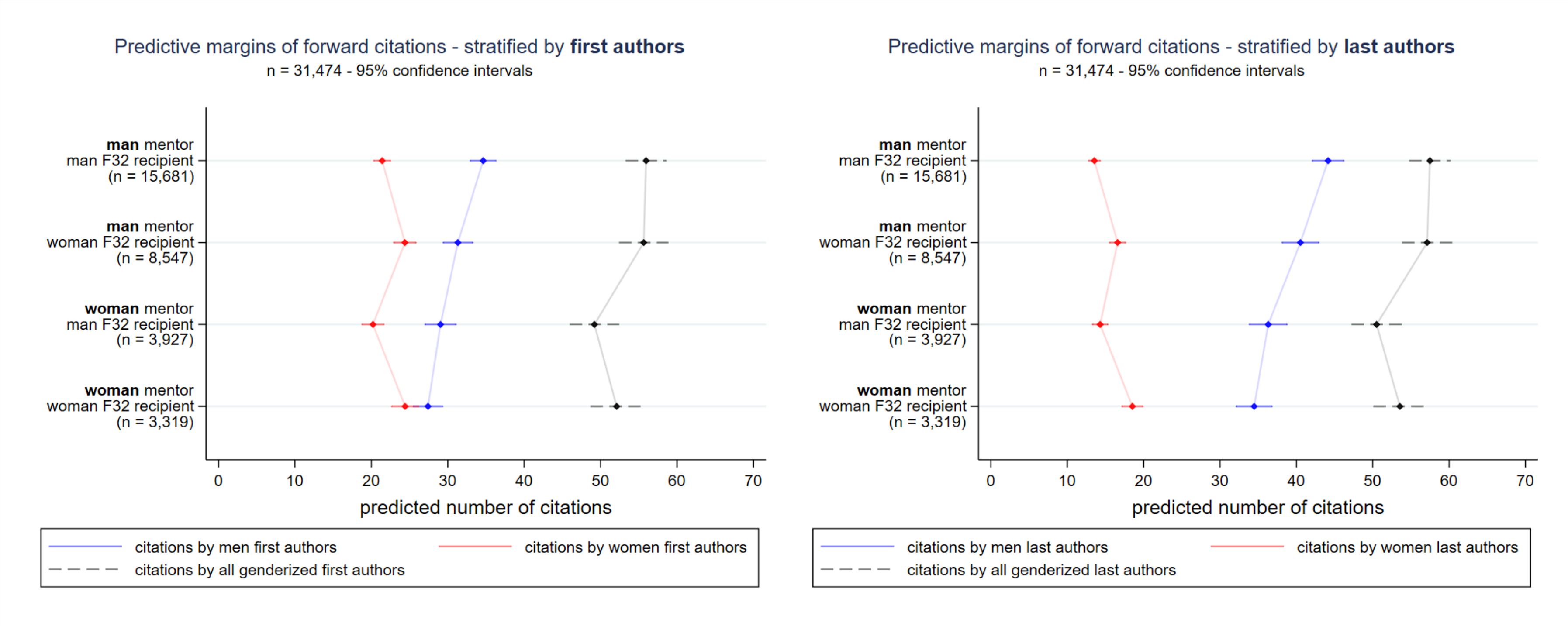
Table A1.1 Interaction Effects of Mentor and F32 Recipient Gender

	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)
dependent variable: forward citations	**all** forward citations	*citations by* ***men first*** *authors*	*citations by* ***men last*** *authors*	*citations by articles from* ***close fields***
independent variables				
woman mentor	0.882***	0.839***	0.822***	0.893**
	(0.034)	(0.033)	(0.032)	(0.040)
woman F32 recipient	0.997	0.905***	0.918***	1.039
	(0.031)	(0.029)	(0.028)	(0.035)
woman mentor x woman F32 recipient	1.061	1.043	1.034	1.071
	(0.057)	(0.058)	(0.057)	(0.067)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included	included	included
risk set of citers	included	included	included	included
publication year dummies	included	included	included	included
CEM matching'	included	included	included	included
academic cohort dummies	included	included	included	included
constant	2.682***	1.971***	1.785***	0.156***
	(0.534)	(0.418)	(0.364)	(0.027)
observations	31,474	31,474	31,474	26,525

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996; 'matching with gender pairings as treatement; Model 6 excludes publications in multidisciplinary journals

b) Predictive Margins of Gendered Forward Citations for Gender Pairings of Mentor and F32 Recipient

Figure A1.1 Predictive Margins of Gendered Forward Citations for Gender Pairings



Appendix 1.2: Literature Review on the Effects of Mentorship

Table A1.2 Literature Review of the Effects of Mentorship

Reference	Field	Context	Study Aim	Independent Variable(s)	Dependent Variable(s)	Method	Unit of Analysis	Data	Findings
Allen et al. (2004)	Psychology	Organization	Meta-analysis to review and synthesize existing empirical research concerning the career benefits associated with mentoring for the protégé	Mentorship relationship	Career outcomes and employee satisfaction	Meta-analysis	Protégé	n/a	- Employees who have been mentored report greater objective career outcomes: greater compensation and number of promotions) - Employees who have been mentored report greater subjective career success: greater career satisfaction, expectations for advancement, career commitment, and job satisfaction
Blau et al. (2010)	Economics	Academia	Assess the effect of a mentoring program for women in economics ("CeMENT") on academic productivity of women protégés	Mentoring program	Academic productivity	Quantitative analysis	Protégé	N = 202 women in economics	- CeMENT increased top-tier publications, the total number of publications, and the total number of successful federal grants in treated (i.e., mentored) women relative to controls - The effects are monotonic with respect to time from CeMENT and robust to several specification checks
Chariker et al. (2017)	Scientometrics	Nobel laureates	Apply network-based analysis of mentor-mentee relationships across Nobel laureates to identify successful mentoring communities	Nobel status	Number of academic Nobel laureate family members	Network analysis	Mentor-protégé dyad	N= 402 Nobel laureates, 57,429 non-Nobel laureates	- Pattern of Nobel laureate mentoring relationships is non-random - Assortative processes occur in the selection of mentors and mentees: Nobel laureates have a greater number of Nobel laureate ancestors, descendants, mentees/grandmentees, and local academic family - Several successful mentoring communities exist (measured by number of Nobel laureates within community), e.g., centered on Cambridge University in the later 19th century
Dohm and Cummings (2002)	Psychology	Academia	Analyze whether women's choice to do research during her career as a clinical psychologist is associated with having had a research mentor	Research mentor	Protégés' research activities and prospects to becoming a mentor	Survey	Protégé	N = 616 women in clinical psychology	- Research mentoring is positively related to a woman in clinical psychology doing research and becoming a mentor herself - No difference in the observed effect of having a research mentor on doing research for women versus men mentors
Dohm and Cummings (2003)	Psychology	Academia	Analyze whether men's choice to do research during his career as a clinical psychologist is associated with having had a research mentor	Research mentor	Protégés' research activities and prospects to becoming a mentor	Survey	Protégé	N= 519 men in clinical psychology	- Research mentoring is positively related to a man in clinical psychology doing research and becoming a mentor himself - No difference in the observed effect of having a research mentor on doing research for women versus men mentors - Mentoring that includes relevant training and practical experience with high-responsibility research tasks was found to be particularly conducive to protégés research activities
Gaule and Piacentini (2018)	Economics	Academia	Investigate whether having an advisor of the same gender is correlated with the	Gender pairings of mentor and protégé	Likelihood of becoming faculty and productivity	Quantitative analysis	Mentor-protégé dyad	N = 20,000 PhD graduates and advisors from	- Students with an advisor of the same gender tend to be more productive during the PhD and more likely to become professors themselves

			productivity of PhD students and their propensity to stay in academic science					U.S. chemistry departments	- Women students working with women advisors are more likely to become faculty themselves - Under-representation of women in science and engineering faculty positions may perpetuate itself through the lower availability of same-gender advisors for women students
Haas et al. (2018)	Information Science	Academia	Compare ways to find optimal mentor-mentee matches	Different algorithms and heuristics	Best mentor-mentee matches	Comparison of algorithms in simulations	Mentor-protégé dyad	N= 29 mentees and 31 mentors	- A combination of evolutionary heuristics and local search approaches works best in finding high-quality solutions, i.e. mentor-mentee pairs which are close to the respective ideal match
Higgins and Kram (2001)	Manageme nt	Organizati on	Provide a framework for understanding the factors that shape the formation of developmental network structures and their developmental consequences for protégés	Work environment and individual-level factors	Formation of developmental network structures	Literature review and theory development	Protégé	n/a	- There are multiple forms of mentorship and factors that shape developmental networks: work environment factors, individual-level influences, and moderating factors - Work environment factors: organizational-level influences (e.g., workforce composition), industry context (e.g., outwardness of industry), and task requirements (e.g., amount of extra-organizational activities) - Individual-level factor: personality (e.g., self-esteem and shyness), demographic characteristics (e.g., nationality or gender), and perceived needs for development (e.g., individuals with negative mentoring experiences in the past may prefer to not to seek developmental relationships again) - Moderating factors: individual's interaction style, mentor's positional power, and protégé's orientation towards career development
Higgins and Thomas (2001)	Manageme nt	Organizati on	Examine the effects of primary as well as multiple developmental relationships on long-term career outcomes	Quality, status and affiliation of developmental relationships	Work satisfaction, intention to remain in the firm, long-term career outcomes	Survey	Protégé	N = 1,800 employees	- Three different aspects of individuals' primary and multiple developmental relationships: relationship quality, relationship status, and organizational affiliation (intra- vs. extra-organizational) - Quality of primary developmental relationship affects shorter career outcomes such as work satisfaction and intentions to remain at the firm - Composition and quality of an individual's entire constellation of developmental relationships accounts for long-run protégé career outcomes such as organizational retention and promotion
Johnson (2007)	Psychology	Academia	Review literature on student-faculty mentoring outcomes	Mentoring	Academic outcomes	Literature review	Protégé	n/a	- There is modest and preliminary evidence that mentoring may improve academic outcomes for undergraduates, enhance scholarly productivity, networking, initial employment success for graduate students, and strengthen professional confidence and satisfaction with academic programs in both undergraduate and graduate populations - There is comparable little empirical research bearing on outcomes for mentors and institutions - Gender appears to have little impact on academic mentorship outcomes
Kirchmeye r (2005)	Manageme nt	Academia	Explore the effects of scientist's PhD departments and several	Sponsorship	Achieved rank, salary	Telephone interviews	Protégé	N=143 PhD students from the US	- Sponsorship appears to play a vital role in the scientists' careers indirectly via performance and directly via politics

			characteristics of their doctoral sponsors on their scientific productivity and positions over their first postdoctoral decade						- Sponsors' productivity affected the sample members' predoctoral productivity, and the caliber of their PhD department affected their postdoctoral productivity - The amount of mentoring predicted achieved rank of protégés and this relationship was not mediated by publication productivity - The results suggest ascriptive effects of doctoral sponsorship, independent of the effects of sponsors' performance, the caliber of the PhD department, and the scientists' own productivity
Kram (1983)	Management	Organization	Characterize the phases of the mentorship relationship	n/a	n/a	Interviews	Mentor-protégé dyad	N=18 mentor-protégé dyads	- The mentor relationship moves through the phases of initiation, cultivation, separation and redefinition - Under certain conditions, a mentor relationship can become destructive for one or both individuals - The lack of an adequate role model in a man mentor caused young women managers to seek support and guidance from other women peers - Peer relationships appear to offer a valuable alternative to the mentor relationship; they can provide some career and psychosocial functions, they offer the opportunity for greater mutuality and sense of equality, and they are more available in number
Kram (1988)	Management	Organization	Investigate the effects of mentor relationships in early, middle, and later career stages	Mentorship relationship	Career advancement, psychosocial development	Literature review	Mentor-protégé dyad	n/a	- The mentor relationship has great potential to facilitate career advancement and psychosocial development in both early and middle adulthood by providing a vehicle for accomplishing the primary developmental tasks (i.e., initiation and reappraisal) during these two stages - The potential value of a mentor relationship is limited, including limitations in cross-sex mentor relationships - The mentor relationship can become destructive
Levitt (2010)	General Science	Academia	Determine the influence of the mentor's citation record on postdoctoral fellows	Mentor citations, mentor publications	Grant success of men and women postdocs	Quantitative analysis	Mentor-protégé dyad	N=439 postdoctoral students in the life sciences	- Women whose mentor's h index was in the top quartile were nearly three times as likely to receive a major grant as those whose mentor was in the bottom quartile - No significant correlation between men's grant success and their mentor's publication record but for women's grant success
Li et al. (2019b)	General Science	Academia	Assess the long-term impact of coauthorship with established, highly-cited scientists on the career of junior researchers	Early coauthorship with established researcher	Academic success: probability to become a top-cited scientist, prestige of institution	Quantitative analysis	Protégé	N=22,601 junior researchers in Cell Biology, Chemistry, Physics, and Neuroscience	- Junior scientists who coauthor work with top scientists enjoy a persistent competitive advantage throughout the rest of their careers, compared to peers with similar early career profiles but without top coauthors - Such early coauthorship predicts a higher probability of repeatedly coauthoring work with top-cited scientists, and, ultimately, a higher probability of becoming one - Junior researchers affiliated with less prestigious institutions show the most benefits from coauthorship with a top scientist
Lienard et al. (2018)	General Science	Academia	Analyze what factors in mentorship relationships predict success	Postdoctoral/ graduate mentor	Trainee's success: 1) whether or not	Quantitative analysis	Protégé	N=18,856 researchers in	- Factors influencing the likelihood of trainees obtaining an independent position: year of entry to the job market, mentor proliferation rate, ability to seize between the intellectual

					a trainee obtains an independent research position and 2) their proliferation rate (number of researchers trained) once a position is obtained			the life sciences	output of their mentors, and professional age of postdoctoral mentor - Main predictors of trainee proliferation: mentor's training rates and publishing research that was similar to that of their graduate mentor - Postdoctoral mentors are more instrumental to trainees' success compared to graduate mentors - Trainees' success in academia is also predicted by the degree of intellectual synthesis between their graduate and postdoctoral mentors - Researchers were more likely to succeed if they trained under mentors with disparate expertise and integrated that expertise into their own work
Liu et al. (2018b)	Scientometrics	Academia	Capture the correlation between advisors' academic characteristics and advisees' academic performance	Advisor's age, advisor's accomplishments	Advisees' performance	Quantitative analysis/ qualitative analysis	Protégé	N= 4,256 advisor-advisee pairs in computer science	- With the increase of advisors' academic age, advisees' performance experiences an initial growth, follows a sustaining stage, and finally ends up with a declining trend - Accomplished advisors can bring up skilled advisees, potentially because advisors are high-performers and can raise their advisees' h-index
Ma et al. (2019)	General Science	STEM	Analyze genealogical data on scientists from various disciplines on their publications to investigate the relationship between mentorship and protégé achievement	Mentorship and mentor characteristics	Success of protégé	Quantitative analysis	Protégé	N=40,000 scientists in biomedicine, chemistry, math, or physics	- Mentorship strongly predicts protégé success across diverse disciplines: mentorship is associated with a 2x-to-4x increase in protégé's likelihood of prizewinning, National Academy of Science (NAS) induction, or superstardom relative to matched protégés - Mentorship is significantly associated with an increase in the probability of protégés pioneering their own research topics and becoming midcareer late boomers - Protégés do not succeed most by following their mentors' research topics but by studying original topics and coauthoring no more than a small fraction of papers with their mentors - Protégés of mentors that went on to win prizes (future prizewinning mentors, "FPWM") are more likely to produce prizewinning research of their own, be inducted into the NAS for career-long scientific contributions, and do high impact work late into their careers when creativity often wanes - Protégés of FPWMs are more likely to pioneer their own original lines of research rather than follow their mentor's established lines of research
Malmgren et al. (2010)	General Science	Academia	Investigate whether protégés acquire the mentorship skills of their mentors by studying mentorship fecundity (i.e., the number of protégés a mentor trains over the course of their career)	Mentorship fecundity	Academic success	Quantitative analysis	Mentor-protégé dyad	N= 7,259 protégés in mathematics	- Fecundity among academics is correlated with multiple measures of academic success - Mentors with low mentorship fecundities train protégés that go on to have mentorship fecundities 37% higher than expected - Average fecundity of mentors remains stable over 60 years of recorded mentorship - Relationship between mentorship fecundities of mentors and their protégés varies across career stages

Noe (1988)	Management	Organization	Literature review on the factors that may inhibit the development of mentorship for women	Mentorship	Guidance and mental support	Literature review	Mentor	n/a	- Mentoring provides career guidance and psychological support (e.g., women who had one or more mentors report greater job success and job satisfaction than women who do not have a mentor) - However, there are not enough mentors available to women, which is harmful for organizations (e.g., failure to utilize talented women) - Reasons for lack of women mentors: lack of women in management positions in men dominated areas; men tend to hold more centralized, critical positions of power which in turns allows them to provide greater visibility to protégés than women mentors - Barriers for establishing cross-gender mentorships that hinder the development of mentor relationships for women: lack of access to information networks, tokenism, stereotyping, socialization practices, norms regarding cross-gender relationships, reliance on inappropriate power bases
O'Brien et al. (2010)	Psychology	Organization	Investigate gender differences in mentoring	Mentor gender/ Protégé gender	Experience of mentorship, psychosocial career development	Meta-analysis	Mentor-protégé dyad	n/a	- Men were more likely than women to report serving as a mentor - Men were as likely as women to report experience as a protégé, with no difference in the career development received but women receiving more psychosocial support - Men mentors reported providing more mentoring on career development than women mentors - Women mentors reported giving more psycho-social support than did men mentors
Ragins and Mcfarlin (1990)	Psychology	Organizational	Investigate same- and cross-gender mentoring relationships	Mentor and protégé gender	Perceived mentor roles	Survey	Mentor-protégé dyad	N=181 employees of three R&D organizations in the US	- Perceived mentor roles were not influenced by either mentor or protégé gender - Significant gender interactions were found for role modeling and social roles - Cross-gender protégés were less likely than same-gender proteges to report engaging in after-work, social activities with their mentors. - Women protégés with women mentors were more likely to agree with the idea that their mentor served a role modeling function
Reskin (1979)	Sociology	Academia	Explore the effects of scientist's PhD departments and several characteristics of their doctoral sponsors on their scientific productivity and positions	PhD caliber, Sponsor's publications/ citations/ eminence	Number of publications, number of citations, job positions	Quantitative analysis	Protégé	N=238 PhD students and their sponsors in chemistry	- Sponsorship appears to play a vital role in the scientists' careers - Sponsors' productivity affected the sample members' predoctoral productivity, and the caliber of their PhD department affected their postdoctoral productivity - The results suggest ascriptive effects of doctoral sponsorship, independent of the effects of sponsors' performance, the caliber of the PhD department, and the scientists' own productivity
Rossi et al. (2017)	Scientometrics	Academia	Present a new metric to quantify the impact of mentoring in an	n/a	n/a	Method	Mentor-protégé dyad	N= 202,147 mentoring relationships	- The genealogical index allows mentoring to be carried out at several generations to quantify the propagation of scientific knowledge

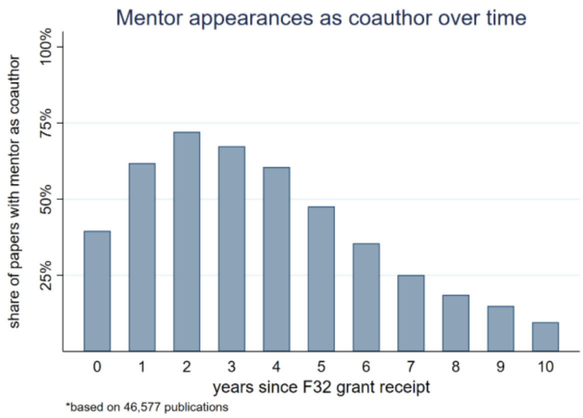
			academic community (the genealogical index)					in mathematics	- The genealogical index can be regarded as an effective way of measuring and analyzing the influence of academic advisors on their communities
Scandura (1992)	Management	Organization	Analyze effects of mentorship types on protégé career outcomes	Mentorship types: vocational, role modeling, and social support	Protégé career outcomes: performance ratings, salary, promotion rate	Survey	Protégé	N=244 manufacturing managers	- Vocational mentoring was significantly and positively related to managers' promotion rate - Social support was significantly and positively related to managers' salary level - Role modeling was not related to any of the career outcome variables
Schwiebert et al. (1999)	Psychology	n/a	Review literature on the importance of women as mentors	n/a	n/a	Literature review	Mentor	n/a	- There is a great need for women mentors - Women may gain greater benefits from participating in a same-gender mentoring relationship - Mentoring relationships in which women are mentored by other women provide the mentees with both psychosocial and career development benefits - Mentoring relationships in which women are mentored by men are more often based on career development, lack the relational component important to many women, and fail to provide role models with which women can identify - Many men have realized the benefits of the mentoring process and continue to use this process to help other men to develop as professionals in many fields - Women are only recently becoming aware of the importance of the mentoring process, particularly the process of women mentoring other women
Singh et al. (2002)	Management	Organization	Examine whether the views of managers are in agreement with the benefits of informal mentoring suggested by the literature	Informal mentoring and mentor/ protégé gender	Career outcomes and personal benefits	Survey	Mentor-protégé dyad	N=222 manager at a county council in UK	- Three main organizational benefits of mentoring: HRM benefits, culture and change benefits, and communication benefits - Women and men mentors shared views on the benefits to the organization - Men protégés appear to focus more on individual benefits - Women protégés put significantly higher value on the impact of mentoring for organizational culture
Tong and Kram (2013)	Psychology	Organization	Literature review on the benefits of mentoring for the protégé, mentor, and organization	Mentorship	Guidance and Mental support	Literature review	Mentor-protégé dyad	n/a	- Career-related benefits of mentorship for protégés: better job performance, faster promotions, higher salaries, greater job and career satisfaction - Psychological support of protégés through mentorship: increased self-confidence, self-esteem, and professional competence - Gender of mentor as a moderating variable on protégé benefits: Examples from literature show that 1) Protégés with women mentors attain lower income levels than those with men mentors; 2) Men protégé and women mentor relationships are associated with lower promotion rates for the protégé, and women protégé and women mentor relationships are related to lowest financial rewards - Intangible benefits of mentoring for mentor: self-satisfaction and renewed meaning in working life

									- Quantifiable benefits of mentoring for mentor: improved job performance and increased promotions - Organizational benefits of mentoring: individual-level benefits (organizational attractiveness as well as organizational satisfaction and commitment) and organization-level benefits (improved employee efficiency, productivity, and creativity as well as enhanced employee retention)

Appendix 1.3: Reliability of Mentor Identification

a) Temporal Patterns in Collaboration between Mentor and F32 recipient

Figure A1.2 Collaboration between Mentor and F32 Recipient over Time

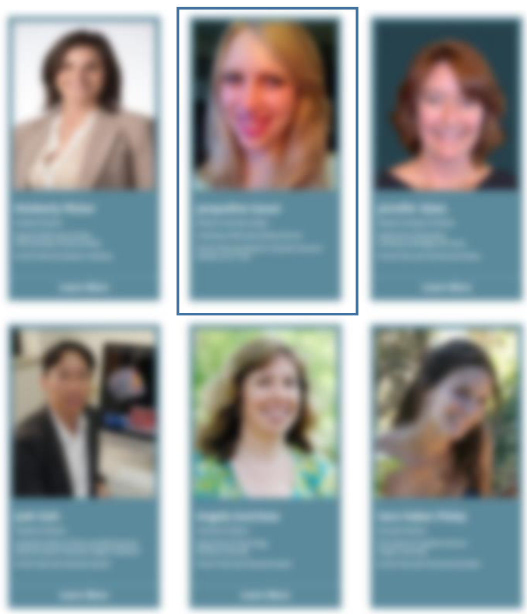


b) Manual Check of Mentor-Protégé Relationships

We drew a random sample of 100 potential protégé-mentor pairings and conducted an internet search to establish whether a connection beyond the F32 fellowship exists. A connection existed for 95 out of the 100 pairings. These connections include examples such as protégés having received their postdoctoral training from the mentor, protégés having worked in the mentor's lab, and protégé and mentor having multiple joint publications.

In the following, we provide a specific example of an established connection between a mentor and her protégé. It is a screenshot of an F32 recipient listed on a university website among the alumni of the mentor's lab after having worked there as a postdoctoral student.

Figure A1.3 Example of Established Mentor-Protégé Connection



Mentor: Denise Park

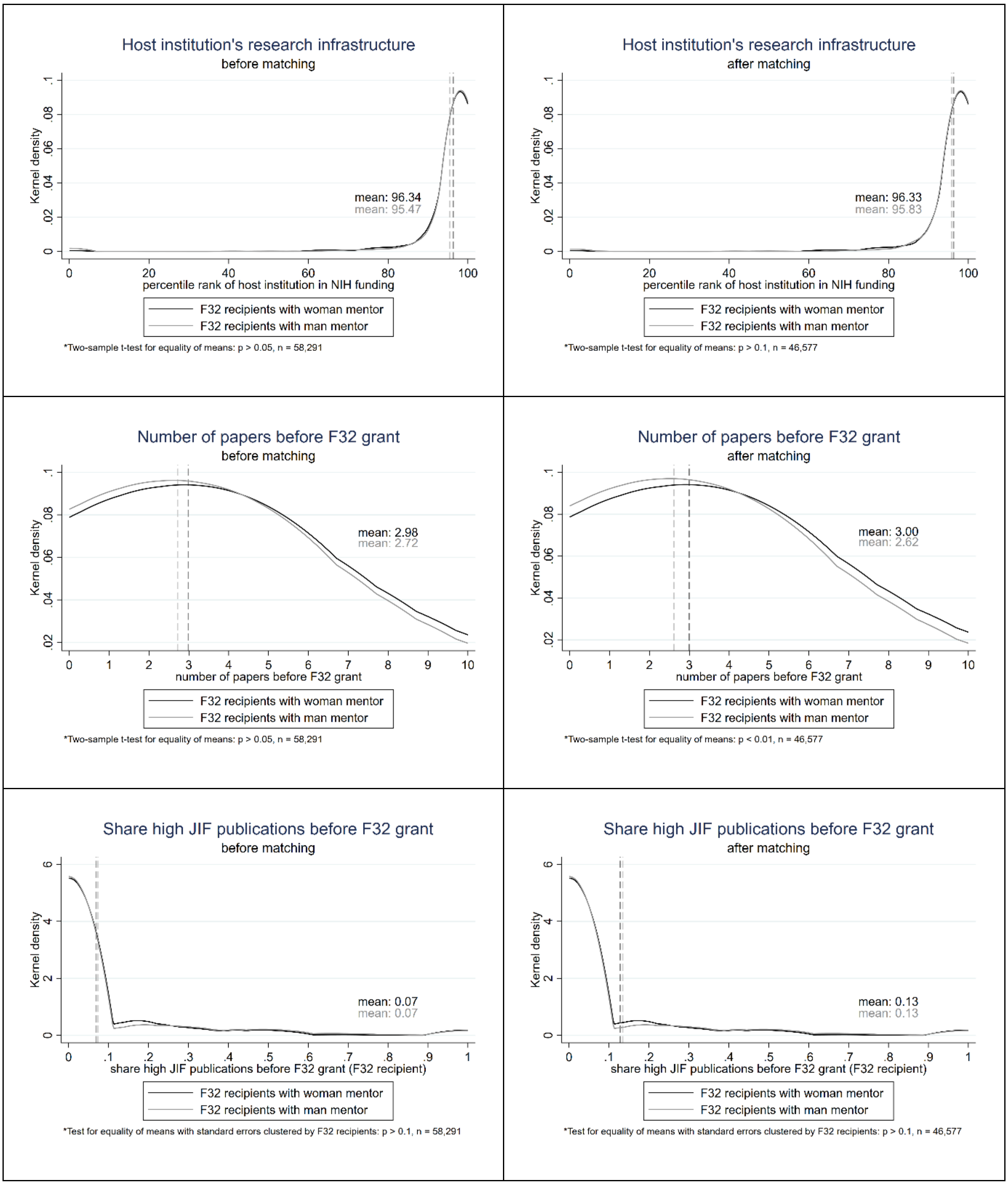
Protégé: Angela Gutchess

Source: http://agingmind.utdallas.edu/who-we-are/lab-alumni/

Appendix 1.4: Balance of F32 Recipient and Mentor Characteristics before and after Matching

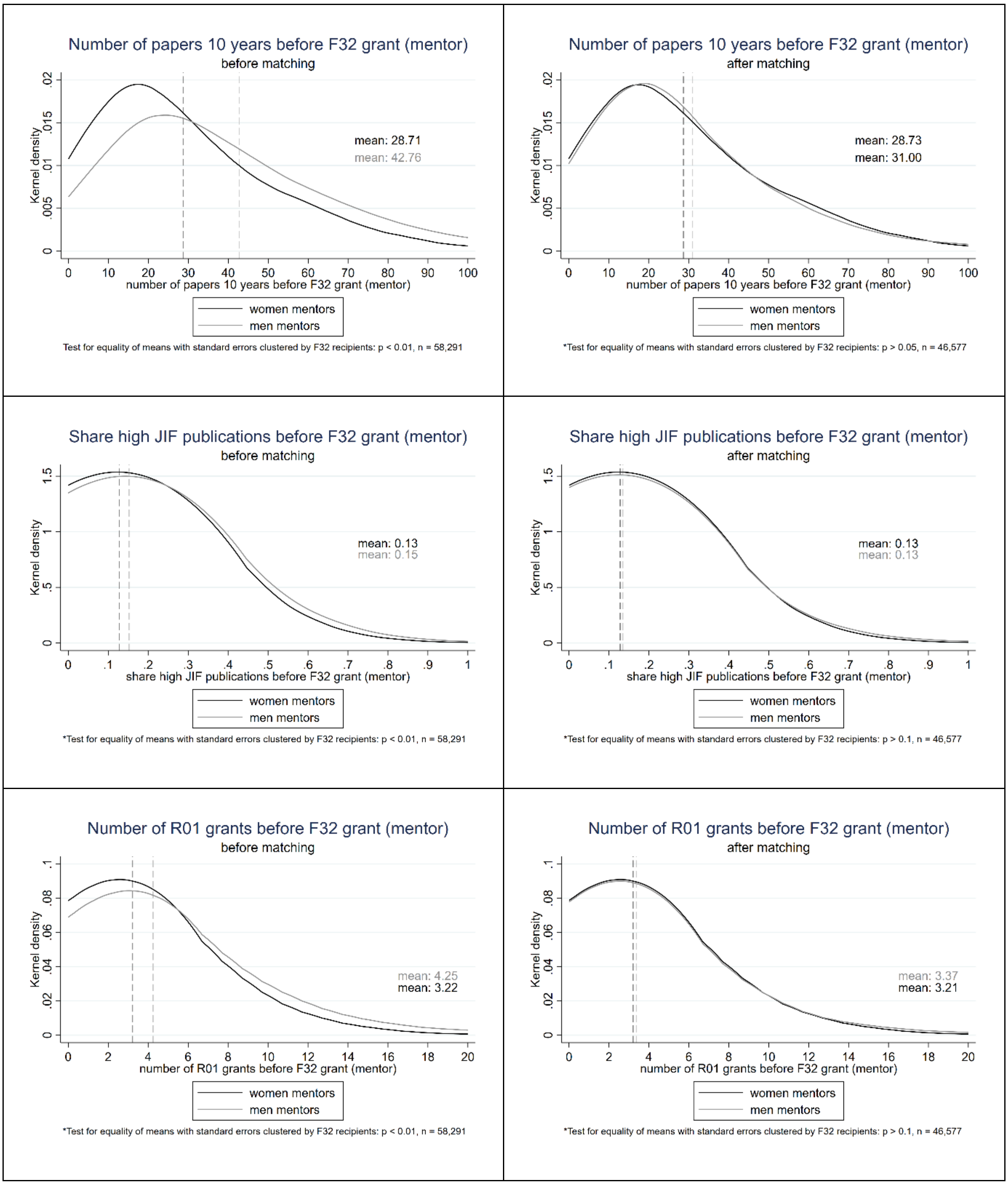
a) Comparison of F32 Recipient and Grant Characteristics before and after Matching

Figure A1.4 F32 Recipient and Grant Characteristics before and after Matching



b) Comparison of Mentor Characteristics before and after Matching

Figure A1.5 Mentor Characteristics before and after Matching



c) Coarsened Exact Matching Balance Statistics

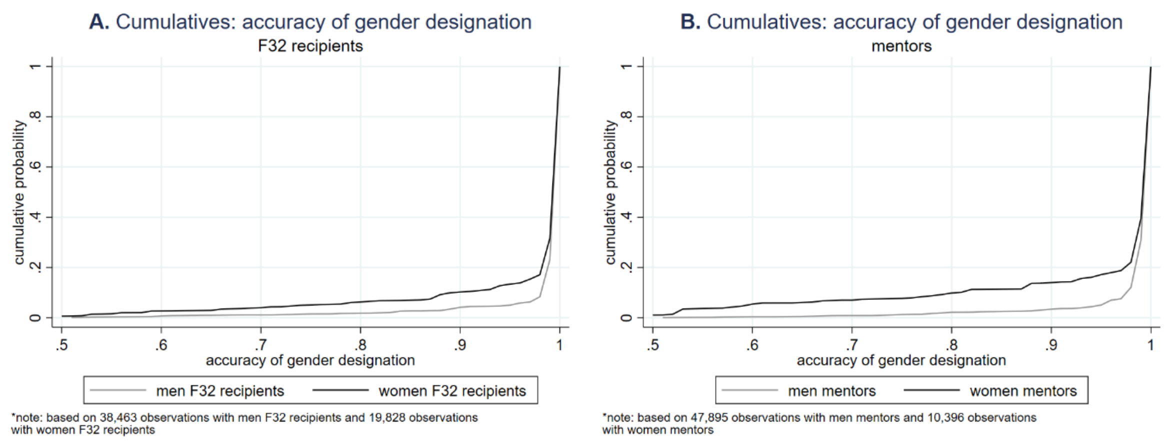
Table A1.3 CEM Balance Statistics

	L1 distance	
	before matching	**after matching**
dummy: female F32 recipient	0.097	0
5-year buckets: academic cohort (fiscal year of F32 grant)	0.095	0
quartiles: number of publications 10 years before F32 grant (mentor)	0.187	0
quartiles: share high JIF pubs 10 years before F32 grant (mentor)	0.068	0
quartiles: number of prior R01 grants (mentor)	0.083	0
multivariate L1 distance	**0.443**	**0**

Appendix 1.5: Probabilistic Gender Designation

We used the genderize database to determine the probable gender of the mentor and the protégé, of all coauthors of the respective research records, as well as of all authors citing the work of protégés. For example, genderize designates the forename “Chris” as man with 93% probability based on 8,631 verified records in the database. We considered a gender determined if the algorithm indicated a designation greater than chance (50%). Setting more restrictive thresholds does not change our results, since most names (95%) were designated with a probability greater than 90%. The average probability, with which we were able to designate the gender of F32 recipients and mentors amount to 98.1 % (see Figure A5). To date, genderize includes 86,710 distinct forenames drawn from 74 countries and 81 languages. Tests of the accuracy and comprehensiveness of four gender assignment algorithms, using a control sample of gender-matched forenames from a US government office, has found that genderize provides the most accurate estimates of gender of all tested algorithms (Wais 2016). This approach does not afford separating effects for individuals who consider themselves diverse, and we note that as a limitation.

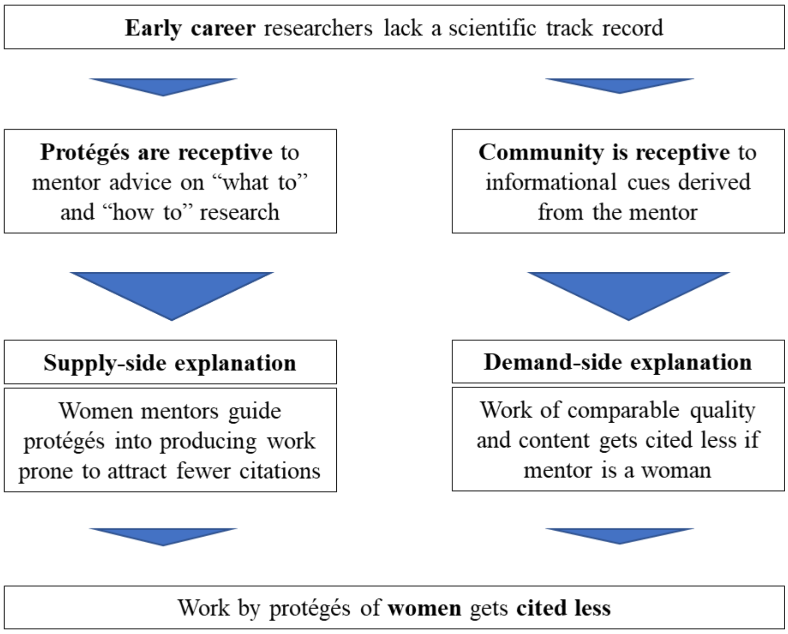
Figure A1.6 Accuracy of Gender Designation for F32 Recipients and Mentors



Appendix 1.6: Conceptual Framework, Research Design, and Sample Construction Diagram

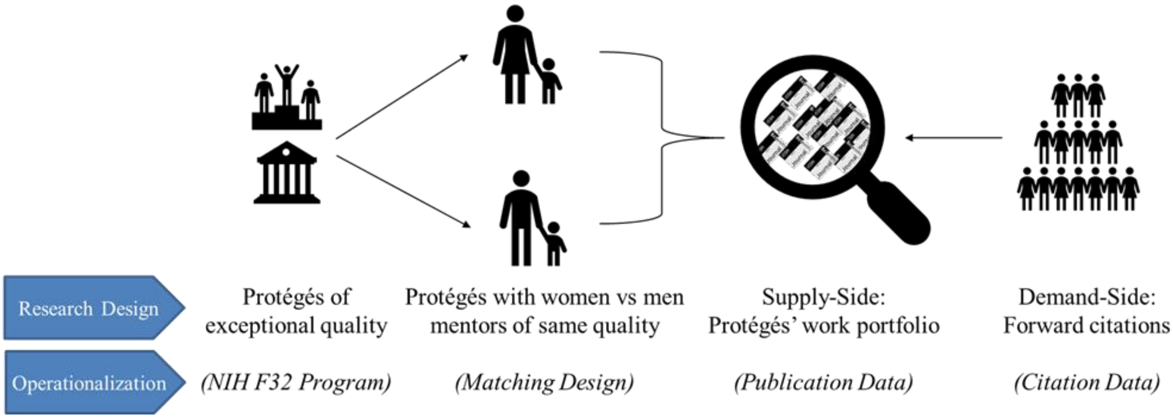
a) Conceptual Framework for Supply- and Demand-side Dynamics in the Evaluation of Protégés' Work, contingent on Mentor Gender

Figure A1.7 Conceptual Framework



b) Research Design and Operationalization

Figure A1.8 Research Design and Operationalization



c) Sample Construction

Figure A1.9 Sample Construction Diagram

Appendix 1.7: Descriptive Statistics

a) Correlation Matrix

Table A1.4 Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)
(1) citations	1.000																																	
(2) citations by articles from close fields'	0.581	1.000																																
(3) citations by articles from distant fields'	0.732	0.489	1.000																															
(4) citations by women first authors'	0.970	0.600	0.745	1.000																														
(5) citations by men first authors'	0.970	0.603	0.690	0.928	1.000																													
(6) citations by women last authors'	0.948	0.567	0.736	0.975	0.894	1.000																												
(7) citations by men last authors'	0.971	0.612	0.698	0.944	0.993	0.892	1.000																											
(8) woman mentor	-0.021	-0.027	-0.018	-0.008	-0.037	0.019	-0.042	1.000																										
(9) woman F32 recipient	-0.006	-0.007	0.002	0.028	-0.025	0.046	-0.022	0.078	1.000																									
(10) host institution's research infrastructure	0.002	-0.007	0.001	-0.005	-0.003	-0.002	-0.006	0.026	-0.024	1.000																								
(11) F32 grant extension	0.003	0.008	0.006	0.006	0.003	0.003	0.005	-0.009	-0.016	-0.001	1.000																							
(12) number of papers before F32 grant	0.012	0.014	0.016	0.010	0.001	0.003	0.007	0.040	-0.025	0.003	-0.047	1.000																						
(13) share high JIF pubs before F32 grant	0.049	0.031	0.037	0.046	0.048	0.041	0.051	-0.008	-0.034	-0.020	-0.016	0.096	1.000																					
(14) paper count since grant receipt	-0.013	-0.025	0.001	-0.030	-0.022	-0.029	-0.025	-0.045	-0.112	-0.023	-0.045	0.077	0.042	1.000																				
(15) papers in last year	0.007	-0.001	0.018	-0.008	0.003	-0.010	0.000	-0.044	-0.104	-0.014	-0.057	0.101	0.036	0.756	1.000																			
(16) academic cohort	-0.009	-0.067	-0.061	-0.039	-0.057	-0.032	-0.056	0.066	0.083	0.092	-0.099	0.131	0.043	-0.145	-0.052	1.000																		
(17) number of papers 10 years before F32 grant (mentor)	0.023	0.015	0.035	0.024	0.024	0.015	0.029	-0.153	-0.025	-0.003	-0.017	0.097	0.023	0.087	0.096	0.059	1.000																	
(18) share high JIF pubs 10 years before F32 grant (mentor)	0.060	0.034	0.059	0.056	0.074	0.043	0.077	-0.062	-0.049	0.008	0.042	-0.017	0.177	0.055	0.057	-0.001	0.017	1.000																
(19) number of prior R01 grants (mentor)	0.025	-0.001	0.035	0.025	0.016	0.016	0.024	-0.091	0.001	0.104	-0.023	0.137	0.037	0.015	0.034	0.253	0.632	0.022	1.000															
(20) number of authors	0.081	0.035	0.079	0.067	0.070	0.054	0.076	-0.008	-0.006	0.006	-0.022	0.017	0.023	0.079	0.084	0.111	0.071	0.049	0.067	1.000														
(21) share of women coauthors	0.002	-0.012	0.001	0.021	-0.036	0.034	-0.030	0.063	0.100	0.008	-0.006	0.025	-0.003	0.036	0.009	0.132	0.022	-0.011	0.056	0.161	1.000													
(22) journal impact factor	0.339	0.113	0.212	0.326	0.373	0.301	0.373	-0.017	-0.027	0.010	0.011	-0.003	0.082	0.001	0.009	0.010	0.034	0.167	0.039	0.078	-0.021	1.000												
(23) mentor among coauthors	0.055	0.053	0.047	0.061	0.060	0.053	0.065	0.002	0.049	0.018	0.013	-0.018	-0.013	-0.274	-0.156	0.133	0.056	-0.001	0.080	0.072	-0.010	0.052	1.000											
(24) research proximity	0.047	0.077	0.045	0.057	0.036	0.047	0.046	-0.026	0.041	0.005	-0.008	0.077	0.003	-0.135	-0.080	0.188	0.284	0.022	0.274	0.117	0.077	0.027	0.373	1.000										
(25) publication year	-0.028	-0.125	-0.102	-0.091	-0.118	-0.076	-0.119	0.060	0.071	0.079	-0.087	0.096	0.032	0.163	0.082	0.861	0.048	0.001	0.219	0.132	0.176	-0.004	-0.052	0.076	1.000									
(26) expected citations percentile	0.116	0.105	0.113	0.138	0.114	0.115	0.136	0.028	0.038	-0.044	0.050	0.094	0.051	-0.144	-0.158	-0.024	0.030	0.104	0.154	0.001	0.048	0.097	0.109	0.162	-0.039	1.000								
(27) number of publications in risk set (log)	0.035	0.032	0.055	0.034	0.031	0.034	0.029	0.015	0.007	0.013	-0.003	-0.029	0.012	0.062	0.070	0.043	0.007	0.023	-0.010	0.100	0.044	0.002	-0.013	0.090	0.050	-0.061	1.000							
(28) number of men first authorships in risk set (log)	0.048	0.062	0.074	0.052	0.060	0.049	0.058	0.005	-0.009	0.009	0.006	-0.047	0.004	0.031	0.052	-0.064	-0.004	0.019	-0.038	0.078	0.012	0.008	0.002	0.080	-0.078	-0.068	0.964	1.000						
(29) number of women first authorships in risk set (log)	0.049	0.052	0.075	0.060	0.048	0.058	0.049	0.036	0.035	0.021	-0.006	-0.014	0.014	0.049	0.049	0.129	0.006	0.017	0.029	0.111	0.081	0.008	0.002	0.119	0.145	0.016	0.954	0.949	1.000					
(30) number of men last authorships in risk set (log)	0.050	0.063	0.077	0.055	0.061	0.051	0.060	0.007	-0.005	0.006	0.009	-0.041	0.006	0.025	0.045	-0.067	-0.002	0.022	-0.028	0.082	0.018	0.010	0.009	0.091	-0.081	-0.016	0.965	0.995	0.958	1.000				
(31) number of women last authorships in risk set (log)	0.049	0.051	0.072	0.059	0.047	0.059	0.046	0.035	0.033	0.018	-0.005	-0.022	0.013	0.050	0.054	0.100	0.000	0.014	0.010	0.102	0.073	0.007	-0.003	0.106	0.111	-0.016	0.962	0.958	0.996	0.963	1.000			
(32) uncertainty - age of MeSH terms	0.033	0.019	0.046	0.036	0.034	0.020	0.048	0.001	0.016	-0.019	0.015	0.038	0.034	-0.074	-0.080	-0.038	0.049	0.091	0.102	0.074	0.027	0.060	0.071	0.084	-0.046	0.443	-0.132	-0.124	-0.083	-0.092	-0.104	1.000		
(33) uncertainty - prior publications with same MeSH terms	0.028	0.029	-0.002	0.031	0.035	0.027	0.038	0.000	-0.008	-0.018	-0.003	0.000	0.022	-0.055	-0.048	-0.044	-0.033	0.027	-0.017	-0.068	-0.032	0.043	0.013	-0.143	-0.057	0.089	-0.574	-0.526	-0.516	-0.523	-0.519	0.206	1.000	
(34) attractiveness - growth in publications with same MeSH terms	0.063	0.059	0.053	0.063	0.059	0.065	0.055	-0.003	-0.010	-0.019	0.001	-0.032	0.014	0.034	0.044	-0.082	-0.038	0.021	-0.064	-0.017	-0.011	0.020	-0.025	-0.059	-0.093	-0.028	0.184	0.176	0.150	0.174	0.166	-0.098	-0.038	1.000
observations	58,291																																	

note: 'based on detailed forward citations available as of 1996 (n=40,005); all correlations with |r| > 0.016 are statistically significant at $p < 0.01$

b) Overview of Different Publication Types

Table A1.5 Publication Types

publication types	**frequency**	**percent**
article	50,287	86.27%
article in press	21	0.04%
book	1,208	2.07%
chapter	208	0.36%
conference paper	502	0.86%
editorial	427	0.73%
erratum	278	0.48%
letter	2997	5.14%
note	58	0.10%
review	993	1.70%
short survey	100	0.17%
not available	1,212	2.08%
total	**58,921**	**100.00%**

c) Descriptive Statistics for Protégés Mentored by Men and Women separately (before Matching)

Table A1.6 Descriptive Statistics for Protégés Mentored by Men and Women Separately

	woman mentor				man mentor				difference in means''	
variable name	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**	**beta**	**t-statistic**
dependent variables										
citations	76.62	122.16	0	3583	85.65	175.92	0	12928	9.028***	3.502
citations by articles from close fields'	20.67	32.38	0	568	23.46	42.83	0	1934	2.783***	(6.318)
citations by articles from distant fields'	22.82	41.13	0	914	25.54	61.74	0	4037	2.721***	(4.670)
citations by women first authors'	21.07	31.95	0	609	21.75	44.42	0	3243	0.684	(1.606)
citations by men first authors'	26.56	43.47	0	1026	32.01	62.36	0	3523	5.446***	(9.311)
citations by women last authors'	15.56	23.40	0	351	14.07	30.65	0	2765	-1.488***	(-4.862)
citations by men last authors'	33.43	54.04	0	1249	41.22	78.91	0	4369	7.789***	(10.648)
F32 characteristics (recipient and grant)										
woman F32 recipient	0.420	0.494	0	1	0.323	0.468	0	1	-0.097***	(-18.358)
host institution's research infrastructure	96.34	8.76	0	100	95.47	13.40	0	100	-0.868***	(-8.229)
F32 grant extension	0.111	0.314	0	1	0.118	0.323	0	1	0.007*	(2.184)
number of papers before F32 grant	2.99	2.68	0	10	2.72	2.53	0	10	-0.265***	(-9.226)
share high JIF pubs before F32 grant	0.069	0.193	0	1	0.073	0.200	0	1	0.004*	(2.063)
paper count since grant receipt	10.62	11.02	1	96	12.10	12.71	1	161	1.475***	(12.026)
papers in last year	2.01	2.26	0	18	2.32	2.75	0	31	0.308***	(12.119)
academic cohort''	1995	-	-	-	1996	-	-	-	-	-
mentor characteristics										
number of papers 10 years before F32 grant (mentor)	28.71	23.82	0	264	42.76	36.79	0	338	14.055***	(48.836)
share high JIF pubs 10 years before F32 grant (mentor)	0.128	0.133	0	1	0.152	0.154	0	1	0.024***	(16.478)
number of prior R01 grants (mentor)	3.22	3.57	0	34	4.25	4.44	0	39	1.030***	(25.463)
research characteristics										
number of authors	4.61	2.21	1	10	4.66	2.22	1	10	0.048*	(1.996)
share of women coauthors	0.324	0.356	0	1	0.269	0.329	0	1	-0.055***	(-14.500)
journal impact factor	5.63	7.23	0	70.67	5.98	7.76	0	70.67	0.350***	(4.416)
publication type'''	-	-	-	-	-	-	-	-	-	-
mentor among coauthors	0.423	0.494	0.000	1.000	0.421	0.494	0	1	-0.002	(-0.386)
research proximity	6.69	4.10	0	26	6.96	4.02	0	34	0.270***	(6.106)
publication year''	2001	-	1985	2009	2000	-	1985	2009	-	-
expected citations										
expected citations percentile	76.273	21.985	1	100	74.569	23.294	1	100	-1.704***	(-7.087)
risk set of citers										
number of publications in risk set (log)	9.28	0.912	4.41	13.73	9.25	0.93	4.92	14.03	-0.037***	(-3.753)
number of men first authorships in risk set (log)	8.42	0.999	1.87	12.97	8.40	1.00	0	13.37	-0.013	(-1.246)
number of women first authorships in risk set (log)	7.90	1.02	1.39	12.56	7.81	1.04	1.79	12.82	-0.097***	(-8.729)
number of men last authorships in risk set (log)	8.68	0.998	1.95	13.22	8.66	0.999	2.20	13.52	-0.018	(-1.638)
number of women last authorships in risk set (log)	7.49	1.01	1.10	12.13	7.40	1.03	1.61	12.52	-0.093***	(-8.476)
demand-side boundary conditions										
uncertainty - age of MeSH terms	0.708	0.455	0	1	0.706	0.455	0	1	-0.001	(-0.298)
uncertainty - prior publications with same MeSH terms	0.496	0.500	0	1	0.496	0.500	0	1	0.001	(0.096)
attractiveness - growth in publications with same MeSH terms	0.448	0.497	0	1	0.452	0.498	0	1	0.004	(0.744)
observations				10,396				47,895		58,291

' detailed forward citation data available as of 1996 (n = 42,905); '' median instead of mean reported; ''' for a detailed overview on descriptive statistics for publication types see Appendix 7b

Appendix 1.8: Expected Citations, Research Proximity, and Risk Set of Citers

We created several variables based on Medical Subject Headings (MeSH), i.e., keywords assigned to life science articles and will explain three of them in more detail in the following. The first variable quantifies the expected citations of certain research content (*expected citations*), the second captures the proximity between research topics historically pursued by the mentor and now pursued by the mentored protégé (*research proximity*), and the third variable identifies the size and gender composition of authors who are at risk of citing a focal article in the years after its publication (*risk set of citers*).

Fundamentally, MeSH terms represent a vocabulary thesaurus used for indexing articles in PubMed (NIH 2021a). These terms get assigned not by the authors of the research, but by specially trained librarians of the U.S. National Library of Medicine (NLM). This institutional feature reduces potential strategizing on the part of the authors (e.g., picking "hotter" keywords to index their research) to zero. Also, MeSH terms come with a unique alpha-numeric identifier (MeSH ID), enabling precise matching and associating of terms to articles and individuals.

a) Expected Citations

The variable expected citations denotes the number of citations an article of certain content and published in a given year can expect to draw from the scientific community. To quantify this construct, we first linked forward citations to almost 200 million MeSH term-publication combinations recorded in PubMed by 2009 (our final sample year). In a next step, we calculated the average number of citations to every single MeSH term in a given year, totaling first-moment calculations for over 26,000 individual MeSH terms. This calculation is based on *all* publications recorded in PubMed to which a particular MeSH term got assigned by the NLM in a given year. Subsequently, we linked this MeSH term-specific average back to protégés' publications that also got assigned that specific MeSH term. Articles generally get assigned multiple MeSH terms to accurately describe research content. We therefore averaged our statistic across all MeSH terms on a publication to derive the publication's overall expected impact. Of note, taking medians as an alternative statistic for the distribution's first moment does not change our results.

Table A1.7 illustrates how we calculated the expected number of citations for the publication "Structural characterization of peptide fragment from hCD81-LEL" (PMID 124902). In sum, this publication is associated with 15 unique MeSH terms[48]. For each of these MeSH terms, we calculated the average number of citations across all articles in PubMed, as described above. For example, the MeSH term "Amino Acid Sequence" received, on average, 13.66 citations across 13,777 publications indexed in 2003. When averaging across all 15 MeSH terms on the focal publication, we arrive at its overall number of citations expected, i.e. 13.88.

[48] We only consider unique MeSH terms, which are reported in the XML files of the PubMed database. In its online interface, PubMed also reports synonymic MeSH terms as indexing is constantly adjusted and names may be updated. For example, the MeSH term "Antigens, CD81" is also reported as "Tetraspanin 28" in the online interface.

Table A1.7 Exemplary Calculation of Expected Impact

Publication title: Structural characterization of peptide fragments from hCD81-LEL
Authors: Dhanasekaran, M., Baures, P. W., Prakash, O., Van Compernolle, S., & Todd, S.
PMID: 12492902
Year of publication: 2003

Medical Subject Heading	MeSH IDs	total citations to publications from 2003 with same MeSH term	total publications from 2003 with same MeSH term	average citations for MeSH term on publications from 2003
Amino Acid Sequence	D020816	188,189	13,777	13.66
Antigens, CD	D015703	27,371	1,933	14.16
Antigens, CD81	D060225	1,150	38	30.26
Cell Line	D041702	140,438	9,160	15.33
Circular Dichroism	D002942	8,545	1,048	8.15
Humans	D006801	1,538,988	191,195	8.05
Membrane Proteins	D064428	87,789	5,643	15.56
Models, Molecular	D008958	103,110	6,875	15.00
Molecular Sequence Data	D058977	254,969	18,822	13.55
Molecular Structure	D015394	20,183	2,633	7.67
Nuclear Magnetic Resonance, Biomolecular	D019906	9,447	1,151	8.21
Peptide Fragments	D010446	30,541	2,771	11.02
Protein Binding	D011485	113,479	7,167	15.83
Protein Conformation	D011487	65,435	4,458	14.68
Viral Envelope Proteins	D064370	8,203	480	17.09
Average across all MeSH terms		**173,189**	**17,810**	**13.88**

To norm the scaling of this variable over time, we use the percentile rank of each publication in relation to the expected citations of all other publications in PubMed appearing in the same year. With 13.88 expected citations and the publication year of 2003, the example publication would be ranked above the 75th percentile (see Table A1.8).

Table A1.8 Distribution of Expected Citations across Publication Years

publication year	average expected citations (across MeSH terms) - publication-level				
	minimum	25th percentile	50th percentile	75th percentile	maximum
1985	0	4.14	4.80	6.16	87.61
1986	0	4.09	4.76	6.08	59.30
1987	0	4.19	4.90	6.29	108.97
1988	0	4.27	5.03	6.65	75.34
1989	0	4.34	5.09	6.75	131.58
1990	0	4.48	5.28	7.12	80.85
1991	0	4.57	5.39	7.28	62.00
1992	0	4.66	5.53	7.49	110.19
1993	0	4.85	5.76	7.91	61.25
1994	0	4.92	5.86	8.02	62.08
1995	0	5.14	6.15	8.44	63.71
1996	0	5.15	6.17	8.52	65.45
1997	0	5.42	6.52	8.92	112.00
1998	0	5.61	6.76	9.19	125.42
1999	0	5.82	6.96	9.34	65.66
2000	0	6.07	7.27	9.70	297.16
2001	0	6.13	7.38	9.83	66.80
2002	0	6.25	7.49	9.96	57.76
2003	0	6.18	7.39	9.81	67.62
2004	0	6.12	7.32	9.69	54.80
2005	0	5.96	7.10	9.36	44.66
2006	0	5.65	6.68	8.68	30.59
2007	0	5.32	6.30	8.18	32.82
2008	0	4.81	5.64	7.21	25.99
2009	0	4.12	4.79	6.04	35.42
2010	0	3.30	3.78	4.64	22.85

When it comes to the interpretation of the variable, it is important to reflect on its two main components, i.e., the numerator and denominator that jointly produce the average number of expected citations. The numerator is forward-looking and captures the sum of all citations a MeSH term will receive in the future. This value increases as more people work on and cite related research. The denominator, on the other hand, is fixing the time to the point of measurement and captures the number of articles relating to a specific MeSH term that are produced today. In other words, this variable represents a ratio of the aggregate future demand for and today's supply of specific research. The resulting average is high if today's supply of research is smaller than tomorrow's demand and vice versa. Thus, this variable captures the attractiveness of certain research content in an unusually precise and reliable way.

This intuition is supported by Figure A1.10, which shows that the cumulative supply of research, measured as the cumulative number of prior publications, tends to be low where expected citations are high (Panel A). At the same time, the actual demand, i.e., realized citations, are high where our variable would expect them to be (Panel B). Taken together, this expected citations variable captures research content that is at the frontier of science at the time of its publication.

Figure A1.10 Research Characteristics by Quartiles of Expected Citations

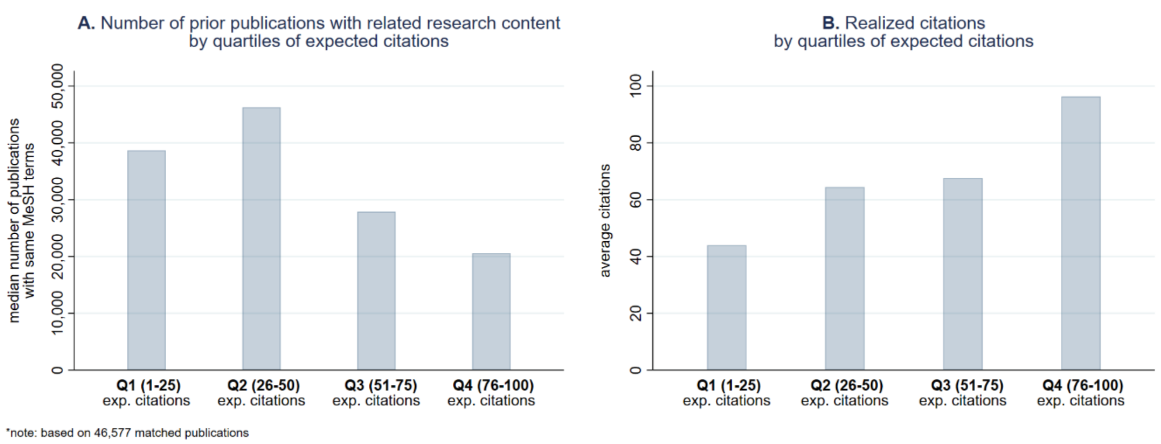


Figure A1.10 shows the number of prior publications with related research content (Panel A) and realized citations (Panel b) by quartiles of expected citation.

b) Research proximity

To capture the degree of research proximity between a protégé's focal publication and the mentor's area of expertise, we calculated the overlap in MeSH terms between a given publication of the F32 recipient and all publications of the mentor appearing within 10 years prior to the F32 mentorship. We created a list of all MeSH terms assigned to a given mentor's publication record and tested whether any of these terms also got assigned to a focal protégé publication using the unique MeSH IDs as a crosswalk. An example of such a list for Jeffery Kelly, the mentor of Paul Baures, is presented in Table A1.9.

Table A1.9 MeSH Terms Associated with an Individual Scientist (1985-1995)

MeSH terms associated to publications of Jeffery Kelly (1985-1995)			
Acids/pharmacology	DNA Primers	Male	Proline
Acquired Immunodeficiency Syndrome […]	Double-Blind Method	Mass Screening/methods	Proline/genetics
Administration, Topical	Doxycycline/therapeutic use	Melanocytes/pathology	Prospective Studies
Adolescent	Drug Eruptions/etiology	Melanoma/diagnosis/epidemiology […]	Protein Conformation
Adult	Dysplastic Nevus Syndrome/pathology	Melanoma/diagnosis/pathology	Protein Denaturation
Age Factors	Dyspnea/chemically induced	Melanoma/diagnosis/pathology/therapy	Protein Structure, Secondary
Aged	Education, Nursing/organization […]	Melanoma/epidemiology/pathology	Proteins/chemical synthesis
Aged, 80 and over	Education, Nursing/standards	Melanoma/etiology/pathology	Receptors, Interleukin-2/analysis
Ageusia/chemically induced	Education/economics/standards	Melanoma/etiology/prevention & control	Recombinant Proteins/chemistry/ […]
AIDS Serodiagnosis	Electrophoresis, Polyacrylamide Gel	Melanoma/prevention & control	Recombinant Proteins/chemistry/ […]
Alanine	Empyema, Pleural/diagnosis/ […]	Melanosis/epidemiology	Reference Standards
Amino Acid Sequence	Encephalitis/drug therapy/parasitology	Meningitis, Aseptic/diagnosis/drug […]	Reference Values
Amino Acids/chemistry	Escherichia coli Infections/drug therapy	Microscopy, Electron	Regression Analysis
Amyloid/biosynthesis	Etretinate/therapeutic use	Middle Aged	Reproducibility of Results
Amyloid/chemistry/ultrastructure	Factitious Disorders/diagnosis/psychology	Models, Biological	Respiration, Artificial
Amyloidosis/genetics	False Negative Reactions	Models, Molecular	Retinitis/diagnosis/drug therapy/ […]
Animals	False Positive Reactions	Models, Theoretical	Retrospective Studies
Anti-Bacterial Agents/therapeutic use	Family Practice	Molecular Sequence Data	Rifabutin
Antibiotics, Antitubercular/adverse effects	Female	Molecular Structure	Rifamycins/adverse effects
Antibodies, Monoclonal	Fever/chemically induced	Mometasone Furoate	Risk
Antigens, CD/analysis	Follow-Up Studies	Mutagenesis, Site-Directed	Risk Factors
Antigens, Fungal/isolation & purification	Fundus Oculi	Mutation	Safety
Antigens, Surface/analysis	Gastric Acid/metabolism	Mycosis Fungoides/blood/ […]	Self Mutilation/diagnosis/psychology
Anti-Inflammatory Agents/therapeutic use	Genes, Lethal	Nalorphine/blood	Severity of Illness Index
Apolipoprotein A-I	Genetic Variation	Neoplasm Staging	Sex Factors
Apolipoproteins A/chemical synthesis	Glutaral	Neoplasms, Radiation-Induced/ […]	Sezary Syndrome/blood
Atrophy	Gram-Negative Bacterial Infections […]	Nevus, Pigmented/congenital/epidemiology	Single-Blind Method
Australia	Hair Color	Nevus, Pigmented/diagnosis/ […]	Skin Diseases/drug therapy/pathology
Australia/epidemiology	Hemophilia A	Nevus, Pigmented/epidemiology	Skin Neoplasms/blood/immunology […]
Bacteremia/drug therapy	Histidine/chemistry	Nevus, Pigmented/epidemiology/pathology	Skin Neoplasms/congenital/epidemiology
Bacteremia/drug therapy/ […]	HIV Infections	Nevus, Pigmented/pathology	Skin Neoplasms/diagnosis/ […]
Bacterial Infections/psychology	HIV Infections/complications	Nevus/diagnosis	Skin Neoplasms/diagnosis/genetics/ […]
Bartonella henselae/isolation & purification	HIV Infections/diagnosis/metabolism	Nevus/epidemiology	Skin Neoplasms/diagnosis/pathology […]
Base Sequence	HIV Infections/enzymology	Nurse Anesthetists/education	Skin Neoplasms/diagnosis/pathology/ […]
Betamethasone/analogs & […]	HIV-1	Nursing Education Research	Skin Neoplasms/etiology/pathology
Biopsy/methods	Humans	Oligopeptides/chemical synthesis/ […]	Skin Neoplasms/etiology/prevention […]
Candidiasis/blood/diagnosis/immunology	Hutchinson's Melanotic Freckle/diagnosis	Ondansetron/blood	Skin Neoplasms/pathology
Cat Diseases/drug therapy/ […]	Hydrocortisone/blood	Optic Neuritis/diagnosis/drug […]	Skin Neoplasms/prevention & control
Cats	Hydrogen-Ion Concentration	Orthopedics	Skin/pathology
Cat-Scratch Disease/diagnosis/drug […]	Hypotension/chemically induced	Ovomucin/chemistry	Societies, Nursing
Cefepime	Hypoxia/chemically induced	Pentazocine/blood/isolation & purification	South Carolina
Ceftazidime/adverse effects/therapeutic use	Immunocompetence	Peptides, Cyclic/chemical synthesis […]	Spectrometry, Fluorescence
Cellulose	In Vitro Techniques	Peptides/agonists	Spectrophotometry, Ultraviolet
Cephalosporins/adverse effects/ […]	Incidence	Peptides/chemical synthesis	Stereoisomerism
Chemical Phenomena	Indicators and Reagents	Peptidyl-Dipeptidase A/blood	Structure-Activity Relationship
Chemistry, Physical	Intensive Care Units	Phenotype	Suction/adverse effects/ […]
Child	Intubation, Intratracheal/adverse […]	Plants	Sunburn/complications
Child, Preschool	Kidney Transplantation	Pneumonia, Pneumocystis/ […]	Sunlight/adverse effects
Chromatography, High Pressure Liquid	Kinetics	Pneumonia/epidemiology/ […]	Survival Analysis
Chromatography, High Pressure Liquid […]	Klebsiella Infections/drug therapy	Point Mutation	Survival Rate
Chromatography, Liquid	Klebsiella pneumoniae	Postoperative Complications/ […]	Syndrome
Circular Dichroism	Latex Fixation Tests	Praziquantel/blood	T-Lymphocyte Subsets/immunology
Colony Count, Microbial	Lentigo	Prazosin/blood	Toxoplasmosis, Cerebral/drug therapy
Costs and Cost Analysis	Lentigo/pathology	Prealbumin/chemistry/drug effects	Tracheostomy
Cross Infection/epidemiology/ […]	Leucine	Prealbumin/chemistry/genetics/metabolism	Trimethoprim, Sulfamethoxazole Drug […]
Cross-Linking Reagents	Leucine/genetics	Prealbumin/chemistry/isolation […]	United States
Cross-Sectional Studies	Lipoproteins, HDL/chemical synthesis	Prealbumin/genetics/metabolism	Urinary Tract Infections/ […]
Cysteine	Lymphadenitis/diagnosis/drug […]	Precancerous Conditions/diagnosis	
Dermatitis, Occupational/epidemiology […]	Lymphoma, T-Cell, Cutaneous/blood	Precancerous Conditions/pathology	
Diagnosis, Differential	Lysosomes/metabolism	Pregnadienediols/therapeutic use	
Diarrhea/complications/drug therapy	Macromolecular Substances	Prevalence	
Disulfides	Magnetic Resonance Spectroscopy	Prognosis	

To illustrate how the variable "research proximity" is then calculated for a given publication, we turn back to the example paper discussed in Table A1.8 For each of the 15 MeSH terms on the paper "Structural characterization of peptide fragment from hCD81-LEL" by Paul Baures (protégé) we check whether they also appear in the list summarizing his mentor Jeffery Keller's body of work within 10 years before mentoring on the F32 grant. Altogether we find that seven MeSH IDs overlap, corresponding to the following terms: "Amino Acid Sequence", "Circular Dichroism", "Humans", "Models, Molecular", "Molecular Sequence Data", "Molecular Structure", and "Protein Conformation". The variable research proximity now simply contains the number of overlapping MeSH terms and therefore takes on the value of seven for this particular publication.

c) Risk Set of Citers

Using citation counts as a dependent variable, we can only observe evaluations, which manifested in citing authors including a focal publication in their reference list. However, to study distortions in evaluations via citations, it is at least equally important to consider instances where a citation could have been included in a reference list but was not. To approximate these instances, we create a set of authors who can be reasonably expected to cite a focal publication, i.e., a risk set of citers, conditional on a focal publication's content and timing of publication. By characterizing the risk set at an unusually granular level, we can further tailor it to the dependent variable of interest. For example, when considering citation counts in general as a dependent variable, we build a risk set consisting of all future articles that could have considered citing the focal research. But when considering forward citations by men last authors only, we limit the risk set of citers to articles published by men last authors.

To empirically arrive at this risk set of citers, we identify articles that were published in temporal proximity (e.g., within five years of publication) and on similar topics as a focal article. To define such articles, we again rely on the externally assigned MeSH terms. In a first step, for every MeSH term in a given year, we count the number of articles recorded in Pubmed that mention a specific MeSH term. Using the genderize.io database (for details see Appendix 5), we assign gender to the first and last authors for whom the first name is available. Then we also count the number of publications with men/women first/last authors. This involves connecting more than 100 million MeSH-article-author combinations across all records in the PubMed database. At the end of this step, we obtain a (gendered) publication count for each MeSH term at the year-level.

In the second step, we build rolling sums over the next five (ten) years. For each MeSH term and in each year since its first appearance, we now know how many related articles were published within the next five (ten) years. We then link these rolling sums back to a focal publication via its MeSH term and year of publication. After this step we have a data structure at the publication-MeSH term level, reflecting the number of publications to a specific MeSH term within five (ten) years of the focal article's publications. We build the measures for articles authored by men/ women first/ last authors accordingly.

Next, we only consider the median value of each of the measures across all MeSH terms on the focal publication. We take the median instead of the mean because the distribution of publications per MeSH term is highly skewed, with very few MeSH terms being assigned to a large number of publications (e.g., the MeSH term "Human"). In a final step, we take the natural logarithm of the median values, again to account for the skewness of the underlying variable. As a result, we obtain five different measures reflecting the risk set of citers: the log number of all articles in the risk set of citers, the log number of articles with women first authors, the log number of articles with women last authors, the log number of articles with men first authors, and the log number of articles with men last authors.

We use these risk sets in selected analyses to account for the possibility that research by men- and women-mentored protégés speaks to audiences (risk set of citers) of different size or gender composition. Throughout the manuscript, we use a 5-year window for the construction of risk sets, but our results remain the same if we consider a 10-year window instead. Figure A1.11 shows the averages of each of these variables for publications by men- and women-mentored protégés, separately. The results show that women-mentored protégés tend to work on research content where there are slightly more women but fewer men in the risk set of citers. Therefore, it is important to also control for this risk set when analyzing gender forward citation patterns (Table 1.5 in the main manuscript).

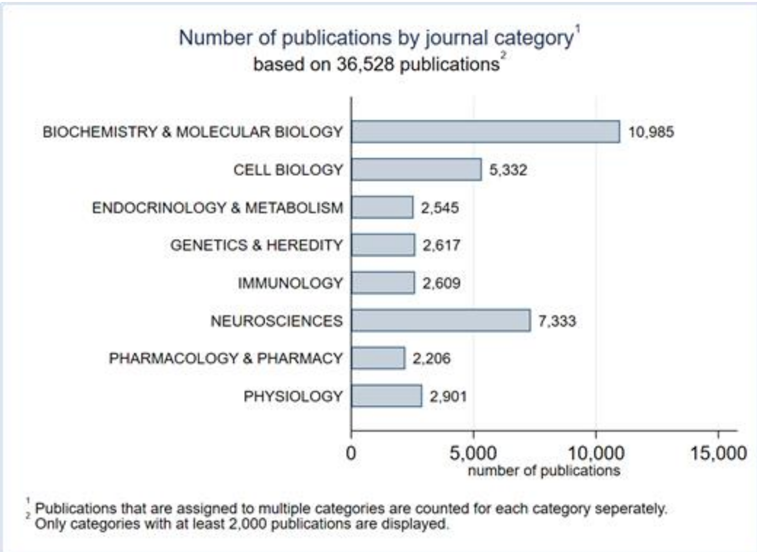
Figure A1.11 Size of Risk Set of Citers by Mentor Gender

Appendix 1.9: Citations from Close and Distant Fields

To capture the number of forward citations a publication receives from close versus distant fields, we create two variables based on Clarivate's Journal Citation Report (JCR). As of 2021, Clarivate reports 254 distinct journal categories, such as, for example, "Biochemistry & Molecular Biology" or "Neurosciences". For each of these categories, Clarivate manages a list of related journals, ranked by journal impact factor. In a first step, we web-scrape these journal lists for every category and merge them into a large dataset at the journal level. Since the categories assigned to a focal journal are not always mutually exclusive, it is possible that the same journal is indexed with more than one category (up to six different categories as simultaneous assignment occur, but assignment to six categories is rare 0.06%). For example, the journal "Cell" is assigned to "Cell Biology" and "Biochemistry & Molecular Biology". Similarly, "Nature Reviews Drug Discovery" is assigned to "Pharmacology & Pharmacy" and "Biotechnology & Applied Microbiology".

In a second step, we use the journals' unique international standard serial numbers (ISSN) reported both in PubMed and in the Clarivate JCR to match the publications from our sample to the journal categories reported in Clarivate. We are able to link 53,102 of 58.291 publications (91.1%). On average, each journal publication is associated with 1.6 categories. Figure A1.12 shows the absolute number of publications within each category, double-counting publications that are assigned to more than one category. Please note that Figure A1.12 only shows categories with at least 2,000 linked publications in our sample. In total, our dataset contains 164 distinct journal categories. Because we are interested in clearly delineated fields, we exclude 8 categories that contain the word "multidisciplinary" in their names from the analysis.

Figure A1.12 Number of Publications by Journal Category

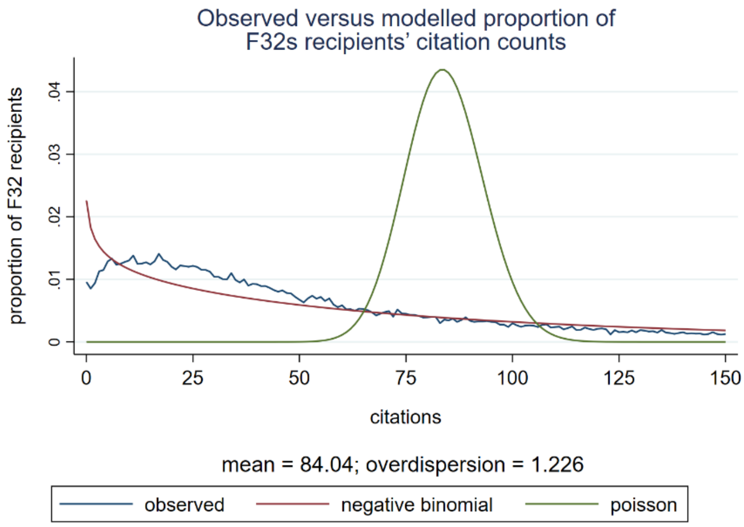


In a third step, we turn to forward citations of our focal articles and extract detailed information, especially journal ISSNs, for more than 6 million citing publications. To do this, we have to use the Scopus database, which contains detailed information on citing articles from 1996. Using the ISSNs, we are able to link approximately 83% of citing publications to the corresponding journal categories (5,012,265 citing publications).

In the next step, we assemble a dataset that links the focal article to the citing articles and contains information on both publications' journal categories. Based on this data structure, we created an indicator variable "close field citation" at the citation-level that takes on the value one if any of the assigned journal categories between focal and citing publication overlap and zero otherwise. In the latter case the citation is considered as "distant field citation". Finally, we calculated the total of close and distant field citations for all focal publications by summing up the corresponding indicator variables across their citations.

Appendix 1.10: Comparison of Different Model Specifications

Figure A1.13 Poisson versus Negative Binomial Model Specification



Appendix 1.11: Regression Tables underlying Test of Boundary Conditions

a) Test of Uncertainty and Attractiveness of Research Content as Boundary Conditions (Figure 1.5)

Table A1.10 Test of Uncertainty and Attractiveness of Research

	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)
dependent variable: forward citations				
independent variables				
woman mentor	0.965	0.971	0.963	1.129
	(0.046)	(0.032)	(0.028)	(0.084)
boundary conditions				
uncertainty (age)	0.901***			
	(0.025)			
ucertainty (age) x woman mentor	0.959			
	(0.046)			
uncertainty (prior publications)		1.226***		
		(0.039)		
uncertainty (prior publications) x woman mentor		0.930*		
		(0.037)		
attractiveness (growth)			1.238***	
			(0.028)	
attractiveness (growth) x woman mentor			0.939*	
			(0.035)	
attractiveness (expected citations)				1.369***
				(0.062)
attractiveness (expected citations) x woman mentor				0.806***
				(0.060)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included		
risk set of citers	included	included	included	included
publication year dummies	included	included	included	included
CEM weights	included	included	included	included
academic cohort dummies	included	included	included	included
constant	14.58***	6.955***	23.94***	16.06***
	(2.880)	(1.547)	(4.340)	(3.001)
observations	46,577	46,577	46,577	46,577

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

b) Test of Non-Linearity of Effect of Attractiveness of Research Content (Figure 1.6a)

Table A1.11 Test of Non-Linearity of Effect of Attractiveness of Research Content

	NBREG
	(1)
dependent variable: forward citations	
independent variables	
woman mentor	1.134
	(0.140)
expected citations	
Q1 (1-25 percentile) expected citations	base
Q2 (26-50 percentile) of expected citations	1.371***
	(0.091)
Q3 (51-75 percentile) of expected citations	1.598***
	(0.107)
Q4 (76-100 percentile) of expected citations	1.805***
	(0.120)
Q1 (1-25 percentile) of expected citations x woman mentor	base
Q2 (26-50 percentile) of expected citations x woman mentor	1.004
	(0.135)
Q3 (51-75 percentile) of expected citations x woman mentor	0.787*
	(0.101)
Q4 (76-100 percentile) of expected citations x woman mentor	0.804*
	(0.101)
F32 characteristics (recipient and grant)	included
mentor characteristics	included
research characteristics	included
risk set of citers	included
publication year dummies	included
CEM weights	included
academic cohort dummies	included
constant	12.94***
	(2.490)
observations	46,577

standard errors clustered by F32 recipients in parantheses;
*p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

Appendix 1.12: Predictors of Final Sample Composition

Table A1.12 Predictors of Final Sample Composition

	Logit
dependent variable: final sample (dummy)	(1)
woman mentor	34.09***
	(14.201)
F32 characteristics (recipient and grant)	
woman F32 recipient	0.521***
	(0.050)
endowment of host institution	1.002
	(0.003)
F32 grant extension	0.884
	(0.118)
number of papers before F32 grant	0.995
	(0.020)
share high JIF pubs before F32 grant	0.667
	(0.153)
mentor characteristics	
number of papers 10 years before grant (mentor)	0.981***
	(0.002)
share high JIF pubs 10 years before grant (mentor)	0.729
	(0.231)
number of all prior grants (mentor)	1.051***
	(0.015)
academic cohort dummies	included
constant	3.932***
	(1.429)
Wald test for joint significance of entire model (χ^2)	*911.726****
observations	4,556

*p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficients (odds ratios) reported

Appendix 1.13: Alternative Explanations

a) Excluding Self-Citations

Table A1.13 Excluding Self-Citations

	NBREG
	(1)
dependent variable: forward citations w/o self-citations	
independent variables	
woman mentor	0.943**
	(0.027)
F32 characteristics (recipient and grant)	included
mentor characteristics	included
research characteristics	included
expected citations	included
risk set of citers	included
publication year dummies	included
CEM weights	included
academic cohort dummies	included
constant	16.74***
	(3.563)
observations	34,609

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996

b) Controlling for Last Author Quality (if not Mentor or F32 Recipient)

Table A1.14 Controlling for Last Author Quality

	mentor not coauthor & F32 recipient not last author	
dependent variable: forward citations	NBREG	NBREG
	(1)	(2)
independent variables:		
woman mentor	0.923**	0.920**
	(0.036)	(0.035)
woman last author		0.994
		(0.041)
average JIF of prior publications (last author)		1.025***
		(0.005)
experience in years (last author)		0.991***
		(0.002)
experience in number of publications (last author)		1.001***
		(0.000)
F32 characteristics (recipient and grant)	included	included
mentor characteristics	included	included
research characteristics	included	included
expected citations	included	included
risk set of citers	included	included
publication year dummies	included	included
CEM weights	included	included
academic cohort dummies	included	included
constant	12.31***	13.79***
	(3.574)	(4.058)
observations	17,452	17,452

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

c) Descriptive Statistics of Quality of Last Authors (if not Mentor or F32 Recipient) by Mentor Gender

Table A1.15 Descriptive Statistics of Quality of Last Authors by Mentor Gender

	men mentors				women mentors				difference in means'	
variable name	**mean**	**sd**	**min**	**max**	**mean**	**sd**	**min**	**max**	**beta**	**t-statistic**
woman last author	0.17	0.38	0	1	0.19	0.40	0	1	0.024	1.85*
average JIF of prior publications (last author)	5.98	3.77	0	70.67	5.96	3.73	0	42.75	-0.018	0.91
experience in years (last author)	18.13	10.58	0	57	18.56	10.42	0	60	0.423	0.21
experience in number of publications (last author)	67.19	76.85	1	1284	72.16	80.12	1	1135	4.967	1.72*
observations				13,481				3,971		17,452

'comparison of means with standard error clustered by F32 recipient, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix 1.14: Robustness Checks

a) Varying Time Window of Forward Citations

Table A1.16 Varying Time Window of Forward Citations

	NBREG	NBREG
	(1)	(2)
dependent variable: forward citations	10-year forward citations	5-year forward citations
independent variables		
woman mentor	0.943**	0.957*
	(0.024)	(0.023)
F32 characteristics (recipient and grant)	included	included
mentor characteristics	included	included
research characteristics	included	included
expected citations	included	included
risk set of citers	included	included
publication year dummies	included	included
CEM weights	included	included
academic cohort dummies	included	included
constant	11.58***	7.253***
	(2.225)	(1.329)
observations	36,211	36,211

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996

b) Propensity Score Matching with 4 Nearest Neighbors

Table A1.17 Propensity Score Matching with 4 Nearest Neighbors

	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)
	all	*citations by*	*citations by*	*citations by articles*
dependent variable: forward citations	forward citations	***men first*** *authors*	***men last*** *authors*	*from* ***close fields***
independent variables				
woman mentor	0.912**	0.872***	0.846***	0.888**
	(0.035)	(0.034)	(0.033)	(0.045)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included	included	included
risk set of citers	included	included	included	included
publication year dummies	included	included	included	included
CEM weights	included	included	included	included
academic cohort dummies	included	included	included	included
constant	4.220***	2.858***	2.858***	12.57***
	(0.957)	(0.584)	(0.593)	(3.508)
observations	13,413	13,413	13,413	11,635

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996; only publications in top two quartiles of expected impact; Model 4 excludes publications in multidisciplinary journals

c) OLS Regression with Logged Citations as Dependent Variables

Table A1.18 OLS Regression with Logged Citations as Dependent Variables

	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)
dependent variable: log forward citations	**all** forward citations (log)	citations by **men first** authors (log)	citations by **men last** authors (log)	citations by articles from **close fields** (log)
independent variables				
woman mentor	-0.042*	-0.086***	-0.129***	-0.068**
	(0.024)	(0.025)	(0.025)	(0.031)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included	included	included
risk set of citers	included	included	included	included
publication year dummies	included	included	included	included
CEM weights	included	included	included	included
academic cohort dummies	included	included	included	included
constant	1.785***	1.403***	1.350***	1.942***
	(0.164)	(0.150)	(0.160)	(0.199)
observations	30,882	30,882	30,882	26,454

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996; only publications in top two quartiles of expected impact; Model 4 excludes publications in multidisciplinary journals

d) Limit Analyses to Mentors who Appear as Last Author on all Publications Citing F32 Grant

Table A1.19 Limit Analyses to Mentors who Appear as Last Author on all F32 Publications

	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)
dependent variable: forward citations	**all** forward citations	*citations by* ***men first*** *authors*	*citations by* ***men last*** *authors*	*citations by articles from* ***close fields***
independent variables				
woman mentor	0.935*	0.884***	0.862***	0.903**
	(0.035)	(0.035)	(0.034)	(0.043)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included	included	included
risk set of citers	included	included	included	included
publication year dummies	included	included	included	included
CEM weights	included	included	included	included
academic cohort dummies	included	included	included	included
constant	25.69***	11.67***	14.55***	24.35***
	(6.445)	(2.770)	(3.786)	(7.301)
observations	15,701	15,701	15,701	13,418

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996; only publications in top two quartiles of expected impact; Model 4 excludes publications in multidisciplinary journals

e) Limiting the Sample to First Five Years after F32 Grant Receipt

Table A1.20 Limit the Sample to First Five Years after F32 Grant Receipt

	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)
dependent variable: forward citations	**all** forward citations	*citations by* ***men first*** *authors*	*citations by* ***men last*** *authors*	*citations by articles from* ***close fields***
independent variables				
woman mentor	0.936**	0.888***	0.849***	0.926*
	(0.030)	(0.029)	(0.028)	(0.038)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included	included	included
risk set of citers	included	included	included	included
publication year dummies	included	included	included	included
CEM weights	included	included	included	included
academic cohort dummies	included	included	included	included
constant	37.02***	18.70***	24.41***	25.63***
	(12.510)	(6.265)	(8.412)	(8.344)
observations	16,955	16,955	16,955	14,560

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data of forward citations available as of 1996; only publications in top two quartiles of expected impact; Model 4 excludes publications in multidisciplinary journals

f) Sensitivity of Gendered Patterns in Forward Citations – Varying the Probability Threshold for Gender Designation of Citing Authors

Table A1.21 Sensitivity of Gender Designation in Forward Citations

	NBREG	NBREG	NBREG	NBREG
	(1)	(2)	(3)	(4)
dependent variable: forward citations *(gender designated with probability > 90%)*	*citations by* ***men first*** *authors*	*citations by* ***women first*** *authors*	*citations by* ***men last*** *authors*	*citations by* ***women last*** *authors*
independent variables				
woman mentor	0.889*** (0.025)	1.018 (0.032)	0.864*** (0.024)	1.151*** (0.038)
risk set of citers				
number of men first authorships in risk set (log)	1.065*** (0.010)			
number of women first authorships in risk set (log)		1.088*** (0.011)		
numer of men last authorships in risk set (log)			1.057*** (0.010)	
number of women last authorships in risk set (log)				1.106*** (0.013)
F32 characteristics (recipient and grant)	included	included	included	included
mentor characteristics	included	included	included	included
research characteristics	included	included	included	included
expected citations	included	included	included	included
publication year dummies	included	included	included	included
CEM weights	included	included	included	included
academic cohort dummies	included	included	included	included
constant	2.493*** (0.448)	0.476*** (0.083)	2.285*** (0.411)	0.466*** (0.085)
observations	36,113	36,113	36,113	36,113

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data on forward citations available as of 1996

g) Using a Continuous Specification of the Expected Citations Variable

Table A1.22 Continuous Specification of the Expected Citations Variable

	NBREG	NBREG
dependent variable: forward citations	(1)	(2)
independent variables		
woman mentor	0.946**	1.169
	(0.026)	(0.115)
expected citations		
percentile of expected citations (1-100)	1.006***	1.007***
	(0.001)	(0.001)
percentile of expected citations (1-100) x woman mentor		0.997**
		(0.001)
F32 characteristics (recipient and grant)	included	included
mentor characteristics	included	included
research characteristics	included	included
risk set of citers	included	included
publication year dummies	included	included
CEM weights	included	included
academic cohort dummies	included	included
constant	19.78***	18.93***
	(6.589)	(6.399)
observations	46,577	46,577

standard errors clustered by F32 recipients in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported; based on detailed data on forward citations available as of 1996

A2. Appendix to Chapter 2

Appendix 2.1: Description of the Gender Designation Process

The accuracy and value of our analysis hinges on the correct designation of the inventors' gender. In general, there are two possible mistakes one can make: i) identify stars as men even though they are women and ii) identify stars as women even though they are actually men. While both mistakes would lead to the true effects being underestimated, the second case is more concerning in our setting. If we consider women stars as the treatment and men stars as a control group, it would imply that we falsely sort units from the control to the treatment group. Given that the treatment group is much smaller than the control group (see Appendix 1), these "false treatments" would have a stronger effect on the average effect size estimated for the treatment group as a "false control" would have on the effect size estimated for the control group. We therefore employ several steps to reduce the risk that we make the second mistake, i.e. classify stars as women even though they are actually men. These steps will be outlined in the following.

The USPTO collects limited information on patent inventors (full name, city and state). The main available information that allows us to identify gender is the inventors' first name(s), and potentially his or her country of residence. Various name-to-gender inference methods exist and are used for research purposes. These algorithms can predict a person's gender from their name with the help of large labeled datasets, sometimes enriched with information from social media, cultural background, and sociolinguistic insights (Santamaría & Mihaljević, 2018).

We use the genderize.io API (https://genderize.io/) to designate the star inventor's gender based on his or her first name(s). A useful feature of the genderize.io API is that it not only provides a gender prediction but also two indicators for the prediction's reliability. Genderize.io uses social network profiles linked to specific first names to report a gender as well as name count and an accuracy score. While the name count states how often a social network profile was linked to a particular name, the accuracy score reports the percentage of profiles for which the name was associated with the predicted gender (Wais 2016). Due to these advanced frequency and accuracy indicators and because of its global and continuously growing reach, genderize.io has been shown to offer strong advantages in comparison to other gender designation algorithms (Wais 2016).

A problem inherent in name-to-gender designation methods is that gender may depend on the language spoken or the country of origin. For some countries and ethnicities, it is difficult to derive a person's gender from their first name, particularly if the first name is not written in Latin script and for languages for which meaning is derived from characters and diacritics (e.g., Mandarin, Japanese). In addition, there is a difference in the name order, commonly known as the Eastern versus Western name order, as some Asian cultures typically use their family name first, which can increase inconsistencies for translated names (Jacques 2009). This generally results in less confident predictions for names of Asian origin (Santamaría and Mihaljević 2018).

In the patent application process, names of Asian origin are often translated by patent officers and hence are not reliable as different examiners might write names in different ways. Additionally, if transliterated to Latin script, it is no longer possible to deduct gender. The high number of inventors with Asian names makes this particularly problematic (USPTO 2019). This issue affects inventors living in Asian countries as well as inventors from Asian origin residing elsewhere.

For these reasons, we carefully assessed the accuracy of the gender designation for Asian countries as well as for any inventors with names that are likely to be of Asian origin. The results of these checks are presented in Table A2.1. First, we checked the prediction accuracy of the algorithm for Asian countries (China, Japan, South Korea, and Taiwan) by relying on the judgment of experts, i.e., two locals from each of the respective countries, in a random draw of up to 300 names. We found that for these countries, no more than 60% of women inventors were correctly predicted by the algorithm, on average. Second, we ran similar checks to assess the problem for people of Asian ethnicity living in foreign countries. We used US census data[49] to determine inventors most likely ethnicity based on their last name (Kerr and Lincoln 2010). Again, we drew a random sample of US inventors whose ethnicity was Asian with a probability of more than 50% and detected a similar pattern as for inventors from Asian countries. No more than 31% of inventors classified by genderize.io as women were also coded women by our local experts. As a benchmark, we can compare these ratios of accuracy as well as the correlation coefficient to non-Asian US investors for whom the algorithm designated almost 86% of the women inventors correctly.

To circumvent the high likelihood of misidentification for inventors from Asian countries, with names of Asian origin, and with rare names, we restrict the sample used in our analysis to inventors for whom we can reliably assess gender. To construct the sample, we therefore first select exclusively inventors who do not come from China, Japan, South Korea, or Taiwan and for whom US census data does not indicate that they are of Asian ethnicity. Doing so we can identify 8,344 women and men star inventors. In a next step, we rely on the frequency indicators (how many times the name is recorded in the database) and accuracy scores (percentage of data records that are associated with the predicted gender) of the genderize.io database. We retain inventors if their first name is recorded at least 10 times and if the gender prediction is based on an accuracy of 99% or

[49] Open source data, available here: https://github.com/rflynn/pro-file/tree/master/data

more.[50] This reduces the sample by roughly 15% so that we are left with 7,151-star inventors who qualify for our analyses.

Our restrictive approach leaves us confident that we only retain (women) stars in the analysis for whom we can correctly and reliably assess gender. However, we are aware that this approach limits the generalizability of our findings to non-Asian inventors. There might be cultural differences between Asian and non-Asian countries, also in relation to the role of women, which require us to interpret the findings exclusively for non-Asian inventor teams. We invite further research to verify if these effects also translate into Asian cultures and countries.

Table A2.1 Accuracy of Gender Designation

	Expert 1		Expert 2		Average	
Country/ Ethnicity	**% accuracy for women inventors**	**Pearson correlation**	**% accuracy for women inventors**	**Pearson correlation**	**% accuracy for women inventors**	**Pearson correlation**
China	32.60%	0.55	88.26%	0.69	60.43%	0.62
Japan	49.55%	0.79	42.23%	0.50	45.89%	0.65
South Korea	9.92%	0.12	19.71%	0.17	14.82%	0.15
Taiwan	20.15%	0.46	54.52%	0.06	37.34%	0.26
US - Asian	39.08%	0.52	23.18%	0.14	31.13%	0.33
US - Non-Asian	85.95%	0.77	85.31%	0.80	85.63%	0.79
Final sample	100.00%	0.98	86.31%	0.89	93.16%	0.94

The basis for the analysis is a random sample of up to 300 forenames within each category, for which all corresponding inventor-patent-combinations were identified. The "accuracy for women inventors" is measured as the share of the predictions made by the algorithm that correspond to the expert's opinion. For example: For Chinese inventors the algorithm assigned the gender "woman" to 32.60% of inventors who were also judged to be woman by Expert 1. The Pearson's correlation coefficients are based on the correlation between the algorithm's prediction (1 if woman, -1 if male) and the expert's opinion (1 if inventor is woman, -1 if inventors is male, 0 if gender could not be determined).

[50] We obtain similar in our analysis if we adapt the threshold to 95%, for example. However, manual inspection of the data showed that even then we include stars falsely classified as women inventors. Results are available from the authors.

Appendix 2.2: Representation of Woman Star Patents across Time and Fields

Figure A2.1 Share of Women Star Patents over Time

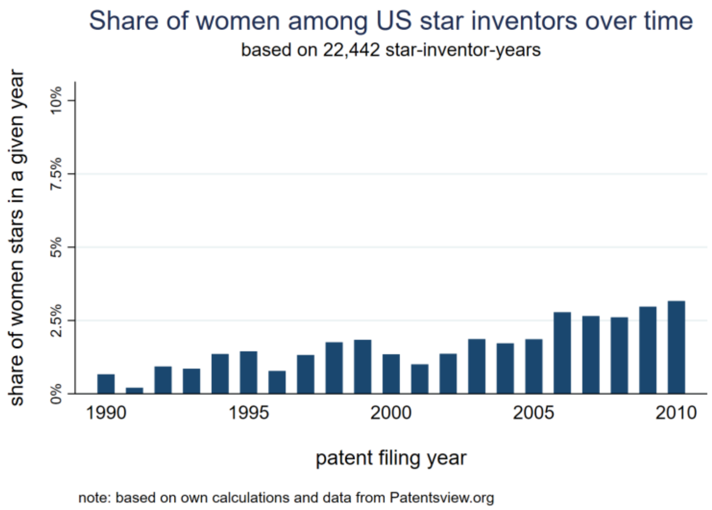


Figure A2.1 depicts the share of unique women stars from all unique stars, for whom we were able to designate the gender in a particular year. For example, in 2010 3.16% of all unique gender-designated stars were women.

Table A2.2 Share of Women (Star) Inventors Across Fields

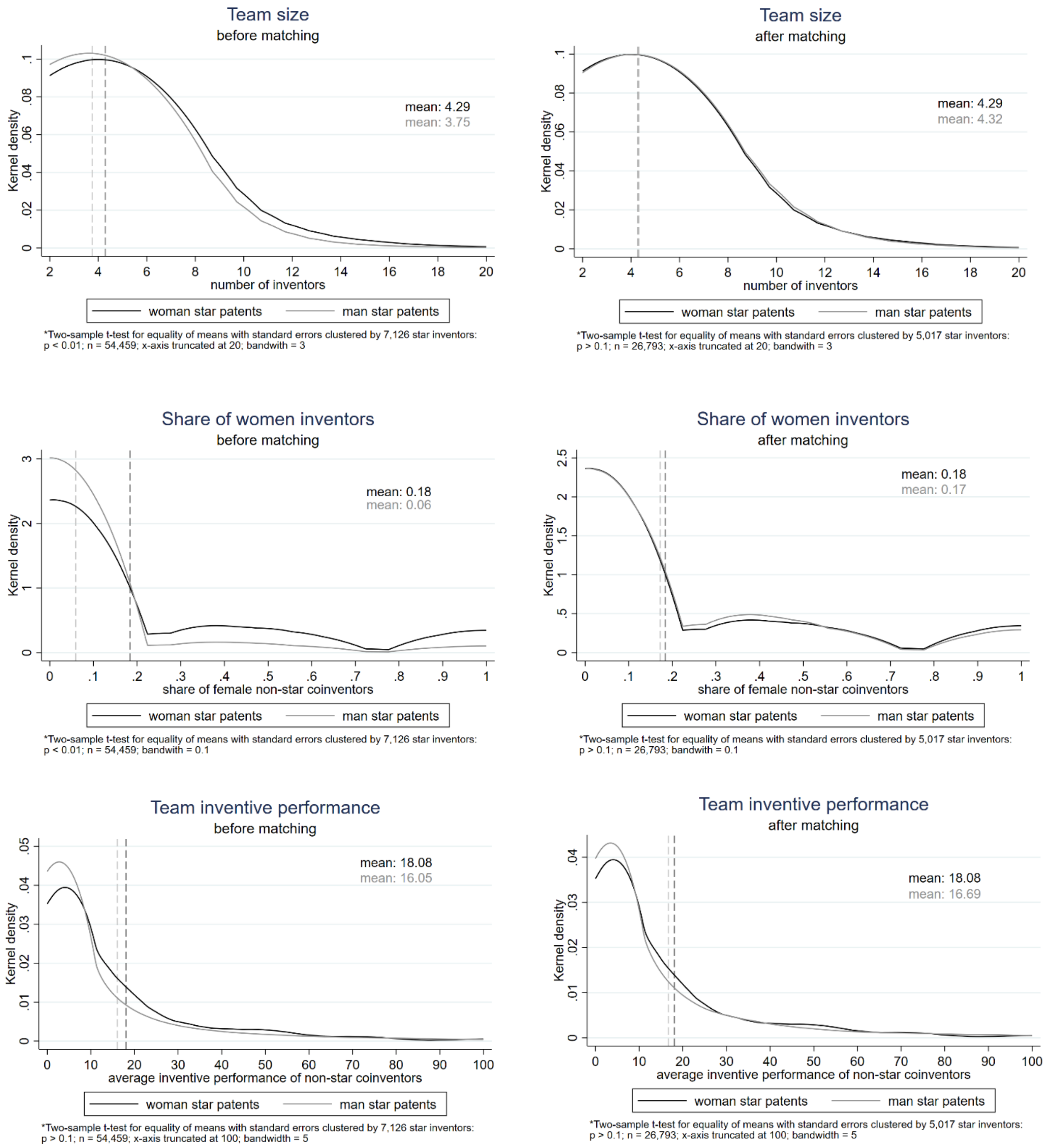
Field (Schmoch 2008)	% women of stars in field	total number of stars in field	% women of inventors in field	Total number of inventors
Analysis of biological materials	0.00%	50	5.94%	21,075
Audio-visual technology	4.00%	150	13.92%	3,003
Basic communication processes	0.60%	166	4.92%	8,266
Basic materials chemistry	7.05%	227	9.51%	11,999
Biotechnology	9.64%	249	17.16%	12,336
Chemical engineering	3.90%	231	5.23%	11,550
Civil engineering	0.00%	194	2.83%	11,972
Computer technology	2.02%	595	7.28%	32,358
Control	0.00%	59	4.87%	7,430
Digital communication	1.83%	328	7.83%	12,572
Electrical machinery, apparatus, energy	0.32%	317	4.66%	28,579
Engines, pumps, turbines	0.56%	180	3.14%	15,105
Environmental technology	3.96%	101	4.93%	5,319
Food chemistry	6.15%	65	11.24%	3,629
Furniture, games	0.00%	83	5.93%	9,808
Handling	1.04%	96	3.26%	11,690
IT methods for management	6.56%	61	10.64%	3,025
Machine tools	1.47%	136	3.23%	12,161
Macromolecular chemistry, polymers	2.61%	307	7.64%	12,691
Materials, metallurgy	3.87%	181	5.85%	10,707
Measurement	1.21%	496	4.29%	26,039
Mechanical elements	0.66%	152	2.57%	13,367
Medical technology	1.97%	559	6.77%	21,114
Micro-structural and nano-technology	3.85%	26	11.92%	1,326
Optics	2.93%	239	6.50%	23,492
Organic fine chemistry	4.97%	583	11.45%	23,278
Other consumer goods	6.67%	90	7.54%	7,664
Other special machines	1.91%	209	3.72%	14,774
Pharmaceuticals	4.39%	114	15.22%	7,267
Semiconductors	2.91%	103	9.62%	16,480
Surface technology, coating	0.00%	128	5.97%	7,594
Telecommunications	3.75%	160	6.19%	13,838
Textile and paper machines	1.01%	99	4.92%	10,866
Thermal processes and apparatus	0.66%	151	3.72%	5,756
Transport	0.75%	266	3.02%	19,156
Total	**2.64%**	**7,151**	**6.44%**	**457,286**

Table A2.2 summarizes the share of unique women (star) inventors of all unique gender-designated (star) inventors across fields between 1990 and 2010. For example, 9.64% of all gender-designated star inventors who have filed most of their patents in biotechnology are women. Similarly, 17.16% of all unique gender-designated inventors in biotechnology are women.

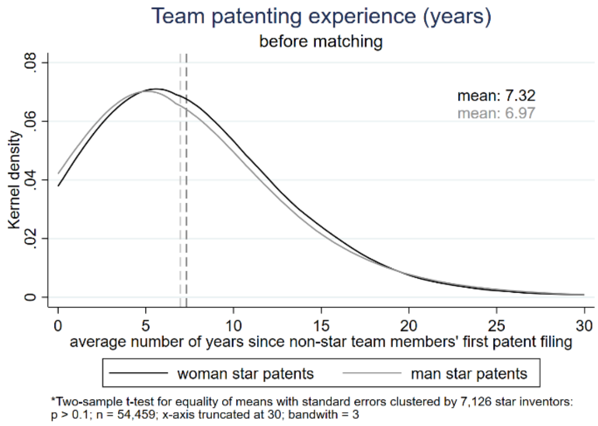
Appendix 2.3: Distribution of Inventor Team and Patent Characteristics for Teams with Women versus Men Stars before and after Matching

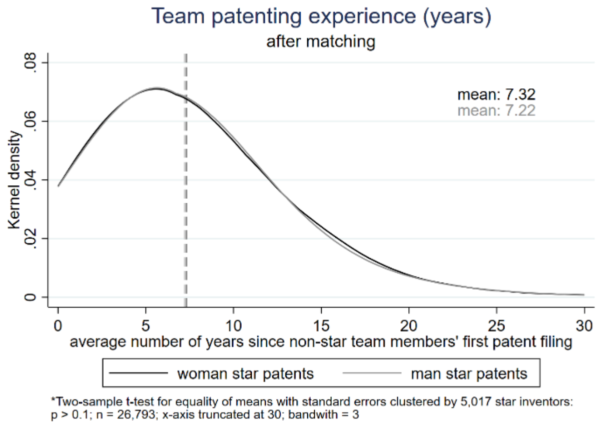
The graphs show the kernel density distribution of inventor team characteristics for teams with women and men stars. Graphs on the left-hand side show the distribution on the full sample (n = 54,459) while graphs on the right-hand side show the post-matching distribution (n=26,793), accounting for the matching weight obtained from CEM.

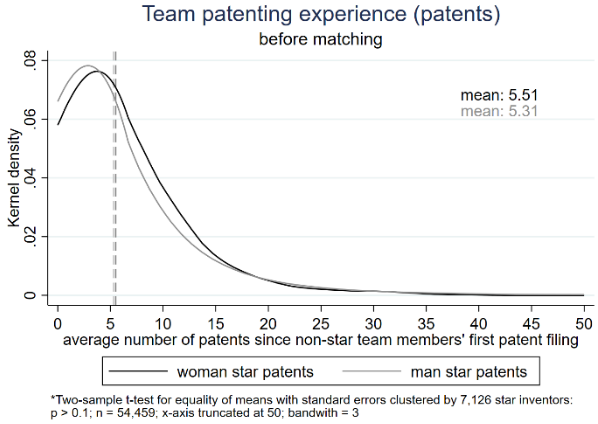
Figure A2.2 Distribution of Team and Patent Characteristics before and after Matching

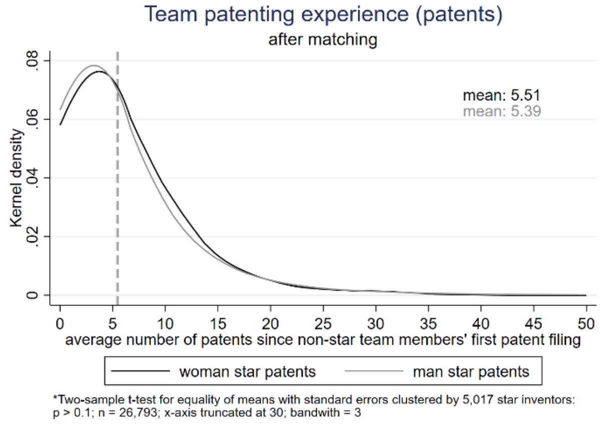


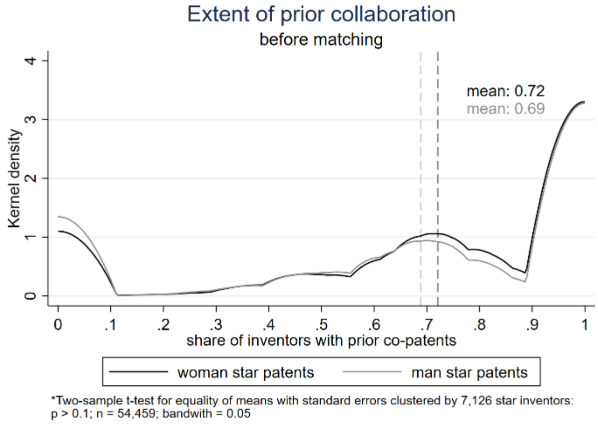
Appendix 2.3: Distribution of Inventor Team and Patent Characteristics for Teams with Women versus Men Stars before and after Matching (continued)

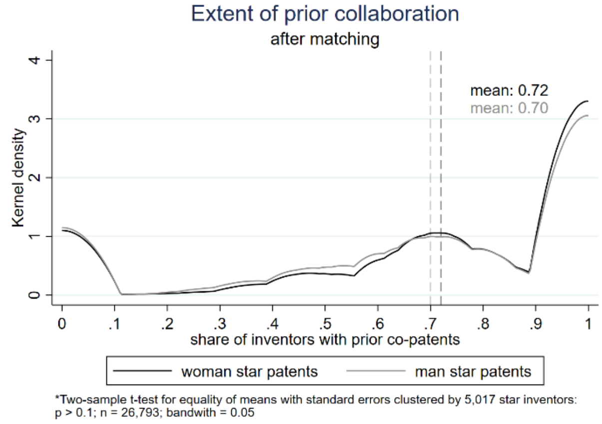




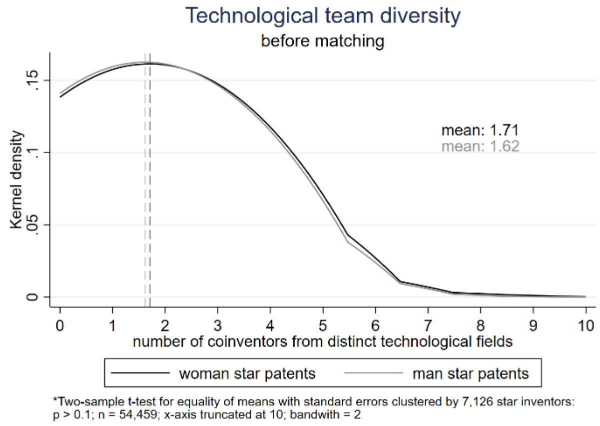


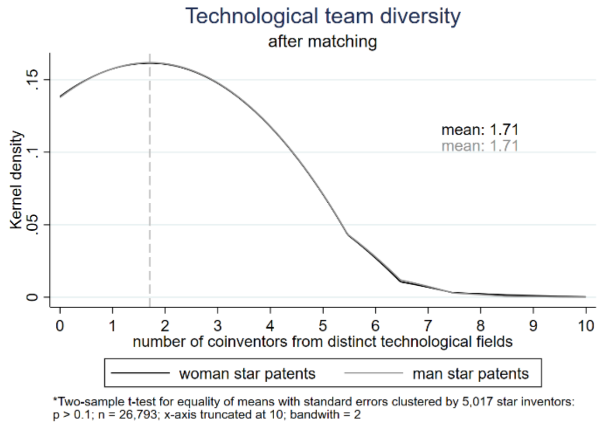


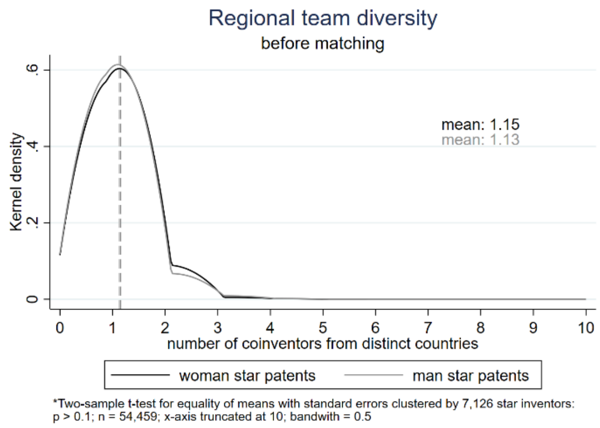


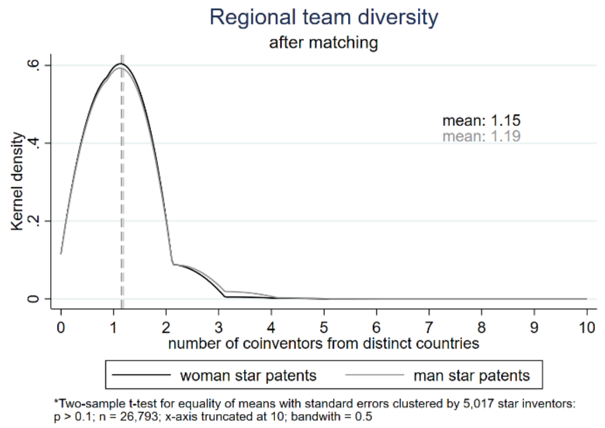


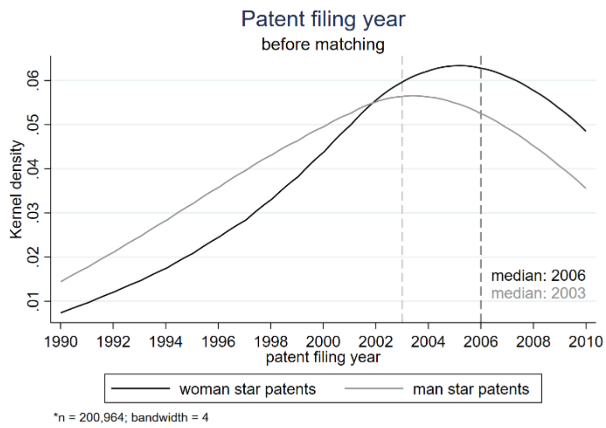
Appendix 2.3: Distribution of Inventor Team and Patent Characteristics for Teams with Women versus Men Stars before and after Matching (continued)

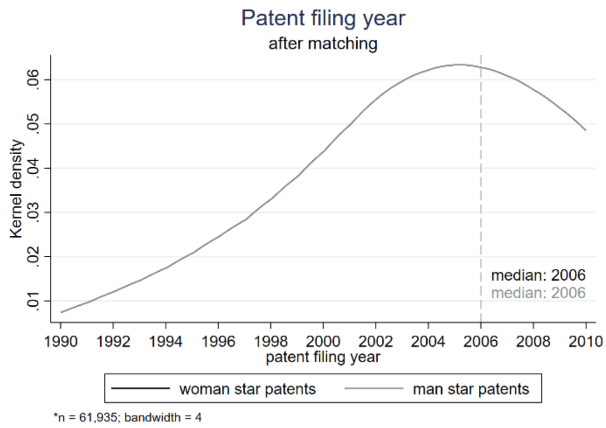












Appendix 2.4: Representativeness of the Sample

Table A2.3 Predictors of Final Sample

dependent variable: final sample (dummy)	Model 1 PROBIT
knoweldge recombination breadth	0.960
	(0.047)
team size	0.983***
	(0.005)
share of women inventors	0.605***
	(0.029)
team inventive performance	1.039**
	(0.017)
team patenting experience (years)	1.002
	(0.013)
team patenting experience (patents)	1.000
	(0.018)
extent of prior collaboration	0.994
	(0.022)
technological team diversity	0.998
	(0.015)
regional team diversity	1.026
	(0.028)
star inventive performance	1.023
	(0.020)
star patenting experience (years)	0.982
	(0.020)
star patenting experience (patents)	0.981
	(0.025)
star technological diversity	1.001
	(0.019)
number of patent claims	1.017**
	(0.008)
size of patent family	0.997
	(0.013)
number of backward citations	1.025*
	(0.014)
number of patent applicants	1.030*
	(0.017)
main patenting field dummies	yes
patent filing year dummies	yes
constant	0.197***
	(0.021)
observations	62,659

note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; standard errors clustered by star inventors in brackets; coefficients reported as inverse rate ratios (IRRs)

Model 1 in Table A2.3 shows a probit regression estimating the likelihood of an observation appearing in the final sample. The independent variables represent team, star, and patent characteristics. The dependent variable is a dummy variable indicating whether an observation was used in the final analysis. The final sample constitutes observations, which meet the gender designation requirements (see Appendix 3) and are selected in the coarsened exact matching.

Appendix 2.5: Robustness Checks

Table A2.4 Robustness Checks

	OLS		TOBIT		OLS	
	full sample		**tobit regression**		**alternative DV**	
	Model 1a	Model 1b	Model 2a	Model 2b	Model 3a	Model 3b
variables	***DV: knowledge recombination breadth***		***DV: knoweldge recombination breadth***		***DV: knowledge recombination breadth (excluding applicant citations)***	
woman star inventor	0.035***	0.030***	0.023***	0.018**	0.028**	0.019
	(0.007)	(0.008)	(0.007)	(0.008)	(0.011)	(0.013)
woman star inventor x no prior collaboration		0.028**		0.036***		0.055***
		(0.012)		(0.012)		(0.020)
no prior collaboration		-0.009***		-0.013**		-0.004
		(0.003)		(0.005)		(0.007)
team size	-0.004***	-0.004***	-0.001	-0.001	-0.002	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
share of women inventors	0.030***	0.030***	0.016*	0.016*	0.012	0.012
	(0.006)	(0.006)	(0.009)	(0.009)	(0.015)	(0.015)
team inventive performance	-0.001	-0.001	-0.006	-0.006	-0.006	-0.006
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)
team patenting experience (years)	0.002	0.003	0.002	0.002	0.002	0.002
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
team patenting experience (patents)	-0.005	-0.005	-0.000	-0.000	0.004	0.004
	(0.003)	(0.003)	(0.004)	(0.004)	(0.006)	(0.006)
extent of prior collaboration	0.011***		0.014***		-0.003	
	(0.003)		(0.005)		(0.008)	
technological team diversity	0.037***	0.036***	0.028***	0.027***	0.034***	0.034***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
regional team diversity	0.004	0.004	0.007	0.006	-0.003	-0.003
	(0.003)	(0.003)	(0.004)	(0.004)	(0.009)	(0.009)
star inventive performance	0.004	0.004	0.002	0.002	0.001	0.001
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)
star patenting experience (years)	-0.004	-0.004	0.000	0.000	-0.008*	-0.008*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
star patenting experience (patents)	-0.016***	-0.016***	-0.014***	-0.014***	-0.008	-0.008
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)
star technological diversity	0.028***	0.028***	0.019***	0.019***	0.023***	0.023***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
country dummies	yes	yes	yes	yes	yes	yes
number of patent claims	0.007***	0.007***	0.006***	0.006***	0.003	0.003
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
size of patent family	-0.001	-0.001	0.002	0.002	0.002	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
number of backward citations	0.012***	0.012***	0.010***	0.010***	0.001***	0.001***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.000)	(0.000)
number of patent applicants	0.000	0.000	0.001	0.001	0.006	0.006
	(0.002)	(0.002)	(0.003)	(0.002)	(0.007)	(0.007)
patent filing year dummies	yes	yes	yes	yes	yes	yes
technology class dummies	yes	yes	yes	yes	yes	yes
CEM weights			yes	yes	yes	yes
Constant	0.511***	0.522***	0.558***	0.570***	0.698***	0.697***
	(0.017)	(0.018)	(0.030)	(0.030)	(0.043)	(0.042)
Observations	54,459	54,459	26,793	26,793	26,793	26,793

note: * p < 0.1, ** p < 0.05, *** p < 0.01; standard errors clustered by star inventors in brackets

Models 1a and 1b replicate the main analyses on the full sample. Models 2a and 2b estimate a tobit regression model bound between 0 and 1, the natural limits of the dependent variable. In Model 3a and 3b the dependent variable is based only on non-applicant backward citations.

A3. Appendix to Chapter 3

Appendix 3.1: Descriptive Statistics - Correlation Matrix

Table A3.1 Correlation Matrix

variable name	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
(1) missed shots	1.000																									
(2) shooting time'	0.274	1.000																								
(3) olympics	-0.019	-0.004	1.000																							
(4) woman athlete	0.012	0.231	0.007	1.000																						
(5) favorite	-0.071	-0.123	0.001	0.034	1.000																					
(6) current world cup rank	0.080	0.148	-0.021	-0.091	-0.530	1.000																				
(7) average rank in last five races	0.120	0.180	-0.017	-0.097	-0.586	0.663	1.000																			
(8) starting number	0.046	0.129	-0.013	-0.091	-0.292	0.402	0.402	1.000																		
(9) average missed shots in first shooting of last five races	0.173	0.155	-0.020	0.024	-0.191	0.227	0.398	0.149	1.000																	
(10) average shooting time in first shooting of last five races	0.099	0.519	-0.022	0.316	-0.173	0.205	0.284	0.143	0.306	1.000																
(11) number of professional races in career	-0.076	-0.118	0.048	-0.102	0.230	-0.268	-0.277	-0.172	-0.155	-0.167	1.000															
(12) number of olympic races in career	-0.068	-0.122	0.095	-0.089	0.174	-0.201	-0.212	-0.162	-0.140	-0.173	0.852	1.000														
(13) number of prior world cup races within the same season	0.010	-0.069	0.100	0.012	0.063	-0.161	-0.124	-0.154	-0.038	-0.060	0.099	0.100	1.000													
(14) prior olympic medal in career	-0.051	-0.084	0.008	-0.007	0.279	-0.200	-0.282	-0.126	-0.103	-0.110	0.360	0.374	0.048	1.000												
(15) age at race	-0.047	-0.067	0.048	-0.195	0.099	-0.129	-0.132	-0.073	-0.101	-0.097	0.820	0.698	0.090	0.243	1.000											
(16) number of races at same event	-0.036	-0.109	0.105	0.018	0.126	-0.166	-0.179	-0.273	-0.075	-0.055	0.088	0.083	0.177	0.060	0.037	1.000										
(17) days since last race	0.051	0.114	0.055	-0.018	-0.113	0.152	0.163	0.240	0.058	0.040	-0.063	-0.046	-0.118	-0.046	-0.013	-0.653	1.000									
(18) fast first lap'	0.037	0.011	0.071	0.027	-0.002	-0.009	-0.008	0.010	0.003	-0.003	0.008	0.035	0.218	0.007	0.006	0.024	-0.063	1.000								
(19) home race	-0.004	-0.038	-0.020	-0.003	0.056	-0.052	-0.061	-0.028	-0.031	-0.027	0.000	-0.027	0.019	0.033	-0.007	0.012	-0.010	-0.012	1.000							
(20) number of team members in same race	-0.026	0.003	-0.084	-0.014	0.114	-0.054	-0.130	0.121	-0.036	-0.044	-0.072	-0.145	-0.169	0.052	-0.065	-0.265	0.151	-0.025	0.121	1.000						
(21) average missed shots in first shooting across all starters	0.217	0.258	-0.092	-0.005	-0.055	0.088	0.071	0.147	0.075	0.090	-0.067	-0.090	-0.013	-0.044	-0.031	-0.264	0.294	-0.037	-0.019	0.120	1.000					
(22) discipline: mass start	-0.021	-0.137	0.018	0.013	0.163	-0.205	-0.208	-0.265	-0.075	-0.071	0.101	0.085	0.205	0.079	0.052	0.491	-0.215	0.034	0.037	-0.240	-0.192	1.000				
(23) discipline: pursuit	-0.022	-0.062	-0.010	0.013	0.035	-0.092	-0.075	-0.234	-0.040	-0.019	0.039	0.024	0.059	0.015	0.022	0.401	-0.497	0.019	0.009	-0.189	-0.222	-0.199	1.000			
(24) discipline: sprint	0.039	0.075	-0.052	-0.014	-0.079	0.125	0.139	0.249	0.049	0.050	-0.044	-0.029	-0.082	-0.035	-0.017	-0.504	0.375	-0.069	-0.014	0.243	0.301	-0.296	-0.557	1.000		
(25) disicpline: individual	-0.009	0.092	0.065	-0.008	-0.063	0.102	0.067	0.151	0.041	0.016	-0.066	-0.055	-0.119	-0.033	-0.043	-0.189	0.256	0.042	-0.020	0.089	0.014	-0.152	-0.285	-0.424	1.000	
(26) world championship	0.022	0.022	-0.069	0.005	0.011	-0.021	-0.021	0.003	-0.010	-0.005	0.011	0.013	0.289	0.004	0.017	0.187	0.074	0.066	-0.002	-0.142	0.096	0.050	-0.027	-0.098	0.120	1.000
observations	53,714																									

' detailed information on shooting and course time available as of the 2001/ 2002 season

Appendix 3.2: Robustness Check – Vary Threshold to Identify Favorite Athletes

Table A3.2 Sensitivity of Favorite Identification

	WOMEN	MEN	WOMEN	MEN	WOMEN	MEN
	(1)	(2)	(3)	(4)	(5)	(6)
dependent variable: number of missed shots	POISSON	POISSON	POISSON	POISSON	POISSON	POISSON
independent variables						
olympics	0.986	1.052	0.995	1.045	0.868**	1.019
	(0.043)	(0.047)	(0.047)	(0.050)	(0.055)	(0.065)
favorite (WC rank <= 10)	0.993	1.044				
	(0.027)	(0.028)				
olympics x favorite (WC rank <= 10)	0.759**	0.931				
	(0.087)	(0.106)				
favorite (WC rank <= 20)			1.029	1.002		
			(0.023)	(0.022)		
olympics x favorite (WC rank <= 20)			0.841**	0.985		
			(0.072)	(0.096)		
olympics x current world cup rank					1.002*	1.000
					(0.001)	(0.001)
controls at the athlete level						
current world cup rank	1.000	1.000	1.001*	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average rank in last five races	1.002***	1.002***	1.002***	1.002***	1.002***	1.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
starting number	1.000	1.000	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average missed shots in first shooting of last five races	1.071***	1.044**	1.071***	1.044**	1.071***	1.044**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
number of professional races in career	1.002***	0.999	1.002***	0.999	1.002***	0.999
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
number of olympic races in career	1.002	1.003	1.002	1.003	1.002	1.003
	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)
number of prior world cup races within the same season	0.999	1.005***	0.999	1.005***	0.999	1.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
age at race	1.011	0.949**	1.011	0.949**	1.011	0.949**
	(0.027)	(0.023)	(0.027)	(0.023)	(0.027)	(0.023)
days since last race	1.001	1.001	1.001	1.001	1.001	1.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
home race	0.995	1.088***	0.996	1.088***	0.996	1.088***
	(0.030)	(0.028)	(0.030)	(0.028)	(0.030)	(0.028)
number of team members in same race	1.013*	0.998	1.013*	0.998	1.013*	0.998
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
athlete fixed effects	included	included	included	included	included	included
controls at the race level						
average missed shorts in first shooting across all starters	2.787***	2.899***	2.786***	2.898***	2.787***	2.898***
	(0.096)	(0.103)	(0.096)	(0.103)	(0.096)	(0.103)
discipline: mass start	1.194***	1.224***	1.194***	1.224***	1.195***	1.224***
	(0.040)	(0.041)	(0.040)	(0.041)	(0.040)	(0.041)
disicpline: pursuit	1.126***	1.106***	1.127***	1.106***	1.127***	1.106***
	(0.029)	(0.031)	(0.029)	(0.031)	(0.029)	(0.031)
discipline: sprint	0.988	0.984	0.988	0.984	0.989	0.984
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
discipline: individual	Base	Base	Base	Base	Base	Base
world championship race	1.018	0.957**	1.017	0.958**	1.018	0.958**
	(0.022)	(0.020)	(0.022)	(0.020)	(0.022)	(0.020)
season dummies	included	included	included	included	included	included
observations (athlete-shooting-level)	25,135	28,579	25,135	28,579	25,135	28,579
athletes	197	194	197	194	197	194

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

Appendix 3.3: Robustness Check – Exclude Star Athletes from Analysis

Table A3.3 Exclusion of Star Athletes

	WOMEN	MEN
	(1)	(2)
dependent variable: number of missed shots	POISSON	POISSON
independent variables		
olympics	0.989	1.036
	(0.046)	(0.049)
favorite	0.999	1.029
	(0.027)	(0.028)
olympics x favorite	0.701***	1.045
	(0.091)	(0.118)
controls at the athlete level	included	included
current world cup rank	1.000	1.000
	(0.000)	(0.000)
average rank in last five races	1.002**	1.002***
	(0.001)	(0.001)
starting number	1.000	1.000
	(0.000)	(0.000)
average missed shots in first shooting of last five races	1.076***	1.052***
	(0.019)	(0.019)
number of professional races in career	1.002***	0.999*
	(0.001)	(0.001)
number of olympic races in career	0.999	1.002
	(0.010)	(0.008)
number of prior world cup races within the same season	0.999	1.005***
	(0.002)	(0.002)
age at race	0.999	0.945**
	(0.030)	(0.024)
days since last race	1.001	1.001
	(0.002)	(0.002)
home race	0.971	1.093***
	(0.034)	(0.029)
number of team members in same race	1.006	0.999
	(0.007)	(0.007)
athlete fixed effects	included	included
controls at the race level	included	included
average missed shorts in first shooting across all starters	2.775***	2.817***
	(0.110)	(0.103)
discipline: mass start	1.163***	1.225***
	(0.039)	(0.044)
disicpline: pursuit	1.121***	1.110***
	(0.030)	(0.031)
discipline: sprint	0.989	0.992
	(0.020)	(0.020)
discipline: individual	Base	Base
world championship race	1.000	0.969
	(0.023)	(0.021)
season dummies	included	included
observations (athlete-shooting-level)	21,275	25,878
athletes	179	183

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01;
exponentiated coefficents (IRRs) reported

Appendix 3.4: Robustness Check – Alternative Model Specifications

Table A3.4 Alternative Model Specifications

	WOMEN	MEN	WOMEN	MEN	WOMEN	MEN
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	LOGIT	LOGIT
dependent variable	*missed shots*	*missed shots*	*no mistake (dummy)*	*no mistake (dummy)*	*no mistake (dummy)*	*no mistake (dummy)*
independent variables						
olympics	0.00774	0.0291	-0.00869	-0.0140	0.962	0.939
	(0.034)	(0.036)	(0.019)	(0.021)	(0.087)	(0.082)
favorite	0.0119	0.0350*	0.000428	-0.0178*	1.003	0.922**
	(0.018)	(0.018)	(0.010)	(0.011)	(0.044)	(0.037)
olympics x favorite	-0.124**	0.0368	0.0719*	-0.00349	1.353*	0.986
	(0.060)	(0.070)	(0.042)	(0.040)	(0.219)	(0.154)
controls at the athlete level						
current world cup rank	0.000400	0.000110	-0.0000990	-0.0000763	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
average rank in last five races	0.00210***	0.00234***	-0.000695*	-0.000670*	0.997**	0.997**
	(0.001)	(0.001)	(0.000)	(0.000)	(0.002)	(0.001)
starting number	-0.0000200	-0.000373	-0.000149	0.000107	0.999	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
average missed shots in first shooting of last five races	0.0625***	0.0368**	-0.0234***	-0.0210***	0.901***	0.912***
	(0.015)	(0.015)	(0.008)	(0.008)	(0.031)	(0.030)
number of professional races in career	0.00176***	-0.000243	-0.000667**	0.000456*	0.997***	1.002
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
number of olympic races in career	-0.000451	0.00226	-0.00194	-0.00141	0.992	0.994
	(0.007)	(0.006)	(0.004)	(0.003)	(0.016)	(0.014)
number of prior world cup races within the same season	-0.000438	0.00289**	-0.000168	-0.00108	0.999	0.996
	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)
age at race	0.00745	-0.0278	0.00296	0.00994	1.015	1.038
	(0.022)	(0.018)	(0.013)	(0.010)	(0.051)	(0.048)
days since last race	0.000750	0.00111	-0.000523	-0.000320	0.998	0.998
	(0.002)	(0.001)	(0.001)	(0.001)	(0.004)	(0.003)
home race	0.00242	0.0632***	-0.0160	-0.0429***	0.930	0.833***
	(0.023)	(0.020)	(0.014)	(0.011)	(0.055)	(0.045)
number of team members in same race	0.00935*	-0.00136	-0.00461	-0.000491	0.980	0.998
	(0.006)	(0.005)	(0.003)	(0.003)	(0.013)	(0.013)
athlete fixed effects	included	included	included	included	included	included
controls at the race level						
average missed shorts in first shooting across all starters	0.922***	0.914***	-0.396***	-0.401***	0.166***	0.169***
	(0.031)	(0.029)	(0.014)	(0.015)	(0.011)	(0.012)
discipline: mass start	0.159***	0.188***	-0.0798***	-0.0912***	0.700***	0.665***
	(0.026)	(0.025)	(0.015)	(0.015)	(0.045)	(0.042)
disicpline: pursuit	0.101***	0.0924***	-0.0570***	-0.0440***	0.778***	0.822***
	(0.021)	(0.021)	(0.011)	(0.012)	(0.039)	(0.040)
discipline: sprint	-0.00812	-0.0135	0.00760	0.00578	1.035	1.026
	(0.016)	(0.015)	(0.009)	(0.009)	(0.040)	(0.037)
discipline: individual	Base	Base	Base	Base	Base	Base
world championship race	0.00879	-0.0348**	-0.00120	0.00991	0.999	1.044
	(0.018)	(0.017)	(0.010)	(0.009)	(0.046)	(0.045)
season dummies	included	included	included	included	included	included
constant	0.0160	0.516*	0.697***	0.650***		
	(0.314)	(0.290)	(0.180)	(0.162)		
observations (athlete-shooting-level)	25,135	28,579	25,135	28,579	25,126	28,579
athletes	197	194	197	194	196	194

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; for Models 5 and 6 exponentiated coefficents (IRRs) reported

Appendix 3.5: Robustness Check – Sensitivity to Excluding Single Olympic Events

Table A3.5 Exclusion of Single Olympic Events - Men

	w/o 1998 Season	w/o 2022 Season	w/o 2006 Season	w/o 2010 Season	w/o 2014 Season	w/o 2018 Season
	MEN	MEN	MEN	MEN	MEN	MEN
	(1) POISSON	(2) POISSON	(3) POISSON	(4) POISSON	(5) POISSON	(6) POISSON
dependent variable: missed shots						
independent variables						
olympics	1.030	1.027	1.006	1.026	1.025	1.057
	(0.048)	(0.052)	(0.054)	(0.053)	(0.054)	(0.053)
favorite	1.041	1.034	1.036	1.047*	1.032	1.030
	(0.026)	(0.026)	(0.028)	(0.029)	(0.026)	(0.027)
olympics x favorite	1.048	1.129	1.111	1.019	1.093	0.913
	(0.111)	(0.122)	(0.137)	(0.120)	(0.129)	(0.100)
controls at the athlete level						
current world cup rank	1.000	1.000	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average rank in last five races	1.003***	1.002***	1.002***	1.002***	1.002***	1.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
starting number	1.000	1.000	1.000	0.999*	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average missed shots in first shooting of last five races	1.041**	1.041**	1.041**	1.048***	1.042**	1.039**
	(0.018)	(0.019)	(0.018)	(0.018)	(0.018)	(0.018)
number of professional races in career	0.999*	0.999	0.999*	0.999	0.999*	0.999*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
number of olympic races in career	1.003	1.001	1.003	0.999	1.006	1.005
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
number of prior world cup races within the same season	1.005***	1.005***	1.005***	1.005**	1.005***	1.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
age at race	0.949**	0.950**	0.946**	0.948**	0.952**	0.952**
	(0.023)	(0.024)	(0.023)	(0.024)	(0.024)	(0.023)
days since last race	1.001	1.000	1.001	1.001	1.001	1.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
home race	1.093***	1.095***	1.097***	1.076***	1.089***	1.088***
	(0.028)	(0.028)	(0.029)	(0.028)	(0.028)	(0.027)
number of team members in same race	0.998	1.001	0.997	0.996	0.998	0.998
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
athlete fixed effects	included	included	included	included	included	included
controls at the race level						
average missed shorts in first shooting across all starters	2.898***	2.913***	2.883***	2.918***	2.871***	2.883***
	(0.103)	(0.104)	(0.106)	(0.109)	(0.103)	(0.102)
discipline: mass start	1.222***	1.221***	1.228***	1.221***	1.222***	1.221***
	(0.040)	(0.043)	(0.040)	(0.041)	(0.042)	(0.041)
disicpline: pursuit	1.104***	1.096***	1.110***	1.100***	1.113***	1.102***
	(0.030)	(0.031)	(0.030)	(0.030)	(0.031)	(0.030)
discipline: sprint	0.982	0.981	0.985	0.981	0.988	0.981
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
discipline: individual	Base	Base	Base	Base	Base	Base
world championship race	0.956**	0.959**	0.959**	0.957**	0.958**	0.956**
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
season dummies	included	included	included	included	included	included
observations (athlete-shooting-level)	28,297	27,343	27,226	27,181	27,312	27,507
athletes	194	194	194	194	194	194

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

Table A3.6 Exclusion of Single Olympic Events – Women

	w/o 1998 Season	w/o 2022 Season	w/o 2006 Season	w/o 2010 Season	w/o 2014 Season	w/o 2018 Season
	WOMEN	WOMEN	WOMEN	WOMEN	WOMEN	WOMEN
	(1) POISSON	(2) POISSON	(3) POISSON	(4) POISSON	(5) POISSON	(6) POISSON
dependent variable: missed shots						
independent variables						
olympics	0.999	1.009	0.999	1.021	1.007	0.962
	(0.046)	(0.051)	(0.050)	(0.050)	(0.052)	(0.050)
favorite	1.009	1.006	1.003	1.008	1.003	1.006
	(0.024)	(0.024)	(0.025)	(0.025)	(0.026)	(0.025)
olympics x favorite	0.774**	0.746**	0.763**	0.710***	0.823**	0.835*
	(0.079)	(0.085)	(0.092)	(0.082)	(0.077)	(0.091)
controls at the athlete level						
current world cup rank	1.000	1.001	1.001	1.000	1.001	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average rank in last five races	1.002***	1.002**	1.002**	1.002***	1.002***	1.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
starting number	1.000	1.000	1.000	1.000	1.000	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
average missed shots in first shooting of last five races	1.072***	1.074***	1.073***	1.067***	1.067***	1.069***
	(0.018)	(0.019)	(0.019)	(0.018)	(0.018)	(0.018)
number of professional races in career	1.002***	1.002***	1.002***	1.002***	1.002***	1.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
number of olympic races in career	1.002	1.000	0.998	0.998	1.000	1.003
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)
number of prior world cup races within the same season	0.999	0.999	0.999	0.999	0.999	0.999
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
age at race	1.010	1.015	1.018	1.013	1.014	1.012
	(0.028)	(0.028)	(0.028)	(0.029)	(0.029)	(0.028)
days since last race	1.001	1.001	1.001	1.001	1.001	1.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
home race	0.993	1.001	0.985	1.007	0.994	0.989
	(0.030)	(0.032)	(0.032)	(0.031)	(0.031)	(0.031)
number of team members in same race	1.012*	1.011	1.011	1.015**	1.011	1.013*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
athlete fixed effects	included	included	included	included	included	included
controls at the race level						
average missed shorts in first shooting across all starters	2.792***	2.784***	2.780***	2.796***	2.759***	2.771***
	(0.096)	(0.097)	(0.098)	(0.098)	(0.094)	(0.096)
discipline: mass start	1.196***	1.184***	1.196***	1.194***	1.184***	1.198***
	(0.040)	(0.040)	(0.041)	(0.041)	(0.040)	(0.041)
disicpline: pursuit	1.126***	1.116***	1.127***	1.130***	1.121***	1.124***
	(0.029)	(0.029)	(0.029)	(0.030)	(0.029)	(0.030)
discipline: sprint	0.990	0.987	0.988	0.987	0.986	0.986
	(0.019)	(0.020)	(0.020)	(0.020)	(0.019)	(0.019)
discipline: individual	Base	Base	Base	Base	Base	Base
world championship race	1.014	1.018	1.016	1.019	1.017	1.019
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)
season dummies	included	included	included	included	included	included
observations (athlete-shooting-level)	24,876	24,049	23,904	23,985	23,956	23,942
athletes	197	197	197	197	197	197

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01; exponentiated coefficents (IRRs) reported

Appendix 3.6: Robustness Check – Limit Analysis to only Olympic Seasons

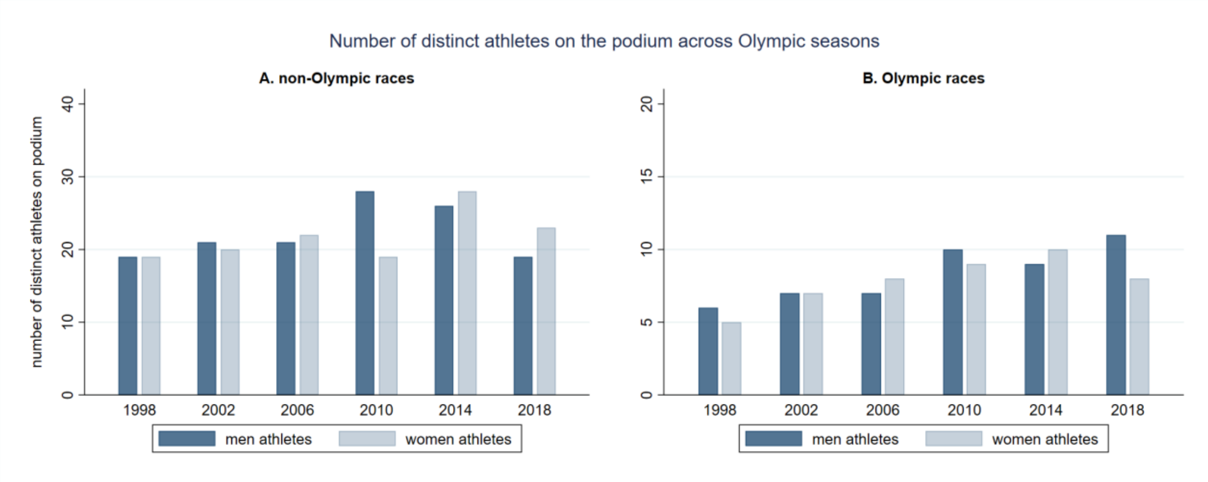
Table A3.7 Limit Analysis to Olympic Seasons

	WOMEN	MEN
	(1)	(2)
dependent variable: number of missed shots	POISSON	POISSON
independent variables		
olympics	0.989	1.051
	(0.047)	(0.054)
favorite	1.035	1.084
	(0.057)	(0.058)
olympics x favorite	0.810*	0.991
	(0.088)	(0.108)
controls at the athlete level	included	included
current world cup rank	1.000	1.000
	(0.001)	(0.000)
average rank in last five races	1.004***	1.002
	(0.002)	(0.001)
starting number	1.000	1.000
	(0.001)	(0.001)
average missed shots in first shooting of last five races	0.964	0.947
	(0.033)	(0.033)
number of professional races in career	1.000	0.999
	(0.001)	(0.001)
number of olympic races in career	1.019	1.001
	(0.019)	(0.015)
number of prior world cup races within the same season	1.005	1.007
	(0.005)	(0.004)
age at race	0.932	0.934
	(0.053)	(0.050)
days since last race	1.002	1.003
	(0.004)	(0.004)
home race	1.027	1.092
	(0.073)	(0.062)
number of team members in same race	1.030**	1.002
	(0.015)	(0.016)
athlete fixed effects	included	included
controls at the race level	included	included
average missed shorts in first shooting across all starters	2.951***	2.978***
	(0.211)	(0.214)
discipline: mass start	1.261***	1.268***
	(0.095)	(0.089)
disicpline: pursuit	1.166***	1.163***
	(0.061)	(0.065)
discipline: sprint	1.010	0.998
	(0.043)	(0.039)
discipline: individual	Base	Base
season dummies	included	included
observations (athlete-shooting-level)	6,097	6,596
athletes	195	188

standard errors clustered by athletes in parantheses; *p < 0.1, ** p < 0.05, *** p < 0.01;
exponentiated coefficents (IRRs) reported

Appendix 3.7: Compare Performance Density between Men's and Women's Biathlon

Figure A3.1 Performance Density in Men's and Women's Biathlon



Appendix 3.8: Heterogenous Effects by Gender and Favorite Athletes on the Full Sample

a) Regression Table

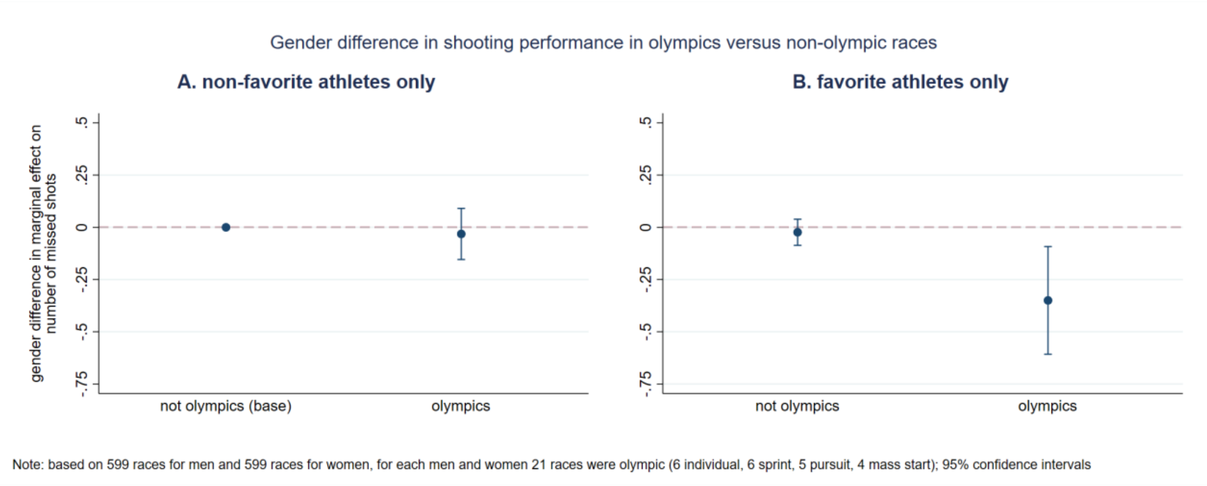
Table A3.8 Analysis of Heterogenous Effect on full Sample

	(1)
dependent variable: number of missed shots	POISSON
independent variables	
olympics	1.030
	(0.047)
favorite	1.037
	(0.025)
olympics x favorite	1.048
	(0.112)
olympics x woman athlete	0.969
	(0.060)
favorite x woman athlete	0.977
	(0.031)
olympics x favorite x woman athlete	0.745**
	(0.110)
controls at the athlete level	included
controls at the race level	included
season dummies	included
observations (athlete-shooting-level)	53,714
athletes	391

standard errors clustered by athletes in parantheses;
*p < 0.1, ** p < 0.05, *** p < 0.01;
exponentiated coefficents (IRRs) reported

b) Plot of Marginal Effects

Figure A3.2 Marginal Effect of Olympics on Performance by Gender and Favorite Athletes



Appendix 3.9: Interview Transcripts

Appendix 3.9a – Interview with Fritz Fischer

Date of the interview	**11.07.2022**
Duration of the interview	**32 minutes**
Interview format	**Mobile phone**
Name of interview partner	**Fritz Fischer (FF) former athlete and coach of DSV**
Name of interviewer	**Leo Schmallenbach (LS)**

Table A3.9 Interview Transcript – Fritz Fischer

LS	Wir haben ein paar Themenblöcke, die würde ich jetzt nacheinander kurz mit ihnen durchgehen. Dann fange ich an, ja?
FF	Ja.
LS	Erster Themenblock. Die Leistungstreiber im Biathlon. Sie waren ja sowohl Athlet als auch Trainer und Funktionär, richtig?
FF	Genau. Also, Athlet und Trainer, ja.
LS	Vielleicht versuchen wir uns jetzt wieder in die Athletensicht zurückzuversetzen. Aber vielleicht haben sie da ja aus Trainerperspektive auch ein paar in-sites. Mit welchem Ziel geht man in ein Biathlonrennen?
FF	Mit welchem Ziel? Man geht immer in ein Rennen, um seine bestmögliche Leistung abzurufen. Ob dies für einen Sieg reicht, ist das eine, aber das andere Thema ist das was man sich erarbeitet hat. Mit dieser Freude, mit dieser Euphorie, mit diesem positiven Gedanken sollte man immer in ein Rennen gehen. Ich habe ja erst mit 18 Jahren mit Sport begonnen. Ich war ja zuvor ein ganz normaler Schlosser, ein normaler Beruf, und habe den Biathlonsport erst über die Bundeswehr mit 18 kennengelernt.
LS	Ah, okay.
FF	Ich habe dann viel gelernt vom Visuellen abschauen. Also ich sage immer, der beste Trainer bist Du selbst. Du brauchst nur gute Trainer oder Betreuer, die dich dahinführen, wo du selbst hin möchtest. Und das effektivste um erfolgreich zu sein ist dein eigener Antrieb, deine eigene ehrliche Einschätzung wie gut die Erstrennen sind und dann von Rennen zu Rennen, von Jahr zu Jahr, über das Training, über das was man lernen will. Das ist der wichtigste Treiber, dass du auch erfolgreich wirst.
LS	Und setzt man sich als Ziel eher eine Position, eine Zeit? Also wie genau definiert man das?
FF	Das kann man ganz schlecht definieren, denn wenn man sagt, dass man es über Zeit definiert, dann ist das ja vom Schnee abhängig, vom Ski abhängig. Man kennt die Stärken der Gegner, wenn es jetzt erfolgreiche gibt. Man kennt seine Stärken, aber auch Schwächen. Und man muss einfach in jedem Rennen das versuchen. Ich kann jetzt nicht irgendetwas erwarten, was ich noch nicht trainiert habe, dann geht es eher um Glück. Aktuelles Beispiel: Gestern Djokovic-Finale, Tennis, Wimbledon. Das ist erarbeitet. Über Jahre hinweg hat der gegen so einen Typen wie Kyrgios gewonnen, weil er sich einfach auf seine Stärken verlassen hat. Und das ist einfach das entscheidende, um erfolgreicher Biathlet zu werden.
LS	Okay, also eher auf sich selbst fokussiert als im Vergleich. Man fokussiert sich auf sich selbst und ignoriert eigentlich die anderen?
FF	Das ist entscheidend. Ich kann nicht warten, bis die Gegner Fehler machen, sondern ich muss schauen, dass ich mich mit meiner eigenen Stärke im Endeffekt erfolgreich durchsetze. Das wird oft ein bisschen verkannt.
LS	Ja. Gibt es Unterschiede zwischen den Disziplinen? Also sagt man in der einen Disziplin, da setzt man sich das Ziel, dass man mehr aufs Schießen fokussiert ist und in der anderen eher aufs Laufen?
FF	Im Sprint ist zum Beispiel der Fokus eher aufs Laufen, denn man kann, wenn man ein sehr, sehr guter Läufer ist eine Runde rauslaufen. Oft sind die Top-Schützen nicht die besten Läufer. Das war damals auch bei der Magdalena Neuner oder beim Beni am Anfang so. Gute, gute Läufer haben eher den Fokus auf das schnelle Laufen. Also der Körper ist eher darauf trainiert sich richtig voll „auszukotzen“ mit der Gefahr, dass man mehr Fehler schießt. Gute Sportschützen sind eher ruhige Leute, besonnene Leute und die Kombination, die es später hat - zum Beispiel Martin Fourcade, der über das schnelle Laufen zum Schluss dann auch gemerkt hat, wie wichtig das Treffen ist. Und diese Komponente Laufen/Schießen, das ist das was du dir ja immer wieder täglich neu erarbeiten musst und du dich weiterentwickelst. Die Eigenreflektion beim täglichen Training bis hin zum Wettkampf ist immer das Wichtigste und die ehrliche Einschätzung.
LS	Also das war jetzt die Disziplin. Gibt es unterschiedliche Zielsetzungen je nachdem, ob das Rennen ein Weltcup- oder ein WM- oder ein Olympia-Rennen ist?
FF	Da ist nur der Unterschied, dass es nervlich von den Medien her anders angesetzt ist. Ich kann hier ein Beispiel aus eigener Erfahrung geben: Wenn Du in der Früh nicht richtig angespannt bist. Ich sage immer, ich war oft so nervös, dass es mich beim Zähne putzen nach dem Frühstück immer so ein bisschen gewürgt hat, weil ich so aufgeregt war. Das waren aber meine besten Rennen. Wenn ich so gedacht habe, das ist nur die Deutsche Meisterschaft, also so ein bisschen leichtfertig rein bin in das Rennen, dann geht ja oft der Schuss nach hinten los. Und bei Olympia wollen die Leute das ja oft zu genau machen. Und das ist dann das Problem, dass das dann auch wieder nicht funktioniert. Also, wenn ich in einem Rennen starte, will ich auch aus dem Rennen das bestmögliche rausholen. Natürlich gibt es Fälle, wo ich etwas probieren kann als Topathlet, mal aggressiver laufen, mal bisschen schlechter schießen. Aber man merkt schnell, wenn man das macht, muss man [Verbindung bricht ab]. Jetzt sind wir unterbrochen worden.
LS	Ja, da sind wir unterbrochen worden. Ich fasse mal zusammen, was bei mir noch angekommen ist. Dass die Rennen, wo morgens die Anspannung da ist, dass die in der Regel ein bisschen besser laufen. Aber wenn man es übertreibt, wenn man zu angespannt ist, dann kann es auch nach hinten los gehen.
FF	Ja genau.
LS	Und bei Olympia, das war so eine Situation, in der man extrem angespannt ist?
FF	Ja, oder eine Freude, so wie es bei mir damals war als wir mit der Staffel Olympia-Sieger wurden. Diese Freude dabei zu sein, sich zeigen zu dürfen bei olympischen Spielen. Natürlich angespannt, aber auch im hintersten Bauchgefühl diese Freude, das zeigen zu dürfen, dann am Biathlon-Schießstand. Das ist etwas, was bei Olympia wahnsinnig wichtig ist. Nicht nur sagen „Olympia um Gotteswillen hoffentlich gewinne ich was“, sondern sich des Stellenwerts dieses Wettkampfes wohl bewusst zu sein. Also auch wieder das Glas ist

	halb voll, nicht halb leer, also wieder der positive Gedanke. Das hört sich immer leicht an, aber so sollte man reingehen. Endlich bin ich bei Olympia dabei, endlich kann ich denen allen zeigen was ich kann. Und so funktioniert es auch meistens.
LS	Und wie vergleicht sich vom Stellenwert Olympia mit einer Weltmeisterschaft?
FF	Olympia ist alle 4 Jahre und Biathlon-Weltmeisterschaft jedes Jahr. Also kann man das gar nicht so vergleichen, da Olympia in der Form über allem steht. Natürlich, als ich damals den Gesamtweltcup gewonnen habe oder 3 Jahre lang hintereinander unter den ersten drei war, da weiß man, dass man persönlich einfach zu den Besten gehört und das ist auch für einem persönlich viel mehr Wertschätzung. Aber von den Medien her, vom Drumrum her steht halt eine olympische Goldmedaille über allem, schon von der Marketinggeschichte her.
LS	Also sagen wir mal Olympia steht über allem und dann kommt die WM und dann kommt der Weltcup, so ein bisschen?
FF	Nein. Erst Olympia, dann Gesamtweltcup und dann Weltmeisterschaft – würde ich persönlich sagen.
LS	Okay. Wenn man den gesamten Weltcup betrachtet. Aber, wenn man jetzt auf ein einzelnes Rennen schauen würde, dann wäre das …..
FF	Nein, Weltcupsiege gibt es viele. Da gibt es einen Haufen Weltcupsieger. Erst Olympia, dann Gesamtweltcupsieger, dann Weltmeisterschaften und dann Weltcupsiege.
LS	Ah ja, okay. Sehr gut. Und wenn wir jetzt an ein einzelnes Rennen denken, was hat ihrer Meinung nach den größten Einfluss auf die Motivation?
FF	Das ist eine gute Frage. Den größten Einfluss auf die Motivation können Freunde, Familie, Mamas, Papas haben, können super Bedingungen haben, können super Schnee, das ist mein Schnee, können Zuschauer haben. Da gibt es viele, viele Faktoren. Das empfindet jeder Sportler anders.
LS	Okay.
FF	Meine größte Motivation war einfach das zu zeigen – als Beispiel – früher, wenn ich Biathlon gestartet bin, waren es hundert Zuschauer. Zum Schluss war meine Motivation: Biathlon hat es fast geschafft wie Fußball mit VIP-Gästen, mit VIP-Zelten. Also die öffentliche Darstellung meiner Sportart war für mich sehr viel Motivation. Da ein Teil davon zu sein. Das empfindet jeder anders. Aber mit dem Unterschied auch wieder, dass du dementsprechend liefern musst. Was wir gebrochen haben an Erfolgen, an Titeln, an Goldmedaillen, daran wird jetzt die neue Generation mit Simon, mit Benni zum Beispiel bei der aktuellen Weltmeisterschaft, gemessen. Denn Deutschland war ja früher immer sehr, sehr erfolgreich und das muss den Athleten heute bewusst werden. Man kann nicht immer gewinnen, aber die Erwartungshaltung Beispiel FC Bayern, Beispiel Dortmund. Das muss man als Biathlet wissen, wenn man dieses Spiel mitspielen will.
LS	Und welchen Einfluss hat wiederum die Motivation dann auf die eigene Leistung?
FF	Das entscheidende ist, wenn du nicht motiviert bist. Zum Beispiel, wenn ich einen Jagdhund auf die Jagd tragen muss, dann ist es kein Jagdhund.
LS	Sehr gutes Beispiel. Ja, verstanden.
FF	Also wenn du nicht motiviert bist mit mir ein Forschungsprojekt zu machen, nachzuforschen, nachzurecherchieren, wird das keine gutes Forschungsprojekt. Da kannst du machen was du willst. Und das ist was viele Sportler nicht können. Viele Sportler machen den Fehler und sagen „Ja Trainer was soll ich tun?“ Das Gegenteil ist, der Trainer muss den Sportler fordern, was willst du machen, an was arbeiten wir denn, wo willst du dich verbessern?
LS	Ja.
FF	Du weißt, du bist läuferisch eine Minute zurück, du schießt immer wieder Fehler. Was müssen wir am Training neu ändern als Team? Das zeigen uns die Topathleten doch immer

	wieder auf. Die haben ein eigenes Ziel im Team oft. Und wenn das nicht funktioniert und die eigene Motivation, der eigene Drang nicht funktioniert, dann kennst du‘s schon vergessen.
LS	Und wenn man jetzt zwischen den zwei Fähigkeiten unterscheidet Laufen und Schießen, was würden sie sagen beeinflusst die Laufleistung am meisten?
FF	Wenn du das Rad überdrehst auf der Strecke dann funktioniert es am Schießstand nicht. Wenn du zu verhalten losläufst, also bei der Laufleistung nicht ausreizt was du kannst, weil du dich nicht vorbereitet hast auf den Wettkampf, dann leidet die Schießleistung darunter. Und das ist eben das Thema. Der Wind spielt natürliche eine riesengroße Rolle. Jetzt nicht bei der Laufleistung. Bei der Laufleistung ist es der Ski, Schnee, Skischliff, Wachs. Das Hauptthema ist hier, wie gut arbeitet dein Serviceteam.
LS	Und so was wie Training und Vorbereitung, das ist auch sehr wichtig fürs Laufen, ja?
FF	Ja, das ist ja das mit entscheidende. Ich glaube, wenn man da meint man macht zu wenig oder man überdreht, man trainiert zu viel, zu hart. Man meint man will was aufholen, macht nicht die nötigen Ruhephasen, reflektiert nicht sein Training. Als Beispiel, ich kann 20 Kilometer laufen. Der Trainer hat gesagt, ich soll 20 Kilometer laufen. Und ein guter Athlet, der läuft halt die 20 Kilometer bewusst beim lockeren Training. Wie war mein Beinabdruck, wie war mein Stockeinsatz, wie war mein Gleitgefühl? Also wie ein Formel-1-Fahrer. Der fährt mit dem Auto und horcht rein, was macht der Motor, was machen die Reifen. Was macht der Tennisspieler, wenn er die Vorhand trainiert, zieht er den Top Spin, wie auch immer? Das sind so Beispiele. Wobei es im Ausdauersport heißt, speziell im Langlaufbereich, ja wir laufen halt mal. Für mich ist die Frage: Wie laufe ich das im Training? Das kann die Laufleistung sehr beeinflussen. Du kannst 1000 Kilometer mehr laufen, aber unterm Strich, fehlt dir die nötige Technik, hast du dann im Wettkampf gegen einen guten technischen Läufer keine Chance.
LS	Und beim Schießen, was ist da der größte Einflussfaktor? Sie haben eben schon einmal Wind genannt.
FF	Der Wind, ja.
LS	Was ist noch beim Athleten? Was kann der Athlet machen, um gut zu schießen?
FF	Das der Athlet spüren muss, wo er den Fehler hin schießt. War der Anschlag zu schwach, war der Liegendanschlag, der Liegendriemen zu leicht eingestellt, hat sich das um ein, zwei Millimeter verstellt? Also wer das nicht macht, da sind wir wieder bei der Eigenreflektion, wenn du nicht spürst, dass du den Fehler immer rechts wegschießt oder der Druckpunkt hinten auf der Schulter nicht da ist, dass du hinten einen Zentimeter verlängern musst, bist du wieder schlechter. Der Trainer in der Außenstellung sieht das nicht, das spürt nur der Athlet.
LS	Und welche Rolle spielt die Zeit, die man sich nimmt am Schießstand?
FF	Treffen geht immer vor Zeit. Und wenn man das nicht trainieren kann, ich war auch immer so ein Typ, wenn ich jetzt meine Schießzeiten bedenke, 1991. Als Olympiasieger 1992 habe ich Schießstandzeiten von 6 Sekunden gehabt in der Staffel, da schießen sie heute auch nicht schneller.
LS	Bis zum ersten Schuss sind das 6 Sekunden, oder was?
FF	Nein, das waren die 5 Schuss. So schnell schießen sie heute nicht. Wenn ich mir das anschaue, erster bis letzter Schuss in der Reihenfolge waren es 5,8 Sekunden für 5 Schuss.
LS	Das ist ja extrem schnell.
FF	Ja, das ist extrem schnell. Aber das hat mir keiner gesagt, das habe ich mir selber, der Charakter, durchgezogen. Fakt ist, man muss wissen, wann man das macht. Aber in der jetzigen Biathlongeneration kommen sie immer schneller zum ersten Schuss und da ist die Gefahr, dass dann der zweite, dritte wegkommt. Wenn ich das merke beim Athleten, dann würde ich sagen mach lieber 2 Sekunden länger bis zum ersten Schuss, dann wird es mal 18

	Sekunden und dann schieß in einem bewussten Rhythmus von 2 Sekunden. Dann gehst du halt nicht mit 25 Sekunden weg vom Schießstand, sondern mit 28. Diese 3 Sekunden würde ich immer bevorzugen, um einen guten Treffer, um einen bewussten Treffer zu setzen. Und wenn ich ein Risiko gehen will, habe ich das Risiko auch dementsprechend trainiert und sage okay, wenn ich das nicht kann, dann darf ich es nicht probieren, denn dann ist es ein Lottospiel. Und die guten Athleten können das.
LS	Und Risiko bedeutet in der Regel schnell?
FF	Risiko bedeutet schnell. Wenn ich weiß Risiko. Ich stehe am Schießstand azf Platz 4, vor mir stehen die 3 Medaillen und ich habe das auch im Training schon immer mal wieder durchgespielt, dann gehe ich das Risiko. Wobei ich persönlich das immer wieder gemacht habe. Ich habe mich durch mein eigenes Selbstvertrauen, denn ich kann ja schnell schießen, denn das muss ich ja vorbereiten, dann ziehe ich das durch. Wenn ich das Risiko gehe und habe die Emotion dabei, die positive, dann ziehe ich das durch und dann funktioniert das auch meistens. Und dann überhole ich und habe die Chance eine Medaille zu gewinnen. Und wenn ich auf Platz 7 stehe, kann ich vielleicht spektakulär schnell schießen, aber es bringt nichts. Du musst immer wissen wann mache ich das.
LS	Okay.
FF	Aber das muss vorbereitet sein, das musst du schon trainiert haben. Jetzt nicht sagen, jetzt mache ich irgendwas. Warum nehme ich mit dem Auto die Kurve schneller? Anstatt mit 100 mit 120 und dann fliegt das Auto raus, so als Beispiel. Ah, das war halt Risiko. Also das muss auch schon kalkulierbar sein. Oder als Beispiel Klettern wie bei der *Dahlmeier* damals. Die geht kein Risiko in der 1000 Meter Wand ein, denn dann stürzt sie ab. Also es heißt immer Risiko musst du auch schon mal für dich persönlich im Training so probiert haben. Wenn ich es brauche, dann setze ich es ein.
LS	Okay. Und gibt es auch so was wie die optimale Zeit, die man sich am Schießstand nimmt? Gibt es auch zu langsam?
FF	Es gibt auch zu langsam. Viele machen den Fehler, die machen es dann zu genau, die wollen dann zu genau schießen. Da sind auch viele da. Aber das sind alles Trainingssachen. Da sind wir wieder bei dem Thema Trainer, Sportler. Alle Varianten, die man sich als guter Biathlet anschaut, wo man auch die Daten dazu hat, musst du im Training durchspielen. Wenn ich zu langsam schieße und merke ich kann es viel, viel besser, und auch dieses Selbstvertrauen habe, dann muss ich einfach schneller schießen. Schneller schießen heißt ja nicht das ich ungenau bin. Und das ist ja diese Reflektion, mit der sich viele Athleten aus meiner Sicht zu wenig auseinandersetzen. Einfach mal probieren, selbst mal probieren. Dass der Trainer sagt, super du stehst doch zu dem, mach doch das. Geh‘ mal aggressiver an, das stehst du doch durch. Also das Risiko, diese Bereitschaft sich da an die Grenze zu wagen wie deine Konkurrenz zum Beispiel. Das ist das, was man permanent üben muss.
LS	Okay verstanden. Dann der nächste Themenblock. Das ist Feedback über die eigene Leistung. Und zwar besonderer Fokus während des Rennens. Können Sie mir kurz erklären, welche Informationen man als Athlet während des Rennens über seine eigene Leistung bekommt und wahrnimmt.
FF	Das entscheidende sind die Schießbilder, wenn ich an der Strecke stehe und der Mark Kirchner hat mir ausgefunkt, die Fehler waren rechts oder links oder waren Randtreffer. Da kriegst du Information von mir an der Strecke, damit du deine Leistung einschätzt, waren das glückliche Treffer, war da Wind, damit du reflektierst. Oder du bekommst eine Zeit. Nach einem Kilometer Angangszeit sage ich dir du bist 10 Sekunden hinter Platz 1, damit du deine eigene Leistung einschätzt. Du meinst zwar, du bist schnell gelaufen, hast aber trotzdem einen Rückstand von 10, 15 Sekunden. Oder du bist es taktisch so angegangen, dass du weißt, okay ich gehe es ein bisschen verhalten an im Rennen mit meiner Leistung, dass hole ich dann hinten wieder raus.
LS	Gibt es da auch Unterschiede zwischen den Disziplinen? Dass man da in anderen Disziplinen je nachdem andere Informationen weitergibt?
FF	Ja, beim Einzelwettkampf zum Beispiel hören wir immer wieder vom Arnd Peiffer auch, der wollte gar keine Zeit haben, sondern der wollte nur das Rennen laufen. Erst auf der Schlussrunde dann die Zeit und auf welchem Platz du bist, sonst machst du dich eh nur verrückt.
LS	Ja.
FF	Und ich glaube, jeder Athlet im Weltcup kann gut einschätzen, wie schnell er selbst unterwegs ist. Denn, wenn wir beide jetzt laufen und du holst mich ein bis zum ersten Liegenschießen oder bis zum zweiten, dann weiß ich, ich bin eine halbe Minute langsamer gelaufen. Also die guten Athleten können schon gut einschätzen, wie sie unterwegs sind.
LS	Und die Abstände aber in der Regel nach vorne? Seltener, dass man sagt hinter dir kommt einer, der ist so und so viel Sekunden hintendran, sondern so und so viel nach vorne?
FF	Nein, nein. Man kann auch schon nach hinten fokussieren. Zum Beispiel, wenn man sagt, okay, du bist auf Platz 3, gerade beim Verfolgungswettkampf, aber 10 Sekunden hinter dir kommt ein schneller Läufer. Damit du auch weißt was kommt hinter dir, wenn du meinst, ja ich bummle da so ein bisschen rum. Das ist immer so ein taktisches Spielchen und auch das Zusammenspiel Trainer, Sportler und Betreuer ist da sehr wichtig.
LS	Und haben sie da auch schon einmal geflunkert?
FF	Na klar. Klar, wenn du jetzt vorn wärst und ich sehe du kommst ein bisschen müde daher, dann sage ich okay, du bist 2 Sekunden auf Platz 1, jetzt sind es aber 10 Sekunden, dann locke ich da schon ein wenig Emotion raus.
LS	Okay, so was hat auch die Andrea Henkel angedeutet.
FF	Ja, das gehört dazu.
LS	Da meinte sie, das macht man einmal mit ihr und dann nie wieder, wenn sie es rauskriegt. Sie wollte das immer genau wissen.
FF	Ja, ist schon klar.
LS	Und wenn sie dann diese Information durchgeben oder auch bekommen haben als Athlet, was glauben sie hat das mit ihnen gemacht?
FF	Es kann enttäuschend sein, dass man meint man ist besser und ist schlechter. Das ist eher das negative.
LS	Und dann würde man auch weiter schlechter werden, da kommt man in so eine Spirale?
FF	Da kann man sich so reinziehen, ja. Also alles was passiert auf der Strecke immer mit positivem Aspekt. Wenn man schlechter ist, sagen wir mal du hast jetzt 20 Sekunden Rückstand, dann würden sie zu dir sagen das sind nur 10 Sekunden. Also wenn dir einer sagt erste Runde im Einzelwettkampf hast du 50 Sekunden Rückstand, uff, dann fällst du schon mal runter. Also da ist immer dieser Grad, da ist jede Situation neu und jede Situation muss man da wirklich neu reflektieren. Vor allem welcher Sportler, welches Wetter, das macht einen guten Trainer aus. Das Fingerspitzengefühl was sage ich meinem Athleten. Ich habe das immer so gemacht, dass ich den Athleten dann Techniktipps gegeben habe, zum Beispiel pass auf den Beinabdruck auf, pass auf den Stockdruck auf. Mit dieser Information kann ein Sportler was anfangen. Da denkt er nicht an die Zeit oder an die körperliche Verfassung, sondern kriegt Information in seinen Körper hineinzuhorchen oder beim Schießen sich halt bei dem letzten Schuss besser auf die Windfahne zu fokussieren. Also immer Gedanken geben, womit der Sportler etwas Positives verbinden kann.

LS	Und sie haben eben angedeutet, dass diese Vergleichszeiten vor allem oder relativ zu anderen Athleten durchgegeben werden. Wie haben sie die relevante Vergleichsgruppe ausgewählt? Also mit wem vergleicht man dann die Leistung der Athleten im Wettbewerb?
FF	Ja immer mit den besseren. Ich schaue nach vorne. Oder, wenn man gewisse Leute ja kennt, wo man sagt man ist gleich gut wie ein Franzose oder wie Österreicher oder ein Norweger. Man kennt sich ja untereinander und dann muss man immer den Bezug haben sich nach vorne zu verbessern, nicht nach hinten schauen, sondern immer die Flucht nach vorne.
LS	Und sind die verschiedenen Nationen gleich gut informiert? Also weiß ein Franzose genauso Bescheid wie er im Rennen liegt wie ein Deutscher oder gibt es da Unterschiede zwischen den Nationen?
FF	Die Top-Nationen sind alle gleich gut informiert.
LS	Okay, weil sie dieselbe Anzahl an Betreuern haben?
FF	Ja, ja. Die Top-Nationen sind alle gleich.
LS	Okay. Aber bei denen die weniger gut ausgestattet sind, keine Ahnung ….
FF	Neuseeland hat einen Mann dabei und eine Frau. Der hat keinen auf der Strecke, aber da wird natürlich auch untereinander geholfen unter den Nationen. Die schwachen Nationen tun sich zusammen, helfen zusammen, also da ist Biathlon eine sehr große Familie.
LS	Sehr gut. – Bei dem nächsten Thema geht es so ein bisschen um die Rahmenbedingungen, Regularien. Gibt es Regeln an welcher Stelle man während des Rennens informiert werden darf? Also dürfen Betreuer nur an bestimmten Stellen stehen?
FF	Ja. Es gibt ausgewiesene Coachingzonen.
LS	Okay.
FF	Du darfst 20 oder 30 Meter mitlaufen, das ist auf der Strecke abgesteckt.
LS	Ich glaube sie sind der Interviewpartner, der am längsten dabei ist. Was mich besonders interessiert ist dieses zufällige Zulosen der Startnummer im Sprint und Einzel. Ist das eine Regel, die es immer schon gab, also das die gelost wurde innerhalb der Startgruppe?
FF	Das ist eine gute Frage. Ja, ja, ich glaube die wurde immer schon gelost.
LS	Okay.
FF	Also Massenstart ist nach Weltrangliste, aber alles andere ist immer schon zugelost worden in den unterschiedlichen Gruppen. Es wurde in 4 Gruppen geteilt und dann ist ausgelost worden.
LS	Und in diesen Rennen, wo gelost wurde, waren Sie jemand der lieber früher oder später gestartet ist?
FF	Man kriegt ja die Chance, wenn man als Athlet weiß, dass wenn es in der Nacht kalt ist und es dann warm wird, ist man immer in die erste Gruppe gegangen, um die Chance auf die Startnummer eins oder zwei zu bekommen. Und in den klassischen Wettkämpfen früher war es besser man ist hinten gelaufen, da die klassische Spur besser eingeschliffen war.
LS	Ah, okay.
FF	Also klassisch war es anders. Aber mittlerweile ist es so, dass man bei den Gruppen vom Wetter her sehr schaut, dass man beim Skaten eher vorne laufen kann, damit die Strecke nicht so tief ist.
LS	Okay. Also eher die Bedingungen im Hinterkopf behalten. Oder welche Rolle spielt es, dass wenn man früh startet auch relativ wenig weiß über die Konkurrenz?
FF	Es gibt Typen, die laufen immer vorneweg. Damit sie keinen Druck haben, wenn sie gut schießen. Das ist auch ein bisschen typbedingt. Aber man richtet sich eher nach den Schnee- und Wetterverhältnissen.
LS	Glauben sie, wenn sie sich jetzt in die erste Startgruppe gewählt haben und dann nach vorne gelost werden, dass das einen anderen Einfluss auf ihre Leistung hat, als wenn sie in

	derselben Startgruppe eher hinten starten würden? Jetzt mal angenommen die Bedingungen bleiben gleich.
FF	Das ist typbedingt. Mir wäre das wurscht.
LS	Okay.
FF	Gibt Typen die sagen, ich bin weg dann hab‘ ich es hinter mir. Dann gibt es Typen, die machen eher Schlussläufer. Ich hatte keinen Stress, dass ich eine Stunde warten muss, bis ich starte. Du musst auch die Zeit überbrücken nach dem Anschießen. Manche Sportler wollen lieber früher weglaufen und andere können mit der ganzen Zeit nichts anfangen, haben dann eher Stress und werden immer nervöser. Also das sind sehr, sehr individuelle Charaktere, immer so ausgedacht, dass du erfolgreich den Wettkampf abrufen kannst.
LS	Haben sie da irgendwelche Muster erkannt in den Eigenschaften bei denen die lieber früher starten und denen, die immer später starten?
FF	Nein, eigentlich nicht.
LS	Das ist nicht so, dass die, die mehr Erfahrung haben zum Beispiel immer früher starten möchten?
FF	Nein, kann man nicht sagen. Ein guter Athlet pickt sich das heraus, was für ihn am besten ist. Und da gehört immer ein guter Schnee, eine gute Piste dazu und das ist Priorität Nummer eins, als wenn ich sage ich laufe lieber als erster weg, dann habe ich den Druck nicht. Also es geht immer um die Verhältnisse wie gut ist mein Ski, habe ich einen Ski der besser geht bei Kälte oder einen Ski der besser geht, wenn es warm ist. Also ein guter Athlet macht das immer so, dass er das bestmögliche herausholt, ob er die Startnummer eins ist oder die letzte Nummer. Das ist einem guten Athleten einfach wurscht.
LS	Haben sie da Unterschiede zwischen Männern und Frauen festgestellt?
FF	Die Frauen sind wahrscheinlich eher etwas übervorsichtig. Wobei Uschi Disl, als Beispiel, der war wurscht, welcher Ski. Die hat zum Trainer gesagt, leg‘ mir den Ski an den Start, ich zieh ihn an und habe das Vertrauen.
LS	Okay. Gibt es sonst irgendwelche Unterschiede zwischen Männern und Frauen im Biathlonsport, die ihnen über die Jahre aufgefallen sind?
FF	Nein. Gerade durch das Damenbiathlon ist die Sportart in Deutschland ja noch populärer geworden. Denn wenn die Männer schwach und die Frauen gut waren, oder auch umgedreht, dann heißt es die deutschen Biathleten. Und ich glaube die Frauen sind auch mittlerweile sehr gut oder über das Thema Frauen wird gar nicht mehr gesprochen, denn die machen einen super Job, schießen gut, laufen schnell, also da gibt es keinen Unterschied mehr und das tut allgemein dieser Sportart gut. Das ist auch wie aktuell im Damenfußball, wo sie sich langsam rantasten. Ich glaube man muss das respektieren. Ich sage immer, was wären wir Männer ohne die Frauen.
LS	Ja, ja. Da bin ich 100%ig bei ihnen. Ich schaue mir wirklich sowohl die Männer- und Frauenrennen gleich gern an. Da gibt es gar keine Unterschiede. Ich meine eher, ob sie Unterschiede festgestellt haben, wie die Athleten ans Rennen gehen. Oder ob sie anders in Drucksituationen reagieren?
FF	Ich glaube es gibt manche Frauen, die sind sehr genau, sehr penibel, aber das gibt es bei den Männern auch. Also ich würde jetzt nicht sagen, dass es da einen pauschalen Unterschied gibt.
LS	Okay.
FF	Wie Waffe ist gleich schwer, die Ski sind ein bisschen kürzer, von den Regeln her ist alles gleich. Von daher gibt es auch keinen Unterschied in der Form. Dass es menschlich immer wieder Unterschiede gibt, das ist klar. Aber so im Allgemeinen würde ich sagen nicht, das

	hat sich ziemlich angeglichen. Vielleicht sehen das manche Trainer oder Sportler anders, aber ich persönlich sehe da jetzt nicht viel Unterschied.
LS	Okay. Sie hatten ja mal angedeutet, dass die Frauen ….
FF	Vielleicht modisch ein bisschen, dass die Frauen mal die Fingernägel beim Schießen lackiert haben oder ein bisschen geschminkt sind, das fällt vielleicht auf. Aber das ist sowieso eher bei den Frauen, dass sie sich eher schminken wie die Männer.
LS	Wer weiß. Und Sie hatten eben mal kurz angedeutet, dass die Frauen vielleicht ein Ticken vorsichtiger sind.
FF	Nein, das ist typbedingt. Es gibt manche Frauen, die fahren Abfahrtslauf, die pfeifen runter und es gibt andere, die Schwingen eher ab. Also ich glaube, das kann man nicht sagen.
LS	Was beide Damen, mit denen ich gesprochen habe, gesagt haben, und auch die Männer, dass auf der ersten Runde im Massenstart, dass da bei den Frauen selbst die, die an dreißig gesetzt sind, versuchen ganz nach vorne zu laufen und sich da irgendwie durchzuwurschteln. Da wäre auf der ersten Runde riesiges Chaos, während des bei den Männern da deutlich normaler oder strukturierter ablaufen würde.
FF	Das stimmt. Das kann es schon geben, denn manche, die hinten sind, meinen sie müssen da vorne was gut machen. Das heißt aber, die sind taktisch schlecht eingestellt, denn es bringt ja nichts. Das bringt ja gar nichts. Also ist das ein Thema oder auch eine Trainingsfrage, dass man die Athleten so vorbereitet. Aber manche wollen vielleicht und meinen sie machen was gut, aber das macht keinen Sinn. Macht gar keinen Sinn.
LS	Super, danke für Ihre Zeit und die Erklärungen. Ich beende jetzt die Aufnahme.

Appendix 3.9b – Interview with Benedikt Doll

Date of the interview	**28.02.2022**
Duration of the interview	**30 minutes**
Interview format	**Video call (Zoom)**
Name of interview partner	**Benedikt Doll (BD) – active athlete of DSV**
Name of interviewer	**Leo Schmallenbach (LS)**

Table A3.10 Interview Transcript – Benedikt Doll

LS	Erster Themenblock: „Leistungstreiber im Biathlon“. Hier interessiert mich mit welchem Ziel du in dein Rennen gehst.
BD	Was sind grundlegende Leistungstreiber? Man macht es schon mit dem Hintergrund der Anerkennung. Ich glaube, da ist schon so ein bisschen Erfolg zu haben, da die Anerkennung zu erhalten. Das ist ein Antreiber. Der andere Antreiber ist natürlich, selbst sich beweisen zu wollen oder selbst sich zu sagen, ich trainiere dafür, ich investiere da was und will dann jetzt zeigen, dass ich es draufhabe. Also hier so ein bisschen der Faktor „Ego“. Und der dritte Faktor ist sicherlich auch, damit seinen Lebensunterhalt zu bestreiten, also auch etwas zu verdienen. Ich glaube, das sind so für mich die Hauptgründe.
LS	Okay. Also ich meinte jetzt speziell auch, wenn du in ein Rennen gehst. Setzt du dir ein bestimmtes Ziel was die Platzierungen angeht oder eher was die Zeit angeht?
BD	Mal so, mal so. Es hängt so ein bisschen davon ab, wie die aktuelle Situation ist. Manchmal ist es so, dass, wenn alles gut läuft, alles zusammenpasst, dann sagt man schon okay ich will da vorne mitkämpfen. Aber das sind dann eigentlich meistens bei mir so Erfahrungswerte. Also ich weiß ich kann vorne mitkämpfen, wenn ich alles gut hinkriege. Aber ab und zu gibt es halt mal Tage, da habe ich so technische Probleme. Da kriege ich es mit dem Schießen nicht so stabil hin, habe da eine Unsicherheit im Schießen. Dann sage ich mir bewusst: „Okay heute ist mir egal was am Ende rauskommt, ich will gut schießen“. Und wenn man dann natürlich gut schießt, dann weiß man auch schon, dass da eine gute Platzierung rauskommt. Aber man legt den Fokus – man sagt jetzt nicht Vollgas laufen – sondern man sagt ich leg‘ den Fokus mal eher auf den Schießstand, lass mir vielleicht 2, 3 Sekunden mehr Zeit zum Anlaufen, um dann am Schießstand auf dies und das, was man sich vornimmt, zu achten. Also manchmal sind es technische Elemente und manchmal sind es einfach Sachen, okay mal gucken, ob heute alles aufgeht. Also so ein bisschen dieses Risikobedachte.
LS	So wie ich das jetzt rausgehörte habe, würdest du sagen je nachdem in welcher Phase du in der Saison bist, also wenn du vielleicht ein paar schlechtere Rennen hast oder hattest, dass du dann eher den Fokus darauf legst mit deiner eigenen Leistung zufrieden zu sein, unabhängig davon was die anderen machen.
BD	Ja genau. Da dann eher zu sagen, ich schau jetzt auf mich. Ich schau, dass ich umsetzen kann, was ich umsetzen möchte.
LS	Gibt es Unterschiede zwischen einzelnen Disziplinen?
BD	Es gibt schon Unterschiede in der Herangehensweise. Es gibt Rennen die bauen sich mehr auf, d.h. so ein Einzel mit 20 Kilometern, da läuft man mal rein und guckt so wie es geht und wenn man da dann 3 gute Schießen hat dann das Vierte noch, okay dann ist man vorne mit dabei, da kann man nichts erzwingen. Bei Rennen, wie jetzt der Sprint, da geht man halt eigentlich schon Vollgas ins Rennen. Entweder es geht auf oder es geht nicht auf. Da kann man nicht sagen: „Ah ja, ich schau jetzt mal, ich taktier mal ein bisschen“. Weil, sonst hat meine keine Chance vorne mitzulaufen, da muss man All-in gehen.
LS	Von Anfang an?
BD	Das unterscheidet sich schon. In der Staffel ist es natürlich immer so ein bisschen. Na ja, da kommt vielleicht ein bisschen mehr Drucksituation dazu, weil man sagt, okay da sind noch andere Athleten und man läuft als Team. Und ja, wenn ich es verbocke, dann ist es für das ganze Team schlecht. Das ist eine Drucksituation. Ich weiß nicht, wie das in anderen Ländern ist, aber das wird in Deutschland meistens so empfunden. Ich habe mittlerweile das Problem nicht mehr, weil ich mir da auch schon viel im Kopf bewusst gemacht habe, dass man es auch anders sehen kann. Dass man auch sagen kann – also man geht ja immer davon vom Versagen und von der Strafe aus - aber man kann ja auch sagen, okay ich kann Geschenke machen oder keine Geschenke, also entweder es kommt nichts oder es kommt was. Also es geht on top und es geht nicht nach unten. Da ist also immer so die Sache wie man ran geht. Aber ja, das sind so die Unterschiede in den Ländern. Und klar, dann gibt es noch die Rennen, wo Du selbst startest, wo man dann schon immer sagen muss, ja da muss man sich immer pushen, immer treiben, immer gucken. Man kriegt zwar die Zwischenzeit, aber man weiß nie, wo man liegt. Und dann gibt es noch Massenstart/Verfolgung, wo man einfach zusammen losläuft, wo man sich ein bisschen an anderen orientieren kann und mal gucken, wie es so zusagen aussieht am Ende.
LS	Okay. Würdest du dann sagen, dass es Unterschiede gibt zwischen den Wettkampftypen gibt? Also, wenn du jetzt Olympia läufst, oder du läufst einen normalen Weltcup. Dass man bei Olympia vielleicht eher immer vom Sieg träumt und andere Ziele sich steckt?
BD	Man ist schon ein bisschen abgelenkt. Na ja, nicht abgelenkt, aber man hat schon ein bisschen mehr im Kopf und schon ein bisschen mehr was anderes im Kopf. Ein Weltcup-Rennen ist dann schon so was, wo man sagt, wenn’s heut‘ nicht klappt, dann klappt’s morgen. Also so in der Richtung. Bei Olympia weiß man schon okay es muss jetzt klappen oder das war es. Und da ist die Kunst es hinzukriegen und das auszuschalten und zu sagen ich konzentriere mich jetzt wieder auf das Wesentliche oder diese Gedanken finden gar nicht statt, weil ich so im Tun oder im Handeln bin, im Aktuellen, ohne mir über Konsequenzen Gedanken zu machen.
LS	Ja, um jetzt noch mal auf die Leistungstreiber zurückzukommen: Was würdest du sagen, was beeinflusst deine Laufleistung?
BD	Meine Form und meine Erholung. Für mich persönlich, ich habe keine Probleme mit psychischen Faktoren, die mich läuferisch beeinflussen. Bei manchen ist dies extrem. Also die sind super im Training, kriegen im Wettkampf aber nichts hin. Dieses Problem habe ich jetzt gar nicht beim Laufen.
LS	Was beeinflusst deine Schießleistung?
BD	Gefühl. Also viel Technik, wie man gerade so dasteht. Vorbelastung auf der Strecke, das ist ein sehr wichtiger Punkt, also Spannung in der Muskulatur und Selbstbewusstsein, Erfahrungen aus dem letzten Rennen. Das sind, denke ich mal, die Hauptfaktoren und natürlich, wie gut man sich auf die Umgebungsbedingung einstellen kann, mit Wind und so. Aber da ist diese psychische Komponente finde ich schon immer dabei, so mit Sicherheit aus dem letzten Rennen.
LS	Wie ist es, wenn neben dir direkt einer steht, der auch schießt?
BD	Man nimmt es wahr. Man muss versuchen sich wieder auf sein wesentliches zu konzentrieren. Ich würde nicht sagen, es macht einen Unterschied, ob jemand neben mir steht oder nicht. Also man kriegt es schon mit. Man muss gucken was gerade die Rennsituation ist, ob man jetzt neben einem steht, und es geht um das Podest oder es geht um Platz 20. Wenn jemand neben

	mir steht und es geht um Platz 20 ist mir das egal. Aber wenn ich natürlich weiß, es geht um Top 3 und man hört einfach, wenn da jemand schießt und was der schießt. Also das hört man am Klang der Scheiben, ob der trifft oder nicht trifft. Das zu ignorieren, geht nicht. Aber man muss halt wieder schauen, dass man wieder schnell bei seinem Schießen ist und sich schnell wieder auf seins konzentrieren kann.
LS	In welchen Situationen würdest du sagen schießt du besonders schnell?
BD	Wenn ich mich sicher fühle. Wenn ich vom Puls gut bin. Also im Höheren, wenn die Wettkampfstrecke in der Höhe liegt, muss man einfach mehr atmen, da schieße ich jetzt nicht so schnell. Aber wenn ich einen ruhigeren Puls habe, dann kann ich auch besser schießen. Es hängt also vom Schießstandanlauf ab.
LS	Und besonders langsam dann genau das Gegenteil?
BD	Ja genau. Also ich habe jetzt keine gute Erfahrung damit, bewusst schnell oder langsam zu schießen. Klar, mal bei windigen Situationen, wenn man sagt, da ist jetzt gerade eine Lücke, da ist gerade kein Wind, da muss ich jetzt schnell alles schießen. Diese Situationen gibt es schon. Aber die sind sehr, sehr rar und da jetzt irgendetwas daraus zu schließen, also für mich, ich versuche immer gleich zu schießen, möglichst schnell natürlich, aber es ist so ein bisschen Selbstbewusstsein, wie sicher man sich fühlt und wie ruhig man ist von der Vorbelastung.
LS	Der zweite Themenblock lautet jetzt: „Feedback über deine eigene Leistung während eines Rennens". Und da würde ich dich zu Anfang bitten, einmal zu beschreiben welche Art von Feedback du während eines Rennens bekommst. Feedback ist hier definiert als Rückmeldung über deine eigene Leistung, also während du im Rennen bist. Welche Rückmeldung bekommst du zu deiner eigenen Leistung?
BD	Ohne Fremdeinwirkung merke ich, wie ich mich körperlich fühle, wie ich mich muskulär fühle. Das Laktat spürt man natürlich. Dann fühle ich auch am Schießstand wie meine Beine sind, ob ich zittere, ob ich nicht zittere, ob ich ruhig stehe. Da spüre ich natürlich, wie viel Bewegung habe ich auf der Waffe, bin ich jetzt ruhiger, bin ich weniger ruhig an der Waffe. Ich kriege das Feedback wie ich schieße oder wie im Verhältnis zu anderen ich mich bewege. Im Sprint und im Einzel weniger, aber im Verfolgungsrennen/ Massenstart merkt man es natürlich, ob andere bessere Ski haben oder weniger, ob du mehr investieren musst oder ob du leicht hinterherkommst. Und dann bekommst du natürlich von dem Betreuerstab die Zwischenzeiten und da weißt du natürlich okay, das fühlt sich jetzt so und so an wie du gerade läufst. Und jetzt ist die Frage, ist es schnell oder nicht schnell. Und das bekommst du dann so zu sagen im Sprint oder im Einzel von denen mit der Zeit mitgeteilt und das ist das Feedback denke ich mal. Ja, mehr fällt mich jetzt dazu nicht ein.
LS	Von den Rückmeldungen, die dir die Betreuer geben, gibt es da eine bestimmte Information, die du besonders wahrnimmst?
BD	Es gibt die Informationen nach dem Liegenschießen, wenn ich noch ein zweites Mal schieße, wo die Fehlerbilder waren. Das ist die wichtigste Information. Dann gibt es die Angangszeit, also wie gut komme ich in ein Rennen rein. Das ist für mich immer wichtig, weil ich jetzt einer bin, der eher langsamer startet und da will ich in der ersten Runde nicht so viel verlieren und da gibt es dann so eine Einschätzung. Und so die Laufzeiten sind, so denke ich mal, das wichtigste. Also die erste Runde, wie schnell ich da bin und dann weiß ich, dass ich meistens ganz gut mithalte. Also das sind so, das würde ich mal behaupten, die wichtigsten Informationen.
LS	Und diese Zeiten sind dann immer im Vergleich zu anderen Athleten?
BD	Die Zeiten sind eigentlich immer im Vergleich zu anderen Athleten, weil wir uns nicht mit uns selber vergleichen können, weil die Bedingungen immer anders sind. Es ist jetzt nicht so wie auf einer 400 Meter Tartanbahn.

LS	Die Deutschen haben ja einen relativ großen Betreuerstab. Da sind auch viele Leute auf der Strecke. Glaubst du, dass andere Nationen genauso gut informiert sind, oder werden vielleicht kleinere Länder schlechter informiert?
BD	Das glaube ich nicht. Ich glaube nur, zwei Betreuer, die an der Strecke stehen, das hat jeder und das reicht. Wenn da mehr stehen ist nett, da geht es um Absicherung, wenn ein Stockbruch mal ist und so. Aber die wesentlichen zwei nach den zwei Zwischenzeiten, das ist das wichtigste und einer am Schießstand.
LS	Wo sind die Zwischenzeiten? Unterschiedlich?
BD	Die sind je nach Rundenlänge unterschiedlich. Es kommt immer auf die Wettkampfsituation an.
LS	Weißt du denn, bevor du an den Schießstand gehst, wo du in dem Rennen liegst, also jetzt im Sprint oder Einzel?
BD	Nein. Ich weiß, ob ich schnell gestartet bin oder langsamer, aber mehr weiß ich nicht.
LS	Weißt du wie gut deine Konkurrenten geschossen haben oder wo die im Rennen liegen? Also angenommen, Martin Fourcade hat vor ein paar Jahren zweimal danebengeschossen, weißt du das im Sprint?
BD	Beim Warmup weiß ich das schon. Also, wenn ich Warmup mache, dann sieht man ab und zu mal die Anzeigen und so. Aber so im Rennen nicht. Ich weiß nur, wie viel Rückstand ich auf Platz 1 habe und weiß, wie lange ich für eine Strafrunde brauche, wenn es keine Strafzeit gibt. Im Einzel kann ich die Minute wegrechnen und dann kann ich das einschätzen. Also ich kriege die Platzierung und ich kriege den Rückstand auf Platz 1. Wenn jetzt Platz 1 ganz vorneweg ist, auch auf Platz 2.
LS	Und daraus könntest du jetzt ableiten, wenn du wüsstest, z.B. Martin Fourcade ist vor dir gestartet und du kriegst gesagt, du hast 10 Sekunden auf 1. Dann wüsstest du – keine Ahnung – du liegst ganz gut im Rennen.
BD	Genau. Genau, also dann wüsste ich okay hier Johannes Tignes Boe, der läuft allen 10 Sekunden in der ersten Runde meistens weg oder 15. Wenn ich jetzt 10 Sekunden von dem kriege, das ist im Soll.
LS	Und du weißt auch wer vor dir gestartet ist in diesen Einzel- und Sprintrennen?
BD	Ja, ja, wir haben ja eine Startliste.
LS	Und die Information holst du dir vorher rein und guckst du dir auch vorher an?
BD	Ach so. Ja, ja, das weiß ich. Dass ich auch weiß, wer vor mir ist. Dass ich, wenn ich eine Zeit kriege, weiß, okay ist die was wert oder ist eigentlich keiner groß vor mir.
LS	Welchen Einfluss hat das Feedback dann auf deine Leistung? Also angenommen, du bekommst die Information, dass du sehr gut im Rennen liegst. Machst du dann noch schneller oder sagst du ja okay dann kann ich ein bisschen vorsichtiger fahren damit ich mehr Zeit beim Schießen habe oder einen ruhigeren Puls beim Schießen habe?
BD	Ja, das kommt auf das Rennen an. Aber zu sagen, ich nehm' irgendwie raus, die Situation finde ich, gibt es bei uns im Biathlon nicht. Also auch auf der Schlussrunde, wenn ich dann sag ich mal ums Podium lauf, dann sag ich nicht: „Na ja ich habe ja noch einen Vorsprung jetzt mach ich langsam". Also dann will man nichts anbrennen lassen. Also es gibt eigentlich immer Sprint. Nein, nein, also das beeinflusst mein Rennen eigentlich nicht, weil ich mir vorneweg einen Plan mache und den durchziehe. Und ich kriege dann eine Bestätigung. Das Einzige was mein Rennen beeinflusst ist, wenn ich merke, okay ich bin so weit weg, dass ich mir Energie sparen kann für die kommenden Rennen. Wenn ich aus den Punkten raus bin und das Rennen ist dann sowieso für umsonst, dann darum. Aber sobald ich in den Punkten bin, dann geht es immer darum so viel Punkte wie möglich zu holen, vielleicht das Preisgeld zu erreichen oder auf dem Podest zu stehen.

LS	Ab welcher Position gibt es Preisgeld?
BD	Ab Platz 20.
LS	Und im Sprint nimmst du ja die Zeit mit in die Verfolgung. Hat das einen Einfluss darauf, dass du sagst im Sprint muss ich immer alles geben, weil ich ja den Rückstand mitnehme.
BD	Ja. Ja. Das schon. Also im Sprint ist man schon immer – ja, es ist auch finde ich schwierig zwei Runden Vollgas zu geben und dann wieder den Körper runter zu regeln und zu sagen mach mal langsam. Also das geht gar nicht. Da bist du auf einen Modus eingestellt und den ziehst du durch.
LS	Das war jetzt die Laufleistung. Würdest du sagen, dass das Feedback deine Schießleistung beeinflusst? Wenn du z.B. hörst, du bist in der vordersten Gruppe.
BD	Ja, also es macht schon einem bewusst ah es geht um was. Man fängt dann schon an so ein bisschen zu rechnen. Und zu sagen, wenn du jetzt Null schießt, dann bist du da und da, da kommst du ja da, da kannst du mitlaufen, dann geht es ums Podium. Also das ist schon und das muss man sich dann versuchen wieder auszureden, also diese Gedanken. Das ist so ein bisschen Engelchen und Teufelchen. Also man denkt dran, aber andererseits muss man wieder versuchen wieder an was anderes zu denken oder sich abzulenken. Also sich aufs Handeln zu konzentrieren.
LS	Also das Feedback würde eher deine Leistung am Schießstand beeinflussen als das was du in der Loipe machst?
BD	Ja, auf jeden Fall. Es macht mich nervös.
LS	Und in der Loipe, wenn du merkst du hast um dich herum Athleten, die ähnlich schnell laufen, vielleicht sogar noch einen Tick schneller, motiviert dich das an denen dranzubleiben, oder?
BD	Es ist schon angenehmer. Ich muss ehrlich sagen, so oft gibt es die Situation nicht, also ich bin ein guter Läufer. Ich laufe meistens alleine. Also im Verfolger Massenstart natürlich nicht. Da läuft man dann schon immer gut mit. Da sind auch alle gefühlt schneller. Also im Sprint und Einzel kommen manchmal Unterschiede in der Laufzeit zustande. Im Verfolger Massenstart laufen dann alle auf einmal auf ähnlichem Niveau. Also das ist schon spürbar.
LS	Weil man taktiert?
BD	Ja, nein und weil dieses Hinterherlaufen so viel bringt. Also im Sprint und Einzel sieht man ganz klar wer ist ein guter Läufer, wer ist nicht so ein guter.
LS	Okay.
BD	Also im Sprint und Einzel da sieht man ganz klar wer ein guter Läufer ist, wer nicht so ein guter. Und im Verfolger/Massenstart haben manche Laufzeiten, wo man sich denkt, wo kommt das jetzt auf einmal her, wenn man die Ergebnisliste des Sprints sieht. Das ist schon das an einem festsaugen, hinterherlaufen. Vorne, die in der Führung sind, die machen jetzt auch nicht den Megadruck. Die sagen auch okay, ich bin in der Führungsgruppe, da kann ich jetzt ein bisschen dosierter gehen.
LS	Okay, dann kommen wir zum nächsten Themenblock „Die relevante Vergleichsgruppe". Mit wem, wenn du jetzt auch im Sprint unterwegs bist, oder im Einzel, wirst du verglichen oder vergleichst du deine eigene Leistung während des Rennens?
BD	Mit den Führenden. Die Sache ist die, ich muss ja meine eigene Leistung irgendwie einordnen. Und am besten kann man die einordnen, wenn man sich mit den Führenden vergleicht. Nicht unbedingt nur mit dem Führenden, sondern auch mit dem Zweiten und Dritten, auch wenn es unterschiedliche sind, aber da weiß man immer, wo man ungefähr steht. Und Platz 10, der kann manchmal so unterschiedlich sein. Also auf der Schlussrunde kriegt man natürlich noch einmal die Platzierungen in seinem Umfeld genannt, was in 5 Sekunden Reichweite nach vorne ist, 10 Sekunden, was realistisch ist, was man noch gut machen kann. Wobei Überraschung: Es

	ist immer einiges möglich, weil es einfach immer knapp ist. Aber um meine Leistung einzuschätzen, vergleiche ich mich immer mit den Top 3 in den Zwischenstandslisten.
LS	Und auch immer nach vorne, selten nach hinten? Außer man ist selbst der Erste.
BD	Ja, immer nach vorne. Also bei mir geht es jetzt nicht darum, dass ich einen Verfolger schaffe. Den sollte ich eigentlich schaffen.
LS	Das heißt aber jetzt zum letzten Kommentar, die Vergleichsgruppe hat sich vielleicht geändert, dadurch, dass man selbst auch in der vorderen Gruppe ist. Früher, weiß ich nicht, ob das bei Dir am Anfang vielleicht so war, hast du dich dann eher mit dem 30. Platz oder so verglichen oder 60., so dass man noch in die Verfolgung kommt.
BD	Ja, habe ich nicht, weil ich wollte während dem Rennen wissen, wie ich drauf bin und wie gesagt, da weiß ich dann ich bin 1 Minute oder 2 Minuten hinter der Führung. Aber es bringt mir nichts zu sagen ich vergleiche mich mit denen, wo ich gerade um mich rum bin.
LS	Dann sind wir im Themenblock 5. Hast Du noch ein paar Minuten? Das wären noch so 5 Minuten schätze ich.
BD	Ja. Ich muss nur ins Training dann, deswegen.
LS	Okay. Und zwar die Regularien/Rahmenbedingungen. Ich habe mir das Regelbuch durchgelesen. Da steht drin, dass im Sprint und Einzel der Kapitän einen in die Startgruppe packt und dann wird innerhalb der Startgruppe die Startreihenfolge gelost.
BD	Ja.
LS	War das immer schon so, weißt du das, dass gelost wird?
BD	Es war schon immer so, dass gelost wird. Also Sprint/Einzel logischerweise.
LS	Ja.
BD	In den Gruppen wird gelost, aber es gibt die Möglichkeit, dass die Top 15 im Gesamtweltcup frei die Startgruppe wählen dürfen.
LS	Genau.
BD	Das heißt, die dürfen dann mehr vorne rein, aber innerhalb der Startgruppe wird immer gelost.
LS	Und das war auch schon die letzten 20 Jahre so?
BD	Die letzten 10, 15 Jahre sicherlich.
LS	Und die Größe der Startgruppe wird dadurch bestimmt wie viele Leute am Rennen teilnehmen?
BD	Ja genau und wie viel in die eine Startgruppe wollen und nicht. Also es darf ja nicht jeder in jede, aber wenn es jetzt ein klassisches Rennen ist, mit festen Bedingungen, dann gehen die meisten vorne rein. Dann ist die Startgruppe 1 meistens mit 40 Sportlern voll und die anderen Startgruppen nur mit 25.
LS	Dann wären wir jetzt im nächsten Themenblock: „Die Rolle der Startnummer". Startest du lieber früher oder später im Einzel und Sprint?
BD	Es hängt von den Bedingungen ab. Aber so ganz vorne starten möchte man nicht, weil man dann keinen Vergleich hat. Außer in einem Einzelwettkampf, da würde es mich zum Beispiel gar nicht stören. Weil man da eh, wie gesagt, eher so seins macht, aber so im Sprint, wenn man einen Vergleich braucht, da startet man lieber so Startnummer 15, 20, so was. Das sind so die beliebtesten Startnummern würde ich behaupten.
LS	Und wenn du die Wahl hast, würdest du dich auch immer vom Kapitän in die erste Startgruppe packen lassen? Angenommen die Bedingungen sind stabil.
BD	Wenn die Bedingungen so sind, dann gehe immer gerne in die erste. Ja. Manchmal hängt es ein bisschen ab von der Tageszeit. Es gibt so Tageszeiten, wo ich dann mit dem Essen und meinem Tagesrhythmus eher so in ein Mittagstief oder so was reinkomme, dann gehe ich manchmal in die zweite Startgruppe. Aber ansonsten in die eins.

LS	Und wenn du als aller erster ausgelost wirst, du gehst als erster jetzt ins Rennen und du hast keine Ahnung wie du dich mit den anderen Athleten vergleichst. Bleibt das im ganzen Rennen so oder kriegst du dann nach und nach Informationen - jetzt kann man ja ungefähr die ersten 10 Leute; die nach dir gestartet sind vielleicht irgendwann einschätzen - wie deine erste Runde war oder kriegst du die Information nicht?
BD	Nein, so möchte ich das dann auch. Also die reichen mir dann die erste Rundenzeit nach.
LS	Okay. Sobald da irgendjemand vorbeigekommen ist, der da relevant ist.
BD	Ja, genau.
LS	Ob du jetzt früh oder spät startest, hat das einen Einfluss auf deine Lauf- und Schießleistung?
BD	Nein, ich würde mal behaupten nicht. Es hat eher eine Einwirkung auf die Psyche. Du kannst dich zwar besser orientieren, es beruhigt manchmal, aber manchmal macht es dir auch Stress, wenn du weiter hinten oder wenn du viele Vergleiche startest, und du merkst ich habe einen Scheiß Ski und kriege schon 30 Sekunden. Also da ist manchmal vielleicht gar nicht so schlecht, wenn man es nicht weiß.
LS	Und würdest du sagen, wenn du ganz am Anfang startest und keinen Vergleich hast, dann gibst Du immer alles?
BD	Ich gebe immer alles. Also ist es Sprint und Einzel. Einzel muss man sich ein bisschen einteilen, aber es macht keinen Unterschied. Weil ich nie taktiere in den Rennen, in denen man mit Startgruppen startet.
LS	Und glaubst Du, das ist eine Typfrage. Gibt es Typen die gerne immer früh starten und andere Typen, die gerne spät starten?
BD	Ja.
LS	Wovon hängt das ab?
BD	Also für manche ist es ganz schlimm, wenn sie die Eins oder die Zwei haben, weil sie dann wirklich den Vergleich brauchen. Bei mir ist das nicht so, weil ich meine Laufleistung einigermaßen gut einschätzen kann. Auch wenn ich gerne eine Referenz habe, weiß ich okay, es ist gut oder es nicht gut. Ich merke auch, ob ein Ski gut ist oder nicht gut. Manche machen sich da schon Gedanken, die starten lieber weiter hinten als dass sie keinen Vergleich haben.
LS	Glaubst Du es gibt Unterschiede zwischen Männern und Frauen?
BD	Lass mich überlegen. Wenn es um die Startgruppen geht nicht. Nein, glaube nicht.
LS	Ja, dann sind wir am Ende angekommen. Es war sehr interessant. Vielen Dank. Vielleicht zum Hintergrund der Studie, ich untersuche oder möchte genauer untersuchen, macht es einen Unterschied, ob ich früh im Rennen starte oder spät im Rennen starte, ob ich viel oder wenig Informationen habe.
BD	Dann wünsche ich dir viel Erfolg, eine gute Arbeit.
LS	Danke. Dir noch eine gute Woche und gute letzte Rennen. Ich glaube ihr habt noch zwei, drei oder so.
BD	3 Wochenenden, neun Rennen.
LS	Dann viel Erfolg.
BD	Danke.
LS	Es war sehr nett dich kennenzulernen. Vielen Dank
BD	Tschau.
LS	Tschau, mach’s gut.

Appendix 3.9c – Interview with Andrea Henkel Burke

Date of the interview	**09.06.2022**
Duration of the interview	**28 minutes**
Interview format	**Video call (Zoom)**
Name of interview partner	**Andrea Henkel Burke (AHB) – former athlete of DSV**
Name of interviewer	**Leo Schmallenbach (LS)**

Table A3.11 Interview Transcript – Andrea Henkel Burke

LS	Fangen wir an mit dem ersten Themenblock. Der wäre Leistungstreiber im Biathlon. Kannst du kurz beschreiben, wenn du damals in deine Rennen gegangen bist mit welcher Motivation du an den Start gegangen bist? Also was war dein Ziel, das du dir vor so einem Rennen gesteckt hast?
AHB	Ich stelle jetzt fest, dass ich ganz schlecht in der Zielsetzung war. Ich wollte einfach nur quasi am besten aufs Podium. Also kommt jetzt ganz darauf an wann. Also in meinem ersten Jahr Weltcup war Top 10 und danach war halt Podium das Ziel.
LS	Aber du hast dir schon eher eine Platzierung als Ziel gesetzt, also nicht eine Zeit oder irgendwie ein Schießergebnis, sondern schon eher immer eine Platzierung?
AHB	Ja, Zeit ist ja eigentlich Quatsch im Biathlon. Das wäre ja okay, ich habe meine Zeit geschafft, aber ich bin trotzdem nicht in den Punkten oder so was. Schießen war ebenso klar, ich will natürlich alle Scheiben treffen.
LS	Okay.
AHB	Und deswegen war das dann schon klar. Aber natürlich, ich hätte mir so im Nachhinein noch ein paar andere Ziele setzen sollen. Was heißt Ziele setzen? Andere Fokuspunkte geben müssen. Auf der Stecke das machen oder am Schießstand das machen. Und das kam spät. Es war ja irgendwie klar, eine kommt schon durch. Egal wer das ist. Wir müssen da jetzt gar nicht ins Detail gehen. Das ist jetzt ganz anders. Jetzt wird ganz anders mit den Athleten gearbeitet.
LS	Okay. Du meinst früher wurde im Team geschaut, Hauptsache eine kommt durch so zu sagen?
AHB	Es kam ja auch immer eine durch. Das war ja jetzt nichts Außergewöhnliches. Die Devise der Trainer war: eine muss durchkommen.
LS	Aber die Zielsetzung war schon eher auf Teamebene und nicht so sehr auf Athletenebene?
AHB	Ja. Also für die Trainer war das erst mal relativ egal. Das war ihr Team, wer auch immer durchkommt. Natürlich wollten alle durchkommen. Sollten mehr durchkommen umso besser, aber eine muss es halt machen. Und das war ja auch oft der Fall. Und individuell gesehen möchte natürlich jeder selbst derjenige sein, der durchkommt.
LS	Ja, okay. Und du hattest eben schon einmal gesagt über die Zeit, jetzt wenn du vergleichst, zum am Anfang deiner Karriere gegen Ende, hat sich das verändert? Die Zielsetzung, ja?
AHB	Na, es wurde mir halt viel klarer. Ich musste anfangs auf ganz andere Sachen achten. Wenn ich jetzt an den Start gehe, dann ist das nicht mehr ganz so. Vor allem, wenn du weißt es ist das letzte Jahr und so oft gehe ich nicht mehr an den Start, dann möchte ich den aber nicht versauen. Da hat man noch einmal einen ganz anderen Einflussfaktor. Und da kommt es dann darauf an sich mehr auf die Details zu konzentrieren als übers Auskommen. Aber im Prinzip davor, das war ja auch, ja ich musste schnell laufen und gut schießen und dann hat es gepasst. Nur so etwas wie auf den Abzug achten, das kam irgendwie erst später. Aber es war dann da. Also die letzten Jahre war so mein Fokus beim Schießen: Den Abzug, den möchte ich nicht versemmeln, weil da habe ich eine große Chance die Scheibe zu treffen.
LS	Und hast Du die Ziele auch verändert, je nachdem in welchem Rennen du warst?
AHB	Nein, ich wollte immer aufs Podium.
LS	Also z.B. jetzt Vergleich Weltcup, Olympia, WM, das war immer dieselbe Zielsetzung?
AHB	Rennen war Rennen. Da gab es keinen Unterschied. Deutsche Meisterschaft war für mich fast das stressigste, weil da hat ja alles danach geschaut. Das ist quasi die deutsche Nationalmannschaft, das sind die, die vorne dran sind und jetzt ging es nicht darum nur einen durchzubringen, sondern alle mussten jetzt vorne sein. Und das war für mich fast das schlimmste. Das war schlimmer als jede Olympischen Spiele. Aber auf der anderen Seite Olympia ist nur alle vier Jahre – da kommt es dann drauf an.
LS	Das ist interessant. Und wenn du die Disziplinen miteinander vergleichst, gab es da eine andere Herangehensweise je nachdem, ob es Sprint war oder Einzel?
AHB	Ja, im Einzel ist man natürlich nicht so aggressiv am Schießstand. Aber im Prinzip war das eher, wie soll ich sagen, die was anderes machen am Schießstand die verschießen ja eher. Und im Prinzip wollte ich immer nur alle Scheiben treffen und aufs Podium laufen.
LS	Und beim Einzel oder auch bei den anderen Rennen, die vier Schießen haben, dadurch das man mehr Zeit hat, legt man sich da eine Taktik zurecht, dass man in einer Runde ein bisschen schneller läuft als in der anderen und beim Sprint haut man alles raus was man kann, egal wie weit fortgeschritten das Rennen ist?
AHB	Ja, Zeit haben ist ja relativ. Man hat ja eigentlich keine. Also das ist ja auch im Einzel das gleiche, nur musst du da mit der Energie etwas anders haushalten, denn die Strecke ist ja doppelt so lang. Und im Prinzip ging es darum so zum Schießstand zu kommen, dass man alles gegeben hat, dass man dann aber noch schießen konnte und in der letzten Runde geschaut hat, was noch übrig war. Weil dann musste man ja, wie auch immer, die letzte Runde laufen, man musste ja nur ins Ziel und die Waffe stillhalten. Wobei das bei mir keinen großen Unterschied gemacht hat. Ich hatte manchmal, wenn wir im Training waren und hatten sechs Runden zu laufen, jeweils so die gleiche Zeit. Uhrwerk schön und gut, aber ich würde gerne auch mal nach oben ausschlagen oder nach unten in dem Fall. Ja, ich finde das ziemlich imponierend, wenn da jemand in den letzten Runden hinhauen kann oder auch in den ersten Runden. So eine Marke setzen und je nachdem, ob man dann durchkommt oder nicht.
LS	Aber so einen Gedanken oder so ein Ziel hast du nicht mal gehabt, dass du im Rennen gesagt hast, so, heute in der ersten Runde greife ich mal an? So was?
AHB	In meiner ersten Runde, wenn ich dann das Ziel hatte, nicht zweistellig hintendran zu sein, das war gut. Aber ich muss sagen im Massenstart oder der Verfolgung, je nachdem wie dicht das war, da wollte ich schon so im ersten Drittel sein. Dreißig Frauen auf einem Haufen, das kannst du dir vielleicht vorstellen, dass ist irgendwie so ein bisschen unharmonisch und da wollte ich nicht so mittendrin hängen.
LS	Okay, ja. Das zur Zielsetzung. Die nächsten Fragen beziehen sich jetzt eher auf die Einflussfaktoren auf deine Leistung. Welche Rolle glaubst du hat deine Motivation gespielt für das was hinten raus kam?
AHB	Ja natürlich muss man motiviert sein für das was man macht, denn da macht man es besser. Aber das war nicht das Problem, denn wenn man an den Start geht und ist nicht motiviert für das Rennen, dann hat man sich den falschen Beruf ausgesucht. Ich denke mal, das hängt ein bisschen mit der Vorleistung zusammen, wie dann auch die Leistung kommt im Rennen. Wenn man viele gute Rennen schon in den Beinen hat, dann läuft es sich auch einfacher.

LS	Ja, und dann guckt man sich, ich weiß ja nicht, so die letzten 10 Rennen an und hat einen Eindruck wie man gerade so in der Saison so performt? Und je nachdem ist man dann ein bisschen motivierter, wenn man weiß, heute kann ich mit dem Sieg mitlaufen?
AHB	Ja, also wenn ich weiß, dass ich da vorne drin auf jeden Fall mitlaufen kann, dann ist das natürlich noch einmal eine ganz andere Herangehensweise. Aber das war ja das Ziel.
LS	Und was glaubst du war der wichtigste Einflussfaktor für deine Laufleistung?
AHB	Mein Training. Also, wie gut ich trainiert habe über das ganze Jahr. Das war der wichtigste Einflussfaktor.
LS	Und da legt man im Sommer dafür die Grundlage. Und beim Schießen?
AHB	Kopf.
LS	Im Sinne von?
AHB	Letzten Endes ob man auch umsetzt, was man kann. Denn Schießen ist ja nicht das Problem, sondern es geht ja ums Treffen. Schießen kann ja jeder.
LS	Und mit Kopf meinst du, dass man sich nicht zu viele Gedanken macht oder dass man sehr konzentriert ist?
AHB	Das kommt auf den Typ drauf an. Also, wenn ich mir zu viel Gedanken gemacht habe ums Schießen, da wurde es auch nicht viel. Wenn man mit so einer Leichtigkeit ran gegangen ist, die man sich natürlich auch wieder im Vorfeld aufbaut, weil wenn das Schießen klappt und klappt, dann klappts. Wenn irgendwie der Wurm drin ist, dann ist es so wie eine Spirale, dann hängt man da drinnen fest unter Umständen. Also das ist immer schwer zu sagen, wie das dann so im Allgemeinen ist. Aber dann kommt es darauf an sich einen Fokuspunkt zu setzen und nicht daran zu denken was rauskommt am Ende, sondern eher an das denkt, was jetzt gemacht werden muss, damit das rauskommt, was man rausbekommen möchte.
LS	Und hast du damals auch mitbekommen was so rechts und links von dir passiert ist auf den Matten? Wie die anderen schießen?
AHB	Also am Anfang meiner Karriere im Weltcup, da habe ich manchmal sogar geguckt was so passiert und irgendwann habe ich damit aufgehört. Am Anfang, da ging das noch, da war jetzt noch nicht so das Verlangen, dass ich jedes Mal aufs Podium laufe oder es war sowieso nicht verlangt jedes Mal aufs Podium zu laufen, auch wenn das das Ziel war. Aber da war irgendwie so eine gewisse Leichtigkeit dabei, dass ich es konnte. Das war schön. Und am Anfang vor allem waren ja Martina und ich da die Schnellschützen und das war irgendwie neu. Und das war einfach cool. Ich komm jetzt, mal gucken wer hier jetzt zuerst wieder weggeht. Also das war wie so ein Spiel und wir hatten Spaß dabei. Ich glaube, das hat auch die Trefferleistung erhöht.
LS	Erhöht? Wenn du wusstest, wer da liegt und wie die geschossen haben? Das hat dir keinen Druck gemacht?
AHB	Nein, wir hatten Spaß in dem Moment. Das waren ja nur zwei Jahre oder so. Ja, ich komm mit dir zum Schießstand und ich will eher wieder weg sein. Man wusste quasi um seine Fähigkeiten. Aber später wird man nicht besser im Schießen, man wird eher irgendwie so ein bisschen verkopfter.
LS	Okay. Und mir hat mal einer, ich glaube der Benedikt Doll wars, erzählt man hört auch, ob der neben einem getroffen hat oder nicht.
AHB	Ja, man hört es. Ich finde es wichtig im Schießen, natürlich bleibt man bei dem was man machen soll, aber man muss auch damit klarkommen, dass da neben einem jemand liegt und dass da andere Geräusche sind und natürlich hört man das, aber das muss ja nicht alles verarbeitet werden. Wir können ja sowieso nicht alles verarbeiten und das ist halt das, was hinten runterfallen sollte. Aber hören tut man das schon.

LS	Und du hast eben schon einmal durchklingen lassen, dass es natürlich auch eine Erwartungshaltung gab. Hat es dann für dich einen Unterschied gemacht, wenn du irgendwie in einem deutschen Stadion das Rennen hattest und geschossen hast, wo du weißt, da sind jetzt irgendwie zwanzigtausend die gucken alle auf mich im Vergleich zu, weiß nicht, irgendwo in Tschechien?
AHB	In Tschechien, da waren noch mehr!
LS	Da waren noch mehr?!
AHB	Ja, aber ich weiß was du meinst. Also nein, da war kein Unterschied, weil die, die nicht im Stadion waren, die waren ja zu Hause vorm Fernseher. Es war natürlich schöner in einem vollen Stadion zu laufen, aber am Ende war es egal, wo ich auf dem Podium stand.
LS	Und das hat dir nicht mehr Druck gemacht?
AHB	Mit Druck habe ich manchmal besser gearbeitet.
LS	Und du hast eben schon einmal gesagt, damals, ich glaube du und Martina wart da die Schnellschützen. Gab es denn Situationen, wo du gesagt hast, heute schieße ich besonders schnell oder heute schieße ich besonders langsam?
AHB	Ja, besonders schneller. Ich wollte ja sowieso so schnell wie es in dem Moment eben möglich war. Aber das wurde zum Schluss dann auch ein bisschen regulierter. Man kann auch nur so schnell schießen, dass man trotzdem noch die Scheiben trifft. Also so war das so schon drin, ich kann nur einen Schuss abgegeben, wenn ich denke das wird auch ein Treffer. Heute schießen wir ein bisschen langsamer, war eben dann, wenn die Bedingungen wechselhaft waren. Aber da reagiert man drauf, da mache ich mir vorher nicht so Gedanken drum. Das ist das Umgehen mit der Situation.
LS	Dann sind wir schon beim nächsten Themenblock, und zwar Thema Feedback. Du hast am Anfang auch gesagt, die absolute Zeit ist eigentlich nichts wert, weil man immer im Vergleich zu den anderen bewertet wird. Wie gut bist du denn über deine Position im Rennen informiert gewesen? Gerade auch in den Disziplinen, wo man nicht gleichzeitig startet, also im Sprint oder Einzel?
AHB	Ja, das kommt darauf an, wo man startet, natürlich. Und ich wollte informiert sein. Da hat man den Stadionsprecher, den hört man ja auch, dann hat man die Anzeigetafeln und die Trainer. Nur die kann man nicht so beeinflussen wie die Anzeigetafeln, die erzählen dir immer so irgendwas, um dir die richtige Richtung zu zeigen. Aber wenn man das einmal rausgefunden hat, dann macht das halt nicht mehr mit mir. Ich brauche immer nur die Fakten, alles gut, ich komme damit klar. Die Martina zum Beispiel, die wollte gar keine Informationen.
LS	Okay.
AHB	Das Ding ist ja nur, was macht man mit der Information. Kann man darauf jetzt reagieren oder nicht? Und wenn man nicht schneller laufen kann, dann kann man da sowieso nicht drauf reagieren. Und im Prinzip ist es egal, ob man die Information jetzt hat oder nicht. Es sei denn, es ist in der letzten Runde und es geht um ein paar Sekunden mit fünfzehn Plätzen. Also ich übertreibe mal, aber dann ist natürlich wichtig und auch irgendwie ein Anhaltspunkt dann noch mal vielleicht so ein paar Kräfte freizusetzen. Aber im Prinzip geht es ja darum alles freizusetzen. Manchmal braucht man eben so ein paar Informationen, um es dann noch einmal auf ein anderes Level heben zu können.
LS	Und die Informationen sind aber in der Regel gewesen wieviel Rückstand nach vorne? Oder auch schon mal nach hinten?
AHB	Das kommt darauf an. Ja, in der Verfolgung wurde auch mitgezählt, weil sonst verliert man die Übersicht. Und dass wir uns auch so ein bisschen orientieren konnten auf welche Scheibe wir schießen und nicht erst wenn wir zum Schießstand kommen. Das war eine gute

	Information und es ist natürlich auch gut zu wissen was hinter einem passiert. Du bist jetzt auf dem Podium, aber hinter dir kommt noch der und der. Da ist auch gut zu wissen wer da noch kommt. Und man weiß es ja, man schaut sich vorher die Startliste an und dann weiß man, dass man da auch ein paar Konkurrenten im Nacken hat. Und wenn man in dem Moment auf Platz 3 ist, dass das nicht heißt, dass man da auch bleibt.
LS	Und kommt es auch schon mal vor, dass du irgendwie das Gefühl hast, heute liegst du sehr gut im Rennen und dann kriegst du die Info vom Trainer, keine Ahnung, du bist zwanzig Sekunden hintendran und du denkst wie kann das jetzt sein?
AHB	Nee.
LS	Selten?
AHB	Nein, also so viel Übersicht habe ich nicht verloren. – Kann sein, dass es jemandem passiert.
LS	Das passiert selten, dass du ein komplett anderes Feedback bekommst als so wie du dich gefühlt hast?
AHB	Ja. Ja. Also vielleicht dachte man mal, oh ich bin heute nicht gut drauf, aber so schlecht hätte ich jetzt auch nicht gedacht. Das vielleicht. Aber man hat jetzt auch nicht das komplette Gegenteil erwartet.
LS	Aber manchmal wird man ja vielleicht auch positiv überrascht. Das du dachtest heute ist kein guter Tag und dann bekommst du die Info du liegst doch ganz gut im Rennen.
AHB	Das passiert öfter der Uschi. Uschi hat immer erzählt wie müde sie ist vor dem Rennen. Aber alles gut, wird ein gutes Rennen. Die hat sich öfter überrascht glaube ich.
LS	Glaubst du auch, du hast es eben schon einmal angedeutet, auf der letzten Runde, da hast du dann vielleicht noch ein paar extra Körner, die man findet, wenn man weiß es geht nur um ein paar Sekunden? Glaubst du das macht auch was mit deinem Schießen? Also bist du nervöser dann, wenn du weißt, da ist direkt einer hinter mir oder vor mir?
AHB	Es kommt auf die Situation drauf an. Ich habe vorhin ja gesagt ich brauche manchmal so ein bisschen Druck, so dass einem das manchmal noch so ein bisschen beflügelt. So zum Beispiel, ich was ich jetzt nicht, ob du das im Kopf hast, Ruhpolding, Staffel, letztes Schießen. Also ich komme da rein zum Schießstand und dann wusste ich, dass meine Form nicht die beste ist auf der Strecke. Also ich muss jetzt alle Scheiben treffen sonst versemmele ich das hier, was man sich so erarbeitet hat. Und in solchen Momenten, hat zumindest mir das ganz gutgetan.
LS	Okay.
AHB	Mehr Druck hatte ich z.B. bei der Deutschen Meisterschaft. Das war ein anderer Druck. Es war nicht, aber ich sollte, aber irgendwie war es auch kein Druck, kein wahrer Druck, nur so ein diffuser. Das war nichts für mich. Aber so ein richtiger, wahrer, echter Druck war super.
LS	So wie du das gerade beschrieben hast hat mich das so ein bisschen erinnert an das nicht verlieren dürfen. Also Deutsche Meisterschaft, das hast du ja gesagt, da musste man performen, weil man war ja Nationalkader, man musste irgendwie gewinnen. In den anderen Situationen wie du es beschrieben hast, da konntest du wirklich was gewinnen, aber es kam halt auch einer durch, wenn du es nicht geschafft hast.
AHB	Ja, bei der Deutschen Meisterschaft, das war eher mit Skirollern. Irgendwie wollte man das, aber man musste nicht, so war das. Im Weltcup muss man schon, denn sonst wird man auch mal ausgetauscht. Und bei uns war es auch so. Mein Ziel war dann auch – zurück zu den Zielen - immer eine der ersten vier zu sein.
LS	Für die Staffel?
AHB	Für die Staffel oder für den Startplatz. Das hat mir nicht gereicht. Später wurden es die ersten drei, denn dann hat man noch einen Puffer.

LS	Und die Staffel, du hast eben beschrieben, in Ruhpolding letzte Runde, du warst wahrscheinlich die Schlussläuferin. Gibt dir die Staffel im Vergleich zum Einzelwettbewerb mehr Druck?
AHB	Nein. Für mich nicht, denn ich bin immer der Meinung gewesen, da habe ich jetzt drei die normalerweise gegen mich laufen, die laufen jetzt mit mir und für mich.
LS	Okay, vor dem Rennen. Und wenn du dann am Schießstand stehst, die sind ja schon gelaufen, trotzdem noch? Du hast nicht das Gefühl, wenn ich es jetzt verkacke, dann hat das ganze Team verkackt? So denkt man dann nicht in der Situation?
AHB	Das weiß man, aber da denkt man nicht drüber nach. Also ich möchte das nicht nur für das Team nicht verkacken, sondern auch für mich selbst das nicht verkacken.
LS	Ja, ja.
AHB	Denn ich habe ja auch den nächsten Wettkampf, also wenn ich den jetzt versemmle, dann ist das ja nicht gut für mein Selbstbewusstsein für die nächsten Rennen. Also unabhängig vom Team.
LS	Ja, sehr gut. Also wir haben noch zwei Themenblöcke, nur um so ein Gefühl zu bekommen, was die Zeit angeht.
AHB	Ich habe nur ein Anruf in ca.15 Minuten.
LS	Ja. Die Vergleichsgruppe im Biathlon. Du hast ja gesagt man setzt sich im Team intern das Ziel ich will unter Top 3 sein. Im Weltcup weiß man vielleicht so wie viele Kandidaten auf einem ähnlichen Leistungsniveau unterwegs sind wie man selbst. Ist diese Vergleichsgruppe relativ konstant oder ändert die sich mit der Zeit? Immer mit sich selbst verglichen.
AHB	Die ändert sich. Bis 2010 war das quasi mit diesem Team, wo man sich dann wirklich durchboxen musste. Was ich persönlich gut finde, denn das hat mich auch zu Levels gehoben, die ich vielleicht sonst nicht erreicht hätte. Und danach war es ja anders. Da wollte ich natürlich meine Position nicht abgeben, wollte dass ich da immer zu denen gehöre, die da eingesetzt werden. Dann war es auch Top 2, weil die Mixed Staffel kam. So verändert sich das. Und dann, wenn es darum geht – ich glaube in meinem letzten Jahr oder in den letzten zwei – war ich die einzige auf dem Podium. Ich weiß es nicht mehr genau. Und das möchte man dann natürlich auch bestätigen. Und da kommt es auch darauf an, was ist jetzt mein Ziel im Gesamtweltcup, dann schaue ich natürlich international und ich möchte ja auch immer noch aufs Podium. Da muss ich natürlich international auch gucken.
LS	Was meintest du eben mit 2010? Was hat sich da geändert?
AHB	Da haben Martina und Simone aufgehört. Und zwei Jahre später die Lena. Und dann war die Kathrin auch nicht mehr dabei. Also es wurde dann lichter im Team.
LS	Ja. Und angenommen du bist jetzt im Sprint oder Einzel, wo die Reihenfolge ja gelost wird, würdest du in diesen Situationen lieber früh oder spät starten?
AHB	Immer früh. Also wenn die Bedingungen es hergeben, immer früh, denn da hat man die Chance, da das Fenster zwischen Anschießen und Start nicht so groß ist, dass man sich auf der Strecke auch warmlaufen kann. Denn das kann man nicht mehr, wenn man hinten läuft. Wenn man hinten läuft, da hat man das Anschießen und dann hat man erst mal eine Weile nichts. Und dann muss man sich erst wieder warm machen und dann muss man an den Start und sieht die anderen schon im Ziel. Da habe ich lieber keine Information und laufe am Anfang.
LS	Man kann sich ja auch in die Startgruppen wählen, du hast dich dann vermutlich oft in die erste Startgruppe gewählt, wenn es ging.
AHB	Eins oder zwei, je nach Bedingungen.
LS	Und bei der Auslosung, wenn du jetzt die Eins bekommen hättest, hättest du dich da gefreut, oder ist die Eins so ganz am Anfang als aller erste?

AHB	Oh, in der Verfolgung, Massenstart war super. Also es kommt darauf an.
LS	Im Sprint oder Einzel?
AHB	Das hätte mich jetzt nicht gefreut, aber ich hätte es halt akzeptiert.
LS	Okay.
AHB	Also eine fünf wäre schon besser, aber irgendwie ist man dann nicht so der erste, der dann los geht, aber am Ende ist das irrelevant.
LS	Aber die Information, die du dann auf der Strecke bekommst, kannst du die verwenden, wenn du als dritter startest und du weißt vor dir sind zwei Läuferinnen gestartet, die sind normalerweise hinten?
AHB	Ja, ich weiß ja ungefähr in was für einer Region die wären und da kann ich mich dann schon orientieren. Also wenn ich normalerweise 10 Sekunden schneller bin oder zwei dahinter, dann weiß ich auch Bescheid.
LS	Setzt du dir dann auch Ziele, keine Ahnung, die sind im Schnitt 10 Sekunden langsamer auf der Runde, die willst du überholt haben nach dem zweiten Schießen, oder so was auf der Strecke?
AHB	Nein. Also ich habe manchmal geschaut, wer wohl mit mir auf die zweite Runde geht, an wem ich mich orientieren könnte unterwegs. Das habe ich schon mal gemacht, aber ob das dann so weit kommt, das ist ja dann die nächste Frage. Aber ich habe schon geguckt wer da um mich rum ist, an dem ich mich orientieren könnte. Einmal hatte ich das in der WM in Hochfilzen, 2005. Da war die Kathi eine Minute hinter mir gestartet, das war natürlich ein guter Wettkampf dann, mit meinem Weltmeister, aber das war jetzt nicht so abzusehen. Und die Kati war ja eine starke Läuferin in der Zeit und ich dachte, ich möchte nicht überholt werden. Das war das einzige Mal, wo ich mich erinnern kann, dass ich im Vorfeld ein Ziel auf der Strecke hatte.
LS	Und ist es passiert?
AHB	Nein, ich habe dann sogar gewonnen. Ich hatte wahrscheinlich so viel Angst, dass ich so schnell gelaufen bin. Aber ich hatte auch gute Ski.
LS	Dann sind wir schon beim letzten Themenblock. Und zwar Unterschiede zwischen Männern und Frauen. Bevor ich jetzt in irgendeine Richtung gehe, was würdest du sagen, gibt es irgendwelche Unterschiede, die dir über die Zeit aufgefallen sind, in denen männliche und weibliche Athleten sich unterscheiden, wie sie ins Rennen gehen?
AHB	Ah ja, das liegt in der Natur. Also Männer sind erst mal viel schneller und stärker. Da ist nicht so eine Variation da bei den Männern, das sind Männer. Und manche gehen natürlich ein bisschen weicheiig mit Misserfolgen um, aber die meisten nicht. Die sind ein bisschen betrübt, aber bei Frauen, da sieht man das ganze Spektrum. Und das ist bei Männern nicht so groß.
LS	Was Emotionen angeht meinst du?
AHB	Ja. Ich glaube die Frauen sind ein bisschen vorsichtiger, oftmals. Das sieht man am Schießstand, außer bei Doro.
LS	Was meinst du beim Schießstand? Wie sieht man das?
AHB	Na also, so „percised“, jetzt kann ich schon nicht mal mehr deutsch. Na, du hast mich schon verstanden glaube ich.
LS	Was meinst du mit „percised“?
AHB	Also, so akkurat, eben vorsichtiger mit ihren Aktionen. Deswegen ist die Trefferquote aber auch glaube ich ein bisschen höher bei Frauen insgesamt.
LS	Das sehe ich in meinen Daten nicht. Also ich habe da ungefähr wirklich hunderttausend Schießen oder so und ich habe die Verteilung mal gezeichnet.
AHB	Ist das runtergebrochen auf die ersten zehn?
LS	Nein.
AHB	Das würde ich vielleicht noch einmal machen, denn hintendran wird es vogelwild. Oder die ersten dreißig, oder so was, irgendwie, wenn das geht, wenn das einfach, wenn das simpel ist, denn das kann noch einmal einen Unterschied machen. Kann sein, dass das auch nicht der Fall ist. – Ja, erste Runde Massenstart. Das ist eine Katastrophe bei Frauen. Bei Männern ist das eher so ein bisschen geregelter. Obwohl es da auch manchmal eins, zwei gibt, die so ein bisschen unbeliebt sind in der ersten Runde Massenstart. Bei den Frauen sind es mehr als zwei.
LS	Was meinst du mit Katastrophe? Wie äußert sich das?
AHB	Ja, bei Männern ist es so, das Feld ist dichter. Also die Leistungsdichte ist ein bisschen doller, ein bisschen enger und deswegen ist es egal, ob du da vorne bist oder hinten, denn es wird keine Lücke geben. Das weiß man. Und bei Frauen weiß man das nicht. Aber wenn da jetzt jemand startet wie eine Wilde und ihr die Luft dabei ausgeht nach einem Kilometer, da entsteht da eine Lücke und das weiß man und das will man natürlich nicht, da will man natürlich nicht hinten sein. Deswegen ist da so ein Gewühle, dass man die Lücke auch nicht entstehen lassen sollte oder wenn, dann vor der Lücke ist. Und deswegen ist das so ein Gewühle. Das ist nicht schön. Deswegen bin ich lieber vorneweg gelaufen. Das war nicht mein Ding.
LS	Das hat mir die Marion auch erzählt, dass bei den Frauen auf der ersten Runde, das selbst die letzte noch überholen möchte.
AHB	Komisch, jede Frau sagt das, aber alle machen es.
LS	Sie hat behauptet, sie macht es nicht.
AHB	Also bei mir war es so, ich habe keine Lücke entstehen lassen. Ich hatte Angst, also eher Bedenken, dass jemand anderes die Lücke entstehen lässt und ich wollte nicht dahinter sein.
LS	Und in so besonderen Rennen wie Olympia oder WM hast du da irgendwie beobachtet, dass Männer eine andere Herangehensweise haben als Frauen?
AHB	Also die Chance besteht ja nur alle vier Jahre. Da nimmt man sich mal mehr zusammen als beim Weltcup. Denn da ist die nächste Chance nächste Woche.
LS	Okay, dass schaue ich mir alles an in den Daten. Du hast mir sehr, sehr viel weitergeholfen. Jetzt habe ich noch einmal viele neue Erkenntnisse. Das ist wirklich interessant. Ich beende jetzt die Aufnahme.

Appendix 3.9d – Interview with Simon Schempp

Date of the interview	**10.03.2022**
Duration of the interview	**48 minutes**
Interview format	**Video call (Zoom)**
Name of interview partner	**Simon Schempp (SS) – former athlete of DSV**
Name of interviewer	**Leo Schmallenbach (LS)**

Table A3.12 Interview Transcript – Simon Schempp

LS	Dann kommen wir zum ersten Themenblock: „Die Leistungstreiber im Biathlon". Ich bitte dich jetzt an die Zeit zurückzudenken als du noch aktiv warst in diesem Sport. Die erste Frage ist: Mit welchen Zielen bist du in deine Rennen gegangen?
SS	Gut. Das Primärziel ist eigentlich in jedem Rennen dasselbe, dass Du wirklich 100 % aus dem Rennen herausbringen magst, mit den gegebenen Umständen. Also, dass du im Nachhinein zu Dir sagen kannst, ja okay, das sind heute meine 100 % gewesen und mehr ging einfach nicht.
LS	Setzt du dir als Ziel eine bestimmte Zeit, die du erreichen möchtest oder eher eine Platzierung im Vergleich zu den anderen?
SS	So etwas finde ich im Vorfeld relativ schwierig. Eine Zeit schon mal gar nicht, weil man das jetzt in unserer Sportart eigentlich nicht so pauschalisieren kann, weil ja doch die Strecken immer unterschiedlich sind, dann ist die Schneebeschaffenheit eine andere, das Wetter anders, die Bedingungen. Und deswegen ist Zeit schon mal überhaupt kein Anker, den man sich setzen kann und Platzierungen, das ist auch so eine Sache. Ich habe beispielsweise mal ein Rennen gehabt, wo ich dachte, ja mehr ging heute wirklich nicht und ich war zweiter. Und ich habe Rennen gehabt, wo ich gewonnen habe, wo ich vielleicht eine bisschen schlechtere Leistung sogar gezeigt habe. Deswegen sind schon Faktoren dabei, gerade Leistungen von Konkurrenten, die man nicht beeinflussen kann. Und deswegen so Ergebnisdenken ist glaube ich auch von der Herangehensweise nicht immer von Vorteil. Und aus meiner Erfahrung kann ich eigentlich sagen, wenn du, ja schon einfach mit der Einstellung hingehst, dass du aus jeder Situation das Beste machen magst und deine 100 % bringen magst, war für mich eigentlich eine bessere Herangehensweise wie im Vorfeld mir fest vorzunehmen ja, heute muss ich halt gewinnen oder heute will ich gewinnen. Deswegen war jetzt eigentlich so ein Prozessdenken für mich besser als mir jetzt eine Platzierung fest vorzunehmen.
LS	Haben sich denn die Ziele über die Zeit verändert? Also vielleicht als du angefangen hast im Sport bis hin dann zu den letzten und jüngeren Jahren.
SS	Ja mit Sicherheit irgendwo. Wenn man natürlich immer ein größeres Potential hat und auch die Leistungsfähigkeit sich immer weiter entwickelt, hat sich natürlich mein eigener Anspruch deutlich erhöht. Dies auf jeden Fall.
LS	Hast du das auch innerhalb eines Rennens beobachtet, also dass du vielleicht das Ziel in der zweiten, dritten Runde angepasst hast?
SS	Ja, eigentlich schon. Irgendwo war dann, wenn du in der dritten Runde warst, im Sprintwettkampf ist das so zu sagen die Schlussrunde, oder in der Verfolgung oder im Massenstart die fünfte Runde, wenn es wirklich darum geht noch einmal Platzierungen gut zu machen und alles noch einmal aus sich herauszuholen, dann sagst du natürlich okay, die nächsten drei Plätze möchte ich unbedingt noch gut machen. Und das ist schon so. Denn vielleicht bist du in den Wettkampf mit der Einstellung reingegangen, wo du sagst okay, heute möchte ich schon irgendwo vorne ankommen, aber dann hast du halt einfach 3 Fehler geschossen und es war dann nicht mehr möglich, dass du eine ganz vordere Platzierung erreichst. Dann ist im Endeffekt das Ziel: Okay, jetzt bin ich auf Platz 18, drei Plätze vor mir, die Athleten sind nur 3 bis 4 oder 5 Sekunden vor mir, das möchte ich noch schaffen.
LS	Gibt es unterschiedliche Ziele oder Herangehensweisen je nachdem, ob es ein Weltcuprennen ist oder ein Olympiarennen oder zum Beispiel bei der Weltmeisterschaft?
SS	Eigentlich nicht, da gilt eigentlich dasselbe auch wieder, weil die Konkurrenz ist ja genau dieselbe bei unserem Sport, egal ob du im Weltcuprennen läufst oder bei Olympia oder bei Weltmeisterschaften. Bei Weltmeisterschaften und olympischen Spielen ist tatsächlich sogar die Konkurrenz geringer als im Weltcuprennen, denn die Topnationen dürfen im Weltcup sechs Starter an die Startlinie bringen und bei olympischen Spielen oder bei Weltmeisterschaften nur vier. Deswegen, der fünfte oder der sechste Norweger hat häufig auch das Potential irgendwo vorne anzukommen. Deswegen ist tatsächlich ein Weltcuprennen eigentlich schwieriger zu gewinnen als Gold bei olympischen Spielen oder bei Weltmeisterschaften. Aber von der Herangehensweise ist natürlich im Hinterkopf bei Olympia gibt es keine Weltcuppunkte, es geht nur um Medaillen. Also, ob du vierter bist oder achter oder achtzehnter, das ist relativ egal. Da geht es wirklich nur darum bist du bei der Siegerehrung dabei oder nicht. Aber von der Herangehensweise ist auch tatsächlich dort genauso der beste Weg für mich gewesen, wenn ich es so sehe, dass ich halt auch wieder in jeder Situation meine bestmögliche Leistung zeigen kann.
LS	Und zwischen den Disziplinen, gibt es da Unterschiede? Also hast du dir im Einzelrennen ein anders Ziel gesteckt als im Sprint?
SS	Ja schon, weil der Wettkampfmodus ja ein anderer ist. Im Einzelwettkampf oder in einem Sprintwettkampf ist es ja so, dass du in einem 30 Sekundenabstand an den Start gehst und so zu sagen häufig allein gegen die Uhr rennst. Bei Verfolgungswettkämpfen oder Massenstartrennen ist das Rennen ein bisschen mehr von Taktik geprägt und da ist natürlich schon die Herangehensweise und auch wie man so ein Rennen gestaltet schon anders. Gerade bei einem Massenstartrennen, wenn wir zu dreißigst zusammen loslaufen, ja dann muss man sich erst einmal zurecht finden in dem Feld, dann möglichst viele Körner irgendwo sparen, um halt möglichst in den letzten beiden Runden noch zulegen zu können. Und das geht natürlich bei einem Sprintwettkampf nicht, da geht es von Anfang an wer ist einfach der schnellste. Und durch den Wettkampfmodus ist die Taktik vielleicht dann auch schlecht zu vergleichen mit einem Ziel. Aber die Taktik ist einfach anders, wie man sich in einem Wettkampf verhält.
LS	Und was würdest du sagen sind die größten Einflussfaktoren auf deine Leistung im Rennen?
SS	Erst einmal natürlich schon die Verfassung. Die Verfassung setzt sich ja eigentlich aus den letzten Monaten zusammen, vielleicht manchmal sogar Jahren, wie einfach die Vorbereitung zu dem Wettkampf war, sicherlich die Tagesform. Dann aber auch die äußerlichen Bedingungen mit Wetter, Schnee usw. sicherlich auch dem Materialfaktor. Wie gut sind heute meine Skier, wie gut ist heute auch das Wachs, welches auf meinem Ski ist, ist es konkurrenzfähig oder hat man da schon Nachteile? Also Einflussfaktoren gibt es immens große.
LS	Welche Rolle spielt deine Motivation?
SS	Auch eine große. Aber die war, wenn ich es jetzt im Nachhinein so betrachte, nicht allzu sehr schwankend, denn ich war doch viele Jahre im Weltcup unterwegs und wusste das immer schon zu schätzen, was für ein Privileg man eigentlich hat, gegen die Weltbesten anzutreten. Du kannst Wettkämpfe zeigen auf allerhöchster Ebene, auf allerhöchstem Niveau. Also, wenn du da Motivationsprobleme hast, dann bist du schon eher fehl am Platz, denn dann wirst du einfach auch keine gute Leistung zeigen können. Deswegen war das für mich eigentlich immer schon auch ein Reiz mich gegen die Weltbesten durchsetzen zu können, hoffentlich natürlich

	oder sich zumindest gegen die Weltbesten zu messen. Und dadurch war meine Motivation eigentlich schon immer sehr hoch.
LS	Und wenn man jetzt unterscheidet in Laufen und Schießen, was würdest du sagen beeinflusst deine Laufleistung vor allem? Also wir hatten Material, Schnee und Wetterbedingungen. Gibt es noch etwas anderes was deine Laufleistung beeinflusst?
SS	Ja sicherlich. Einfach meine körperliche Verfassung, natürlich. Wie bin ich an dem Tag drauf. Wenn ich eine super Vorbereitung hatte, heißt es nicht, dass ich am Dienstag genauso gut drauf bin wie am Mittwoch. Manchmal läuft die Erholung nicht so gut wie gewollt, manchmal kann man es sich auch gar nicht erklären, warum man vielleicht an dem Tag plötzlich super Beine hat oder einfach schwere Beine. Und deswegen, die körperliche Verfassung ist fürs Laufen schon wahrscheinlich der ausschlaggebende Punkt.
LS	Macht es einen Unterschied, wenn du um dich herum Athleten hast, die in einer ähnlichen Laufform sind?
SS	Da muss man auch total unterscheiden zwischen den Wettkampfarten. Wenn du ähnliche Athleten um dich herum hast bei einem Massenstart beispielsweise, wenn es Mann gegen Mann geht, dann ist es schon von Vorteil, wenn du auf der Runde mit ähnlich guten Leuten unterwegs bist oder sogar einen Tick besseren Läufern, denn dann kannst du dich immer abwechseln bei der Führungsarbeit und dann kann sich der eine mal das ein oder andere Korn sparen, indem er halt einfach den Windschatten nutzt. Und du kannst eigentlich in einer Gruppe natürlich schon die ein oder andere Sekunde gewinnen gegenüber jemand der komplett allein auf der Runde unterwegs ist. Deswegen haben Konkurrenten schon Einfluss auf einen selbst. Und wie gesagt bestmöglich hat man natürlich ähnlich starke oder sogar ein bisschen stärkere Konkurrenz um sich.
LS	Und im Sprint oder Einzel?
SS	Im Sprint oder Einzel wäre es natürlich schön, wenn alle schlechter sind als du. Weil dort geht es ja wirklich Mann gegen Mann im Wettkampf und da ist natürlich die Wunschvorstellung, dass du der stärkste bist und dadurch natürlich einfach einen Vorteil hast.
LS	Aber angenommen, du kommst jetzt aus dem Schießen beim Sprint und merkst zufällig ist bei dir in der Runde, gerade der mit dir geschossen hat, der Fourcade. Ihr lauft zwar beide gegen die Uhr, aber der läuft jetzt vor dir. Macht das was mit dir auf der Runde, wenn es ums Laufen geht.
SS	Klar. Wenn du, sage ich mal, als zweiter auf die Schlussrunde gehst und du kriegst von den Betreuern gesagt, zwei Sekunden vor dir läuft Martin Fourcade oder sonst irgendein Athlet, dann bist du natürlich total im Angriffsmodus. Rein von der kämpferischen Leistung kannst du vielleicht doch noch einmal die ein oder andere Zehntel mehr herausholen, wenn du weißt, okay, es geht um zwei Sekunden. Und der größte Antreiber wäre natürlich noch, wenn du bei der ersten Zwischenzeit 2 Sekunden Rückstand hast und bei der zweiten vielleicht nur noch 0,5 oder vielleicht bist du zeitgleich. Dann weißt du okay, ich habe jetzt schon was gut gemacht, das beflügelt noch einmal.
LS	Also das war das Laufen. Und was würdest du sagen sind die größten Einflussfaktoren auf dein Schießen.
SS	Auf mein Schießen? Ich glaube, über die Einflussfaktoren gerade beim Laufen und Schießen, da könnte man ein Buch schreiben, weil das so vielfältig ist und beim Schießen auch die äußeren Bedingungen. Es gibt zig Windwettkämpfe, wo der eine mehr Wind hat als der andere Sportler, das ist natürlich ein riesiger Einflussfaktor. Dann zählt aber auch beim Schießen die körperliche Verfassung an dem Tag. Du hast Tage dabei, wo du in den Liegendanschlag oder in den Stehendanschlag gehst und dastehst oder daliegst und bist einfach ruhig. Ab und zu ist es wirklich auch gar nicht erklärlich, warum du dann plötzlich am anderen Tag einfach körperlich

	unruhiger dastehst, daliegst und natürlich dadurch deine Waffe auch mehr Bewegung draufhat und es dadurch schwerer wird am Schießstand zu treffen. Hast du manchmal ein sicheres Gefühl schießt du mit 23 oder 25 Sekunden. Am nächsten Tag kann es ganz unterschiedlich sein, plötzlich brauchst du 30 oder 31 Sekunden, weil du einfach unruhiger im Anschlag bist, eine unruhigere Körperposition hast. Das ist natürlich ein großer Einflussfaktor. Und wahrscheinlich ist schon auch ein Einflussfaktor, ob du in einem Sprintwettkampf beim Schießen bist, weil du da eher mehr alleine bist beim Schießen, oder ob du in der Verfolgung oder im Massenstart oder Staffel beim Schießen bist, wenn es wieder Mann gegen Mann geht. Da hat man auch wieder äußere Einflussfaktoren: schießt der andere neben dir schneller, schießt er langsamer, möchtest du ihn unter Druck setzen mit einem möglichst schnellen Schießen oder bist du eher in der abwartenden Position und versuchst dich komplett nur auf dich zu fokussieren und nur dein Ding zu machen, egal was jemand anderes macht oder bist du beim letzten Schießen zu zehnt in einem Massenstart, wo du weißt, okay jetzt geht's um die Plätze 1, 2 und 3.
LS	Bekommst du mit, ob der andere trifft, der neben dir steht?
SS	Man kriegt es schon mit. Es ist sehr schwer alles auszublenden. Manchmal funktioniert es, manchmal geht es nicht. Aber das kommt auf die Situation an. Manchmal bist du in der Lage, okay ich muss es jetzt einfach riskieren, alles oder nichts, dann schießt du mit mehr Risiko oder du bist in der Lage okay, jetzt ein sauberes Schießen und der Wettkampf geht gut zu Ende. Dann bist du mehr auf Sicherheit getrimmt, also Millionen Einflussfaktoren gibt es.
LS	Und mehr Risiko bedeutet schneller schießen?
SS	Risiko bedeutet schneller zu schießen.
LS	Okay. Ja, spannend. Und wenn du jetzt Situationen beschreiben müsstest, in denen du besonders schnell oder besonders langsam schießt, die hängen davon ab, wie viel Druck gerade da ist, so wie ich das verstanden habe.
SS	Genau. Oder ich komme zum Schießstand und merke ich bin heute einfach sicher. Das Gewehr ist ruhig, die Gewehrmündung hat nicht viel Bewegung und ich kann einfach schnell schießen, weil ich gleich wieder im Ziel bin. Es ist auch wieder die körperliche Verfassung, die da auch entscheidend ist über 21 Sekunden oder 28 oder 30 Sekunden Schießzeit.
LS	Dann kommen wir zum zweiten Themenblock, der heißt „Feedback über deine eigene Leistung beim Biathlon". Da würde ich dich zunächst bitten zu beschreiben, welche Art von Feedback du während eines Rennens bekommst. Und Feedback ist hier definiert als eine Rückmeldung über deine eigene Leistung. Also welche Rückmeldung bekommst du während eines Rennens über deine eigene Leistung?
SS	Man bekommt immer die Zeitabstände zugerufen und oftmals natürlich dann auch die dementsprechende Platzierung. Für mich als Athlet, ich wollte immer wissen, wo bin ich, einfach wo befinde ich mich momentan im Feld. Manchmal wusste man es selbst, gerade wenn man Mann gegen Mann im Wettkampf unterwegs ist. Aber gerade in Sprintwettkämpfen hat man ja keine Ergebnisliste vor sich, wo man sich gerade befindet oder den aktuellen Stand. Ich wollte immer wissen, wo ich bin, das gab mir irgendwo immer auch eine gewisse Sicherheit, weil ich einfach wusste, wie es um mich steht. Es gab aber auch tatsächlich Sportler, die wollten während des Einzelwettkampfs bis zur letzten Runde gar nicht wissen, wo sie liegen. Aber bei mir war das so, ich war immer neugierig, ich wollte immer wissen, wo ich bin. Und deswegen geben Betreuer, Trainer an der Strecke einem Zeitrückstände oder Zeitabstände zu Konkurrenten wieder oder die Platzierung, wo man sich gerade befindet. Ja, und irgendwo bei Wettkämpfen, aber ab und zu gerade zum Schluss, Einschätzungen, wie man sich vielleicht bestmöglich verhält, wenn man weiß, okay jetzt geht's gleich um einen Zielsprint oder es wird auf einen Zielsprint hinauslaufen. Gerade wenn man zu dritt in der Spitzengruppe ist, muss

	man noch einmal Gas geben, dass von hinten keine Athleten mehr heranlaufen und wir die drei Plätze unter uns ausmachen können oder ob wir uns einfach taktisch verhalten, dass wir natürlich eine bestmögliche Platzierung im Zielsprint dann haben. Da kann es durchaus auch zu taktischen Anweisungen kommen, wobei ich auf die nie groß was gegeben habe. Denn du hast das eigentlich am besten selbst im Blick, wie die Taktik ist. Du kriegst als Sportler viel mehr mit wie deine Konkurrenten sich im Wettkampf verhalten. Und deswegen wollte ich das immer für mich selbst einschätzen und habe mich da eher an mir selbst orientiert, was jetzt für mich die beste Lösung ist.
LS	Glaubst du, was die Zwischenzeiten angeht, die von den Betreuern durchgegeben werden, dass da alle Nationen gleich gut informiert sind oder die kleineren Nationen, haben die weniger Betreuer und kriegen diese Informationen nicht?
SS	Glaube ich. Ja, da gerade natürlich die Betreueranzahl auch von der Mannschaftsgröße abhängt. Wenn du eine Nation bist, wo du 6 Frauen und 6 Männer an den Start bringen darfst im Weltcup, dann hast du natürlich ein größeres Betreuerteam, wie wenn du in einer Nation unterwegs bist, wo vielleicht 2 oder 3 Männer am Start sind und 2 oder 3 Frauen. Natürlich bekommst du dann in einer großen Nation mehr Feedback auf der Strecke, allein weil du mehr Manpower an der Strecke hast.
LS	Sieht man als Athlet auch was auf der Anzeigetafel steht?
SS	Komplett unterschiedlich. Manche Anzeigentafeln sind auch echt ersichtlich. Man muss sich natürlich dann auch immer, die Zeit oder nicht die Zeit nehmen, aber man muss halt im Vorbeilaufen immer links oder rechts schauen, je nachdem wo die Anzeigetafel ist, um sich da zu informieren. Bei manchen Weltcuporten war es tatsächlich so, dass die Anzeigetafeln gut im Blick waren, gerade neben der Strecke. Man kann es nicht pauschalisieren. Mal schaut man auf die Anzeigetafel, weil man es einfach im Blickwinkel sieht und mal verlässt man sich auf den Trainer.
LS	Und manchmal hört man auch den Stadionsprecher?
SS	Ja genau das stimmt. Ist echt so. Manche Stadionsprecher sind sehr präsent und da hört man definitiv häufig Informationen. Stimmt. Jetzt, wo du es sagst.
LS	Und, wenn du dann dieses Feedback bekommst, was macht das mit Dir? Also, was hat das für einen Einfluss auf dein Laufen?
SS	Auf mein Laufen? Das ist halt einfach so, ich kann mich einordnen. Ich weiß, wie vielleicht auch meine Tagesverfassung ist. Es ist tatsächlich auch das ein oder andere Mal passiert, wo du ein schlechtes Gefühl auf der Strecke hattest, aber du echt gut unterwegs warst. Oder im schlechteren Fall, du hast ein richtig gutes Gefühl eigentlich, aber du bist nicht schnell genug. Für mich gab es da eine Sicherheit, weil ich mich selbst gut reflektieren konnte, was heute irgendwo auch für mich möglich ist. Und deswegen war das einfach für mich schon wichtig und wie gesagt, gerade in den Schlussrunden, wenn man hört, okay, 2 Sekunden auf die nächste Platzierung oder auf den nächsten Sportler hat man Rückstand oder Vorsprung. Und ja, vielleicht gibt das schon noch einen extra Kick.
LS	Und wenn du gesagt bekommst es sind 20 Sekunden Rückstand?
SS	20 Sekunden sind eigentlich gar nicht möglich auf 2 Kilometern oder auf 3 Kilometern irgendwie gut zu machen. Und da wusstest Du okay, dass wird für mich normalerweise nicht mehr möglich sein, außer der Athlet oder der Konkurrent, der stürzt noch, bricht sich den Stock, verliert den Ski, irgendetwas in der Richtung, aber unter normalen Umständen ist das nicht mehr möglich.
LS	Und bekommst du die Abstände nur nach vorne gesagt oder auch was hinter dir passiert?
SS	Total unterschiedlich. Das ist halt so eine Gefühlssache was jetzt wichtiger ist. Nach vorne gibt es noch so einen Anreiz, aber genauso gut okay ich muss unbedingt alles geben, ich muss rennen, bis ich umfalle, denn 2 Sekunden hinter mir kommt gleich der nächste. Das ist einfach so eine Gefühlssache des Betreuers.
LS	Du meinst welche Information der Betreuer dir gibt?
SS	Okay. Der Konkurrent spielt ja auch eine Rolle. Wenn ich jetzt weiß, als Betreuer, 10 Sekunden hinter dem Sportler ist ein ganz starker Läufer, wo es vielleicht noch möglich sein könnte, dass der starke Läufer ihn überholt, dann bekommst du den Vorsprung gesagt. Oder wenn du weißt okay du bist ein starker Läufer bzw. der Betreuer weiß, der Sportler ist ein starker Läufer, und er hat jetzt nur 5 Sekunden oder 10 Sekunden auf die nächste Platzierung, dann bekommt er natürlich den Abstand nach vorne gesagt, denn die Chance besteht noch, dass er den Konkurrenten dann überholen kann im Endklassement.
LS	Und das Feedback, das du bekommst, hat das auch einen Einfluss auf deine Schießleistung? Also du bist vor dem letzten Schießen und du bekommst die Information, dass meinetwegen wie Du es gesagt hast, du 5 Sekunden auf den ersten hast. Macht das was beim Schießen?
SS	Ja. Es gibt ja, wenn du einfach gut im Rennen unterwegs bist, wenn du weißt läuferisch passt es einfach, dann hast du eine Sicherheit und du stehst am Schießstand und du bist nicht unbedingt in der Muss-Situation. Dann bist du nämlich in einer Situation, wo du kannst. Das ist dann eine wesentlich angenehmere Situation am Schießstand, als wenn du vorher schon mit 15 Sekunden Rückstand zum Schießen kommst, und du weißt ich muss treffen, weil sonst wird das heute nichts. Und deswegen macht das definitiv schon einen großen Unterschied, denn es ist wahrscheinlich wissenschaftlich nicht bewiesen, aber ich kann es bestätigen, dass es so ist, wenn du in einer Zwangssituation bist, dass du unbedingt treffen musst, hast du meistens eine schlechtere Trefferquote als in der Situation, wo du zum Schießstand hinkommst, und weißt ich kann halt, um viel zu bewegen heute. Deswegen ist häufig, wenn du eine schlechte Phase auf der Strecke hast, dass es sich auch auf das Schießen überträgt, obwohl, eigentlich im ersten Moment beides nichts miteinander groß zu tun hat. Aber wenn du eine schlechte Phase auf der Strecke hast, sind meistens deine Schießergebnisse auch noch einmal schlechter.
LS	Okay. Weil du es eben angesprochen hast, dass man auch während derselben Runde zwei oder drei Mal Feedback bekommen hat, kann man generalisieren, wo und wie oft man Zwischenzeiten bekommt im Rennen?
SS	Nein, da nicht an jedem Ort oder weil nicht an jedem Platz auf der Strecke dürfen Betreuer stehen. Das sind ja immer vorgegebene Plätze, wo die sich halt positionieren können und es ist vorgeschrieben und nicht frei wählbar, wo wer steht.
LS	Und das ist von Weltcup zu Weltcup verschieden?
SS	Ja, von Weltcup zu Weltcup unterschiedlich. Man kann nicht sagen alle 400 Meter steht jemand oder alle 800 Meter steht jemand, sondern das ist immer abhängig von der Streckengegebenheit.
LS	Ist es dann immer so, dass man direkt nach dem Schießen so eine Station hat oder auch nicht immer?
SS	Schwierig zu sagen. Direkt nach dem Schießen ist es ganz, ganz selten oder fast nie. Eher so nach grob vielleicht 500 Metern, aber das ist wirklich total abhängig. Man kann das überhaupt nicht generalisieren.
LS	Also im Fernsehen sieht man ja die Zwischenzeit immer direkt nach dem Schießen, die kriegt ihr nicht mit?
SS	Nein. Außer mal die Leinwand oder die Anzeigetafel ist irgendwie gut einsehbar, wenn man vom Schießstand wegläuft, dann kriegt man es vielleicht mit, wenn man darauf achtet. Aber sonst muss man erst einmal schon ein bisschen warten bis man dann seine Platzierung oder seinen Rückstand/Vorsprung, was auch immer, dann von den Betreuern mitbekommt.

LS	Und die Betreuer geben dir aber die Zeit von dieser Zeitmessung nach dem Schießen durch, oder haben die ihre eigene Zeitmessung?
SS	Ja, im Weltcup ist es so, dass du ja Transponder am Bein hast, dass es dann auch Zeitmessungen auf der Strecke gibt. Händisch ist es nicht möglich oder macht eigentlich keiner, weil viel zu viele Starter am Start sind, dass du da alles im Blick hast, ist dann auch nicht genau genug. Deswegen bekommst du meistens vom Betreuer immer die Zeit, die von der letzten Zwischenzeit vor dem Platz, wo der Betreuer halt steht.
LS	Und das ist dieselbe Zwischenzeit wie im Fernsehen. Also die Zeitmesspunkte aus dem Fernsehen sind so zu sagen auch die, die ihr bekommt. Mehr gibt es nicht?
SS	Ja, im Fernsehen werden nicht immer alle Punkte gezeigt, wo die Messungen sind.
LS	Ah okay.
SS	Im Biathlon gibt es eine IBU-App, so ein Datacenter, wo man die Zwischenzeiten einsehen kann, wo halt der Veranstalter seine Schleifen gelegt hat, um Zwischenzeiten zu nehmen und daran orientiert sich eben jeder Betreuer.
LS	Okay. Sind die Starter im IBU-Cup-Rennen, das ist ja die zweite Liga vom Biathlon so wie ich das verstehe, gleich gut informiert?
SS	Ich glaube nicht, da gerade in den zweiten Mannschaften weniger Manpower unterwegs ist. Dadurch glaube ich nicht, dass die gleich gut informiert sind. Weil weniger Betreuer auf der Strecke sind und es gibt wahrscheinlich pauschal gesagt schon auch weniger Zeitmessungen innerhalb einer Runde. Weltcup ist hoch professionell und dann stuft es sich halt auch immer ab wie in der Bundesliga beispielsweise von Liga zu Liga geht es auch von der Professionalität immer weiter runter.
LS	Ja. Dann Themenblock 3: „Die relevante Vergleichsgruppe“. Mit wem vergleichst du deine eigene Leistung im Wettbewerb?
SS	Oh, das ist ganz schwer zu sagen. Das ist abhängig davon, ob du im Gesamtweltcup irgendwie gut platziert bist, dann vergleichst du dich natürlich mit denjenigen, die nahezu gleich mit dir platziert sind. Dann aber auch so, wenn du vielleicht zwanzigster bist, du möchtest aber irgendwo einer der weltbesten sein, dann vergleichst du dich trotzdem mit den weltbesten. Aber genauso gut mit denen, die vielleicht neunzehnter, zwanzigster, einundzwanzigster sind. Wahrscheinlich schon mit dem kompletten Feld. Je nach Leistung, wenn du weiter vorne platziert bist, natürlich schon eher mit der vorderen Hälfte oder mit den vorderen zehn, wenn du einer von denen bist. Wenn du achtzigster bist, kann man vielleicht sagen vergleichst du dich mit neunzig. Wenn du zwanzigster bist, vergleichst du dich mit dreißig vielleicht. Und wenn du so ein Überflieger bist wie Martin Fourcade, der hat halt seine drei, vier Leute wahrscheinlich, die ihm gefährlich werden könnten und die hat er halt am meisten auf dem Schirm. Also da kann ich eigentlich nichts pauschal sagen.
LS	Und in einem Rennen würdest du aber die Zwischenzeiten im Vergleich zu den Leuten, die um dich herum platziert sind, bekommen?
SS	Genau.
LS	Nicht zum Führenden, wenn du nicht vorne in der Gruppe bist?
SS	Wenn der führende 1 Minute weg ist, das bringt mir ja gar nichts. Sondern, da ist eher in deinem engen Umfeld.
LS	Und die Frage hast du glaube ich schon ein bisschen beantwortet. Die Gruppe hat sich über die Jahre in dem Sinne verändert, dass wenn du ein gutes Leistungsvermögen hattest, du dich eher nach vorne verglichen hast und dann je nachdem wie es halt läuft.
SS	Ja, genau.
LS	Dann Themenblock 4: „Rahmenbedingungen und Regularien“. Ich habe mir die Regelhandbücher durchgelesen und habe aber trotzdem noch ein paar offen Fragen, weil die alten nicht aktuell einsehbar sind. Welchen Einfluss haben die Athleten im Sprint bzw. im Einzel auf ihre Startnummer? Ich weiß, dass gelost wird innerhalb der Startgruppen und man sich Gruppen zuordnen kann. Bis zu 3 Athleten aus einem Land dürfen in eine Startgruppe oder, wenn man unter den Top 15 im Weltcup ist.
SS	Genau, dann ist es noch abhängig bin ich in einer Nation, die 6 Starter hat und sind von den 6 Startern beispielsweise 2 nur in den Top 10 oder Top 15. Das sind so Regeln, die kann ich dir auch gar nicht so richtig genau sagen, weil die sich auch immer ändern.
LS	Okay.
SS	Das was ich noch weiß: Zu meiner Zeit war es meistens so, dass halt die Top 15 glaube ich waren es oder Top 10 sogar, dass die frei wählen konnten. Und dann aber eine Top-Nation, die 6 Starter hat und sagen wir mal von dieser Top-Nation sind 2 in den Top 10 platziert und 4 weitere nicht. Dann musst du als Top-Nation jede Startgruppe besetzen, mit einem Sportler. Das heißt, die 2 dürfen frei wählen in welche Gruppe und bei den anderen vieren muss einer in die Eins, einer in die Zwei, der nächste in die Drei und der letzte halt in die Vier, wahrscheinlich, wenn es normal von den Bedingungen ist. Es muss auf jeden Fall von einer Top-Nation jede Gruppe besetzt werden, außer du hast halt einfach wirklich 3 ganz vorne drin, dann kann es wegfallen, so dass die 3 frei wählen dürfen und dann musst du die anderen 3 in 3 verschiedene Gruppen einteilen. Also das ist unheimlich komplex. Ich gehe mal davon aus, dass viele Trainer das nicht einmal checken, die eigentlich dafür verantwortlich sind, dass bei der Meldung abzugeben.
LS	Ich habe gelesen, dass der Teamkapitän dafür verantwortlich ist. Ist das ist ein Trainer und kein Athlet?
SS	Das ist meistens der Bundestrainer, der halt die Sportler fragt, ab und zu, grad halt die guten, in welche Gruppe möchtest du gehen, das ist dann natürlich abhängig von den Bedingungen, welche Gruppe du dann wählst. Und je nachdem je schlechter das du bist, desto weniger Entscheidungsmöglichkeiten hast du natürlich.
LS	Und weißt du, also angenommen du bist jetzt im Team Deutschland, du sagst jetzt dem Bundestrainer ich möchte gerne in die Gruppe so und so, weißt du dann auch was die anderen Konkurrenten für eine Gruppe wählen?
SS	Gerade wenn es schwierige Bedingungen hat und du dir nicht sicher bist, ist jetzt die Eins besser, die Zwei oder die Drei oder vielleicht die Vier, dann beredest du das schon eigentlich teamintern ein bisschen. Jetzt nicht in der großen Runde, sondern das entscheidest du ja im Training davor oder einen Tag zuvor, weil dann die Meldung ja abgegeben wird. Dann kann es schon mal sein, Arndt Peiffer beispielsweise was nimmst du für eine Gruppe und holst dir da ein bisschen Feedback. Oder was auch sehr sinnvoll ist und was häufig passiert ist, dass du halt zu den Technikern hingehst und fragst morgen ist ja Schneefall angesagt, die erste Gruppe ist ja wahrscheinlich nicht von Vorteil, wahrscheinlich ist die zweite oder dritte Gruppe besser. Von denen holst du auch noch Feedback ein und es ist durchaus möglich, dass du dann mit den Trainern dich auch noch kurzschließt und dich mit denen noch einmal austauschst, und dann entscheidest du selbst.
LS	Aber du würdest nicht Athleten aus anderen Nationen fragen?
SS	Nein, das ist nie vorgekommen. Mich hat z.B. auch nie ein ausländischer Athlet dann gefragt: Morgen welche Gruppe?
LS	Ist es denn vorgekommen, dass du die Startliste bekommen hast, und du gedacht hast, warum geht der denn in die erste Startgruppe?
SS	Ja, das ist schon vorgekommen, gerade bei schwierigen Bedingungen, wenn du dann siehst, was, okay der geht auf Risiko, der geht halt dann in die Eins beispielsweise. Oder ah, okay der

	verspricht sich in der letzten Gruppe werden die Bedingungen besser, weil vielleicht die Sonne weg ist und er vermutet, dass er da schneller ist, dann geht er in die Vier, das kann auch sein.
LS	Würdest du sagen, dass dann in der Regel, die die wählen können, schon in der gleichen Gruppe sind?
SS	Grob ja, aber es gibt immer Ausreißer.
LS	Dann sind wir auch schon im fließenden Übergang zum letzten Themenblock: Und zwar ist das die Startnummer im Sprint bzw. Einzel. Bist du früher lieber früh oder spät gestartet im Rennen?
SS	Wenn es normale Verhältnisse hatte, ohne Schneefall, tiefe Bedingungen oder sonst irgendwas, war es mir immer recht ganz vorne zu starten. Ja. In der ersten Gruppe, in der zweiten Gruppe.
LS	Warum?
SS	In der ersten Gruppe, weil du halt einfach weniger Betrieb auf der Strecke hast, du kannst dein Rennen machen. In der zweiten Gruppe, vielleicht magst du auch, wenn ein bisschen mehr Betrieb auf der Runde ist, dass du vielleicht einfach mal Lücken schließen kannst, dich kurz vielleicht mal im Windschatten ausruhen kannst bzw. dich an jemanden ran hängen kannst. Also die zwei Gruppen habe ich favorisiert, aber mehr sogar die Gruppe Eins als die Gruppe zwei.
LS	Bist du damit allein oder würdest du sagen, das sehen die meisten Athleten so?
SS	Wenn man die Wettkämpfe verfolgt, kann man glaube ich schon pauschal sagen, dass die ersten beiden Gruppen allgemein favorisiert werden und dass die Topfavoriten immer in der ersten oder zweiten Gruppe sind, wenn es einfach normale Verhältnisse hat.
LS	Und glaubst du, die Startnummer hat einen Einfluss auf deine Leistung? Auch hier getrennt nach Laufleistung und Schießleistung.
SS	Auf die Schießleistung hat es keinen Einfluss. Laufleistung, also wenn ich normale Bedingungen habe, dann sage ich mal, renne ich natürlich rein vom Potential gleich in der ersten Gruppe oder in der dritten Gruppe. Aber es gibt halt andere Faktoren, die dies beeinflussen können, gerade mit dem Verkehr auf der Strecke oder auch einfach bedingungsmäßig, es hat Schneefall. Dann ist klar, wenn du in der Gruppe Eins bist, bist du Spurgerät und hast natürlich schlechtere Bedingungen als die Leute, die dann mit Startnummer 30, 40 ins Rennen gehen, wenn vielleicht das ein oder andere schon plattgedrückt ist. Deswegen hat eine Nummer bei Laborbedingungen glaube ich keinen Einfluss darauf, wie du im Rennen dann agierst. Nein, nicht wie du im Rennen agierst, aber wie du halt einfach von der Belastung im Rennen dann unterwegs bist, aber die Bedingungen können dann Einfluss nehmen, ob deine Nummer Einfluss hat auf deine Geschwindigkeit.
LS	Und angenommen, du hast dich für eine Startgruppe entschieden, sagen wir jetzt mal die Eins, dann wird gelost und du wirst auf die Eins gelost. Also du startest als allererster im Rennen. Würde dich das freuen?
SS	Also die Eins hast du natürlich gerne angenommen in der Verfolgung oder in einem Massenstart. Aber da ist immer so im Hinterkopf, du entscheidest dich für die Startgruppe Eins und hoffst immer du hast aber nicht die Eins. Ab Zwei, Drei ist eigentlich gar kein Problem, aber die Eins möchte man eigentlich nicht. Also das war immer so ein bisschen die Angst oder das war immer so im Hinterkopf, das Bibbern und Bangen bei der Auslosung, ja hoffentlich habe ich halt nicht die Eins.
LS	Und warum?
SS	Du hast halt gar keinen Anhaltspunkt, gerade in der ersten Runde und auch in der zweiten Runde bist du dann wieder normalerweise, wenn du keine 3 Fehler oder 5 Fehler schießt, bei der Zwischenzeit immer der erste. Und du kriegst dann immer Zeiten von zuvor und nichts Aktuelles und deswegen ein Rennen zu eröffnen im Einzel oder im Sprintwettkampf ja, das mag glaube ich keiner.
LS	Weil das dann auch einen demotivierenden Effekt hat auf dich?
SS	Nein.
LS	Du hast keinen Vergleich?
SS	Nein, demotivierend ist es nicht. Aber es ist einfach nur vom Vergleich her und es gibt dir einfach ein bisschen ein besseres Gefühl, wenn schon einer die Zeit halt vorgegeben hat.
LS	Also angenommen, du entscheidest dich für die Startgruppe Eins, die Laborbedingungen sind da, was wäre dann eine gute Auslosung?
SS	Ich sage mal bei Laborbedingungen ab Startnummer 15 bis 22, so was. Oder vielleicht 12 bis 22, so was. Das sind tolle Nummern.
LS	Und weißt du wer vor dir gestartet ist? Also auch im Einzel oder im Sprint. Du siehst ja die Athleten nicht unbedingt auf der Strecke. Aber hast du dir vorher die Startliste angeschaut und du weißt vor mit ist der und der?
SS	Ja, also du schaust dir immer die Startliste an, um dich auch so ein bisschen zu orientieren. Das ist ein Teil von der Wettkampfvorbereitung. Du schaust, okay wo sind so meine Konkurrenten oder die härtesten Konkurrenten irgendwo verteilt. Einfach aus Interesse. In welche Gruppe ist der ein oder andere gegangen, gab es Überraschungen und dann natürlich schon auch als Wettkampfvorbereitung, du hast jetzt sage ich mal die Startnummer 20 und vor dir sind schon 5 Favoriten. Dann weißt du, okay hinter dir ist noch der und der Favorit. Wenn du ein gutes Rennen hast, der könnte noch gefährlich werden. Und du weißt im Rennen 5 Favoriten sind schon vor dir unterwegs gewesen und du kriegst die Zwischenzeit, du bist Erster und du weißt, es ist ein gutes Rennen, weil einfach schon 5 richtig gute vor dir waren, bei der Zwischenzeit aber hinter dir platziert sind. Als Orientierung ist das immer von Vorteil und das macht man auch, dass man sich die Startliste immer anschaut.
LS	Und wäre dir lieber, dass die Konkurrenten vor dir starten?
SS	Teils, teils. Es ist schon von Vorteil, wenn richtig gute schon vor dir gestartet sind. Einfach von der Orientierung her. Es muss aber nicht jeder Konkurrent jetzt vor dir starten. Konkurrenten sind ja hundert unterwegs irgendwo, aber halt so die wichtigsten für einen selber.
LS	Glaubst du es gibt Unterschiede zwischen Männern und Frauen, wie sie auf diese Startnummern reagieren, also wie sie die Startnummer wählen und wie wichtig ihnen das ist früh einen guten oder nicht so guten Vergleich zu haben?
SS	Tja, das ist eine gute Frage. Ich glaube, aber das ist nur so die eigene Meinung, dass unter Männern der Konkurrenzkampf untereinander und das Mann gegen Mann noch einmal ausgeprägter ist. Und dadurch glaube ich, dass bei Frauen die Startnummer Eins vielleicht nicht so blöd empfunden wird wie bei Männern. Weil, wenn man Mann gegen Mann oder Frau gegen Frau Wettkämpfe anschaut, bei Mann gegen Mann ist es meistens wirklich so 5 Männern sind zusammen, die haben alle das gleiche Ziel möglichst schnell irgendwo hinzukommen und die wechseln sich dann ab, auch in Führungsarbeit, und versuchen irgendwie auch meistens gemeinsam zu arbeiten. Sind 5 Frauen unterwegs, wenn die Strecke enorm breit wäre, die würden zu fünft nebeneinander laufen. Und das fällt halt auf und ich glaube, es könnte schon eine verschiedene Einschätzung bezüglich der Startnummern geben im Vergleich von Frauen zu Männern.
LS	Ja, interessant. – Das waren die Fragen. Der letzte Themenblock ist „Sonstiges". Wenn dir noch irgendetwas einfällt zur Rolle von „Feedback Startnummern Biathlon" was du los werden möchtest, wäre das jetzt die Gelegenheit.
SS	Ja, es ist eigentlich so, ich finde es halt interessant, weil über ein paar Dinge hat man sich selbst eigentlich nie so Gedanken gemacht. Aber das eine ist halt einfach die Wissenschaft und das

	andere ist das Praktische. Und gerade jetzt, das mit den Startnummern, gerade auch zwischen Männern und Frauen, ja das ist eigentlich irrelevant für einem selbst im Wettkampf, aber für die Wissenschaft ist es hoch interessant. Aber ich fand die Fragen wirklich gut und wie gesagt macht man sich nun über ein paar Sachen mehr Gedanken, weil man es von einem anderen Blickwinkel sieht.
LS	Dann vielen Dank für deine Zeit und die super interessante Einblicke. Ich werde jetzt die Aufnahme beenden.

Appendix 3.9e – Interview with Marion Wiesensarter

Date of the interview	**03.06.2022**
Duration of the interview	**38 minutes**
Interview format	**Video call (Zoom)**
Name of interview partner	**Marion Wiesensarter (MW) – active athlete of DSV**
Name of interviewer	**Leo Schmallenbach (LS)**

Table A3.13 Interview Transcript – Marion Wiesensarter

LS	Kommen wir zu Frage 1: Kannst du mir mal beschreiben mit welcher Motivation du in ein Rennen gehst. Also welches Ziel setzt du dir vor dem Rennen und setzt du dir z.B. absolute Ziele, dass du sagst du brauchst eine bestimmte Zeit oder eher relative Ziele, so dass du sagst ich möchte einen bestimmten Rang erreichen?
MW	Also bei mir kann man das eigentlich schon ein bisschen trennen. Beim Schießen sind es eher absolute Ziele, so dass man sagt, wenn z.B. auch kein Wind ist, das ist ja immer unterschiedlich, dann heute maximal ein Fehler oder eigentlich am besten heute Null Fehler. Und beim Laufen hängt es davon ab, weil jeder weiß immer selbst am besten wie fit er ist und dann gibt es auch während des Winters lange Phasen, wo man einfach merkt man ist nicht ganz so fit und dann kann man das einschätzen, dass man sagt, heute wäre ich mit dem 10. Platz voll zufrieden. Oder wenn man richtig fit ist, dass man sagt ich will unbedingt aufs Stockerl. Ich würde das immer so ein bisschen trennen wie man selbst drauf ist und wie z.B. die äußeren Bedingungen sind, denn das spielt ja beim Biathlon auch viel mit rein. Manchmal ist es einfach extrem windig und da hat man vielleicht schon ein absolutes Ziel, aber nicht so wie normal. Da sagt man ich wäre total zufrieden, wenn ich 80 % der Scheiben treffe, und das ist bei normalen Rennen, wo kein Wind ist, eigentlich viel zu wenig. Also beides eigentlich.
LS	Also beim Schießen eher ein absolutes Ziel wie du gesagt hast Fehler minimieren und beim Laufen eher an den anderen orientieren.
MW	Genau. Schießen ist eigentlich immer ein absolutes Ziel.
LS	Und haben sich deine Ziele über die Zeit verändert? Du bist jetzt glaube ich auch schon ein paar Jahre dabei und wenn du da zurückdenkst an dein früheres ich, hat sich über die Zeit da etwas getan?
MW	Ja, auf alle Fälle. Je länger man das macht, desto besser wird man ja und dann läuft man ja in verschiedenen Ligen. Ich laufe hauptsächlich IBU-Cup und war nur manchmal im Weltcup. Und früher war man halt nur zu Juniorenrennen und wenn man z.B. zum ersten Mal beim internationalen Juniorenrennen war, dann hat man das nur schlecht einschätzen können. Da war man vielleicht schon zufrieden mit einem Top 20 Platz, aber wenn man öfter dabei war, dann hat man doch mehr gewollt. Und genauso, wenn man im IBU- oder im Weltcup als junger Athlet am Anfang startet, da will man erst mal so schauen, wo man steht, und dann entwickelt sich das natürlich auf alle Fälle, dass man immer bessere Platzierungen erwartet. Da kommen mit der Zeit schon absolute Ziele.
LS	Startest du mit anderen Zielen, je nach dem in welcher Disziplin du unterwegs bist?
MW	Also ob es jetzt ein Sprint oder Einzel oder so ist?
LS	Ja.
MW	Ja, eigentlich so direkt nicht. Vielleicht so ein bisschen indirekt, denn man hat ja doch irgendwie so seine Lieblingsdisziplinen. Ich mag ganz gerne Massenstarts und wenn man das total gerne mag, dann weiß man auch oder dann ist man meistens auch ziemlich gut darin, denn das macht ja doch viel im Kopf. Unser Sport ist ja sehr mental und wenn man da schon so motiviert rein geht, weil man es einfach mag, dann setzt man sich vielleicht schon höhere Ziele als wie jetzt beim Sprint, den man auch gerne mag, aber der jetzt nicht so das absolute Lieblingsrennen ist. Also indirekt würde ich jetzt sagen. Aber grundsätzlich will man ja immer eine gute Leistung erreichen. Aber vielleicht schon je nach dem, wenn es eher so deine Favoritendisziplin ist, vielleicht ein bisschen mehr noch.
LS	So dass man sich in der Lieblingsdisziplin sogar höhere Ziele setzt?
MW	Ja.
LS	Aber du würdest sagen im Sprint gehst du genauso, dass du sagst Schießen so gut es geht und Laufen so schnell es geht?
MW	Ja, genau. Immer. Immer das gleiche. Aber oftmals ist es ja gerade so, wenn man sich quasi nach Platzierungen das Ziel setzt und bei seiner Lieblingsdisziplin hat man die ja oft, da man die Male zuvor immer total gut war, dann weiß man ja schon okay das ist genau mein Ding, z.B. so Mann gegen Mann, das mag ich total gern oder Frau gegen Frau dann eben. Und da hat man auch mehr Selbstbewusstsein finde ich und traut sich da vielleicht eher ein bisschen ein höheres Ziel zu setzen und nicht jetzt irgendwie heute Top 5, sondern ja, heute schon Stockerl, weil ich weiß, das kann ich.
LS	Du hast ja auch Juniorenweltmeisterschaften und Weltmeisterschaften gemacht, wo es dann wirklich darauf ankommt unter die Top 3 zukommen. Geht man in so Rennen mit einem anderen Ziel als in ein normales IBU-Cup-Rennen?
MW	Ja, auf alle Fälle. Es ist einfach so. Es ist zwar manchmal finde ich ein bisschen schade, weil der 4. Platz ist ja auch gut. Aber es ist halt einfach was Besonderes und es ist auch irgendwie cool, weil wenn man es dann geschafft hat, dann ist es ja mehr besonders als nur ein normaler Stockerlplatz beim IBU-Cup oder beim normalen Weltcuprennen. Also da ist meist, wenn man sich fit fühlt und dementsprechend gut drauf ist und man es sich zutraut, dann schon auf alle Fälle der volle Fokus nur auf Medaille. Das ist einfach so. Das wird einem aber auch mit den Jahren von außen schon mitgegeben. Aber als Sportler selbst erlebt man das auch von innen irgendwie. Klar der Druck von außen kommt schon auch, aber das entwickelt sich so über die Jahre einfach so von selbst.
LS	Gehst du dann in solchen Rennen mit einer anderen Strategie an den Start?
MW	Ja, tatsächlich. Manchmal, da versuche ich mehr Entspannungsübungen zu machen, durch Atemübungen. Meistens bin ich persönlich so, dass ich es halt irgendwie zu krass will und dann einfach nur noch total verkrampfe und dann geht einfach gar nichts mehr.
LS	Und das gilt dann auch fürs Laufen und fürs Schießen gleichermaßen oder betrifft das nur eine Disziplin?
MW	Nein, das gilt bei mir gleichermaßen. Da gibt es sicher Unterschiede. Manche haben einfach nur beim Schießen immer Probleme, beim Laufen nie. Aber bei mir ist es beim Laufen auch, weil da verbringt man ja doch so viel Zeit an der Strecke und du hast viel Zeit nachzudenken, was man ja eigentlich nicht machen soll, aber es ist halt so. Und da merke ich dann, dass wenn ich unbedingt will, dass ich die Medaille erreiche, schon im Vorfeld, okay das ist ein Ziel, das ich schaffen kann, aber es kippt gerade so ein bisschen über, dass es eher mich nicht mehr motiviert, sondern zu sehr unter Druck setzt.
LS	Hat das einen Einfluss auf deine Schießzeit?
MW	Nein, auf die Schießzeit würde ich persönlich bei mir sagen nicht. Mittlerweile bin ich ja auch im Vergleich zu vor ein paar Jahren schon schneller im Schießen im gesamten Feld.

	Und das trainiert man im Sommer ja auch. Ich bin jetzt nicht die absolute Schnellschützin, aber es geht eigentlich ganz gut und da habe ich mich schon immer recht gut im Griff, denn ich weiß genau, wenn ich das so und so mache und schieße, da fühle ich mich gut, da kann ich treffen. Und wenn es halt doch schneller ist, dann fühl ich mich einfach nicht mehr sicher. Da bin ich aber relativ entspannt in der Schießzeit.
LS	Du versuchst überall immer gleich schnell zu schießen?
MW	Ja, aber das ist von den äußeren Faktoren abhängig. Manchmal ist es wie vorhin gesagt windig und da muss man einfach abwarten. Aber mich stresst so etwas nicht, weil das habe ich oft im Training, da hat man ja auch Wind, da trainieren wir das auch. Und ich denke mir wichtig ist für mich einfach der Treffer und nicht, dass ich vielleicht 2 Sekunden schneller schieße.
LS	Ja. – Okay dann kommen wir zum zweiten Block. Das haben wir eben schon ein paar Mal angeschnitten, und zwar die Einflussfaktoren während eines Rennens. Als erstes: Wie wichtig glaubst du ist deine eigene Motivation für deine Leistung?
MW	Ich finde extrem wichtig. Also bei mir persönlich ist es so, wie glaube ich bei fast allen Sportlern, dass man wirklich immer sehr hoch motiviert ist, aber manchmal vielleicht dazu tendiert zu viel zu wollen. Und dann wie vorhin schon erklärt, dann kippt das so ein bisschen über, wenn man zu viel will. Und man muss ja die gewisse Gelassenheit auch mitnehmen und das gewisse Selbstbewusstsein dann auch. Das ist eigentlich bei mir schon oft mal eher ein Problem. Also ich finde das sehr, sehr wichtig.
LS	Und wenn du jetzt unterscheidest zwischen Laufen und Schießen was beeinflusst deine Laufleistung am meisten?
MW	Klar meine Fitness. Aber eigentlich das mentale. Die Trainer stehen ja an der Strecke – oder die Techniker oder so – und man bekommt da ja immer Zeiten zugeschrien oder du bist jetzt auf Platz 3. Manchmal startet man raus und die stehen nach einem Kilometer oder so und man denkt, ah irgendwie fühlt es sich heute nicht so gut an und du hast aber trotzdem die schnellste Angangszeit. Also wo ich mir auch oft denke, das wäre eigentlich jetzt einfach schön mal loslaufen und nicht zu sehr in sich reinhören oder dass man das nicht zu ernst alles immer nimmt. Also beim Laufen auf alle Fälle das mentale, weil man halt im Wettkampf viel Zeit mit sich verbringt.
LS	Und beim Schießen?
MW	Ja, Schießen ist auch mental. Eigentlich ist ab einer gewissen Leistung, die halt alle bringen, für mich sehr krass das mentale wo immer mit reinspielt. Beim Schießen auf alle Fälle, denn du musst schnell sein und du musst treffen. Das ist ja das Einzige was da zählt. Du kannst natürlich versuchen durch Technikelemente, dass man halt sauber abzielt oder so, das ein wenig auszublenden, so dass es nicht überhandnimmt, aber das ist genau wie beim Laufen, dass man immer sagt, den Arm hoch machen oder ganz banale Sachen sind das oft. Aber dann ist es ja schon wieder ein mentales Spiel irgendwie.
LS	Beeinflussen dich die anderen Athleten, z.B. beim Schießen, die die um dich herumlaufen oder beim Schießen neben dir liegen oder stehen?
MW	Manchmal. Nicht immer. Aber manchmal schon. Also sagen wir mal so, jetzt beim Massenstart, wo man nebeneinander schießt, die ersten zwei Schießen vielleicht nicht unbedingt, weil da kann wirklich noch viel passieren, aber dann zum Schluss raus schon. Man hört ja auch oder je nachdem wo man ist, wenn der andere einen Fehler schießt oder auch nicht. Oder wenn jemand schneller schießt und dann beeinflusst es einem schon.
LS	Auch wenn man gleichzeitig am Schießstand ist, kriegst du mit was der neben dir schießt?
MW	Ja, sollte man zwar nicht, aber ich bekomme das mit. – Aber ich glaube, das bekommt jeder mit. Also alle, die sagen, sie sind da komplett bei sich, das glaube ich immer nicht so genau.

LS	Das habe ich auch schon öfter gehört. Ich glaube der Benedikt Doll oder Simon Schempp meinte das man das am Klang der Scheiben hört.
MW	Ja genau. Da hört man, ob das ein Treffer oder ein Fehler ist.
LS	Gibt es Situationen, in denen du besonders schnell schießt?
MW	Ja, beim letzten Schießen. Da schon oftmals oder wenn man mit mehreren zusammensteht. Wie vorhin gesagt, die ersten Male Schießen, die stressen einem nicht so, aber wenn man weiß, okay jetzt muss man noch einmal Gas geben. So ganz extrem bin ich da jetzt auch nicht, weil wie vorhin schon erklärt, kann ich das eigentlich ganz gut händeln, dass ich da das mache, was ich gut kann, normal schießen einfach. Aber ich kann auch schon ein bisschen schneller schießen, wenn ich denke das ist trotzdem noch in einem guten Rahmen. Aber davor würde ich das nicht immer so drauf anlegen, wenn es gerade keinen Grund dafür gibt. Wenn man noch beim Ersten Schießen ist, denke ich mir dann schieße ich 2 Sekunden schneller und habe einen Fehler mehr. Also lieber beim letzten ein bisschen mehr Risiko eingehen.
LS	Also du würdest sagen, je schneller du schießt desto höher auch die Wahrscheinlichkeit das etwas daneben geht?
MW	Ja, auf alle Fälle. Es gibt da so einen gewissen Spielrahmen. Natürlich, wenn du zu langsam schießt und dann jeden Schuss auszielst, dann ist man manchmal zu lange auf der Scheibe und drückt ihn dann auch wieder weg. Aber es gibt einen Rahmen, wo man sich wohlfühlt, und dann kann man schon schneller schießen, aber dann steigt das Risiko schon sehr extrem. Das ist so wie bei einer Waage, finde ich.
LS	Ja.
MW	Du trainierst es und wenn du schneller schießt, dann können eben mehr Fehler passieren.
LS	Du hast eben beschrieben, dass du beim Laufen schon mal das Gefühl hast, die Techniker geben dir eine Zeit durch, und du denkst oh das ist aber jetzt schneller als gedacht. Ist das beim Schießen ähnlich, dass du manchmal denkst, jetzt habe ich schnell geschossen und es war dann extrem langsam oder umgekehrt, dass du dachtest du schießt langsam, es war aber extrem schnell?
MW	Also unter dem Wettkampf eigentlich nicht, denn beim Schießen geht doch alles relativ schnell vorbei und da bekomme ich das nicht mit. Nur manchmal schaust du dir danach die Auswertung an und du denkst ach krass habe ich doch so schnell geschossen, das hat sich gar nicht so schnell angefühlt und war ja ganz gut, was ja dann manchmal auch gut für das eigene Selbstbewusstsein ist. Zum Beispiel wie letztes Jahr gegen Ende, da ist es bei mir beim Schießen ganz gut gegangen, da habe ich oftmals unter 20 Sekunden stehend geschossen und das hat sich eigentlich gut angefühlt und das ist dann für einem selbst für die nächsten Rennen gut für das Selbstbewusstsein.
LS	Okay, dann sind wir schon beim nächsten Block. Und zwar, das hast du eben schon angesprochen, wenn du im Rennen bist, kriegst du von außen Zwischenzeiten durchgegeben. Auf welche Informationen achtest du während des Rennens vor allem von außen?
MW	Meine Platzierung und je nachdem auf den Zeitrückstand oder -vorsprung. Die Zeit natürlich und eigentlich immer nur im Vergleich zu anderen kann ich sagen. Die Platzierungen im Vergleich zu anderen und die Zeit auch im Vergleich zu anderen.
LS	Und eher nach vorne oder eher nach hinten?
MW	Nach vorne. Also wir bekommen eigentlich nur die Zeit nach vorne. Außer so wie letztens, da war ich erste, da habe ich auch die Zeit nach hinten durchgesagt bekommen. Das ist ja dann auch irgendwie wichtig, weil manchmal muss man sich da noch einmal richtig quälen, aber wenn man einen richtig krassen Vorsprung hat, dann würde man schon zügig Laufen, aber man weiß, man kann es schaffen ganz normal.

LS	Gibt es da Unterschiede zwischen den Disziplinen, worauf man besonders achtet?
MW	Nein, das würde ich jetzt nicht sagen. Also höchstens beim Einzel, aber den gibt es ja nicht mehr so oft, denn da bekommt man ja auch pro Fehler eine Minute Strafzeit und wenn man da irgendwie Erster ist, weil man Null geschossen hat und andere total viele Fehler und die Nächste ist dann 2 Minuten hinter dir, ja das passiert eher selten, aber das kann schon mal passieren, dann läufst du natürlich entspannter ins Ziel, wenn du weißt es kommen da vielleicht noch 10 Leute und die sind keine Gefahr mehr.
LS	Beim Sprint, da nimmst du ja den Abstand mit in das nächste Rennen dann in die Verfolgung. Gibt man da immer Vollgas bis zum Ende oder auch wenn du da hörst du hast Luft, dass du da ein bisschen rausnimmst?
MW	Ja, also es gibt manchmal Sprints, wo es dann keinen Verfolger danach gibt, aber das ist ganz selten, klar wenn man sagt, da habe ich noch ein bisschen Luft. Aber beim Sprint, da ist alles immer sehr, sehr eng zusammen, also da passiert das eher ganz selten, dass man da Luft hat und entspannt ins Ziel laufen kann. Und sonst immer alles, denn man würde ja quasi vielleicht für den nächsten Tag noch ein paar Sekunden gut machen, wo die anderen dann aufholen müssten.
LS	Ja, sehr gut. – Die Informationen, die man auf der Strecke bekommt, die hängen denke ich mal auch stark davon ab wie viele Betreuer unterwegs sind. Gibt es da Unterschiede zwischen den einzelnen Nationen oder auch zwischen IBU-Cup und Weltcup?
MW	Ja, zwischen IBU-Cup und Weltcup schon. Im IBU-Cup sind nicht immer so viele Leute dabei, denn schon allein die Skitechniker sind zum Weltcup 6 und im IBU-Cup sind es 6 oder manchmal auch nur 3. Und das macht natürlich schon was aus. Und es gibt auch einen Riesenunterschied in den Nationen, also sowie bei den Russen zum Beispiel, da kommt es einem manchmal vor als wären das auf jeden Sportler 2 Betreuer. Also ich weiß auch nicht, die haben glaube ich 10 Trainer oder so immer dabei. Beim IBU-Cup sind ja nicht so viele Zuschauer an der Strecke, also dann hauptsächlich Betreuer, und da hört man schon immer viel russisch. Also bei denen fällt das extrem auf. Andere Nationen haben jetzt nicht so viele.
LS	Okay. Und wenn du dann die Information kriegst, du liegst heute ganz gut im Rennen, vielleicht besser als du gedacht hast, was macht das mit dir dann während des Rennens?
MW	Ja, das motiviert mich auf alle Fälle extrem. Denn das sagt einem ja, obwohl du denkst, du bist gar nicht gut drauf heute, bist du trotzdem noch schneller als die anderen. Das motiviert einem und entspannt einem irgendwie auch. Ich meine, es gibt einfach Tage, da fühlt man sich richtig scheiße und das bekommt man dann auch wiedergegeben im Rennen. Das gibt es einfach. Das will keiner, aber das ist so. Und wenn es dann halt trotzdem nicht so wäre, weil keine Ahnung, weil man trotzdem schnell ist oder weil die anderen sich auch nicht gut fühlen heute, ist es dann halt eine extreme Motivation und beruhigt einem irgendwie auch. Und das gibt einem auch finde ich so die gewisse Lockerheit mit, dass man da trotzdem ganz gut Gas geben kann und auch entspannter am Schießstand ist, da man weiß, ich bin heute so gut, ich kann da vielleicht richtig Zeit gut machen.
LS	Und umgekehrt, wenn du hörst du bist viel schlechter unterwegs als du eigentlich gedacht hast?
MW	Ja, das ist dann immer schwierig. Da ist auch so bisschen eine ewige Diskussion bei uns Sportlern, weil manche mögen ja gar keine Zeiten durchgesagt haben, manche schon, weil sie sagen, wenn sie jetzt eine schlechte Zeit durchgegeben haben, tut das einem richtig runter ziehen. Ja, da versuche ich dann einfach, das ich denke okay jetzt noch einmal Vollgas geben und das Beste daraus machen. Das man das halt eher so sieht und nicht so sieht, Scheiße jetzt schaffe ich meine Ergebnisse nicht, sondern das gibt's und man muss einfach damit klarkommen und dann das Beste daraus machen.

LS	Und du hast es eben schon mal angedeutet, wenn du versuchst dich selbst einzuschätzen orientierst du dich auch an den Ergebnissen aus deinen letzten Rennen und ist es richtig, dass du sagst, ich war in den letzten 5 Rennen immer fünfter, wenn ich jetzt vierter bin, dann bin ich besser als gedacht, oder?
MW	Ja, so ist es im Großen und Ganzen ungefähr, denn man kann ja trotzdem dann noch Laufzeiten und so auch anschauen. Und keine Ahnung, nur an der Platzierung kann man es ja nicht immer festmachen, denn wenn man die letzten 3 Rennen fünfter geworden ist, aber die schnellste Laufzeit gehabt hat, aber immer 3 Fehler geschossen hat, dann kann man ja trotzdem sagen okay jetzt einfach Fokus aufs Schießen. Ich weiß, ich kann es besser und dann weiß ich, ich kann gewinnen, weil ich bisher immer die schnellste Laufzeit gehabt habe. So ein bisschen, das ist eigentlich hauptsächlich, würde ich jetzt sagen, über die Laufzeit zu definieren, denn da kann man schon grob langfristig einschätzen, wo man ist. Beim Schießen kann man schnell mal besser oder schlechter sein, aber das Laufen, das verändert sich nicht, außer man hat wirklich mal kein gutes Material, das kann ja bei uns auch passieren, aber das verändert sich sonst nicht extrem innerhalb von zwei Wochen.
LS	Ja, sehr gut. Diese zwei Szenarien, die wir eben besprochen haben, dass du die Information bekommst, dass du besser im Rennen liegst als du es vielleicht gedacht hast, wirkt sich das auch auf deine Schießleistung aus?
MW	Ja, auf alle Fälle. Das gibt einem einen richtigen Motivationsschub und das ist gut für das Selbstbewusstsein - bei mir immer. Ich weiß, es ist bei mir und ich glaube das ist auch weil du vorhin gesagt hast das weibliche Pendant dazu. Manchmal glaube ich liegt es auch daran, wie Frauen sind irgendwie, dass die oft ja mal eher ein bisschen niederstapeln und wenn man dann gesagt bekommt, he, du bist viel besser, dann ist das einfach gut für das Selbstbewusstsein. Klar gibt es manche, die haben das nicht, die sind einfach so selbstbewusst, aber das sind eher wenige würde ich sagen. Bei mir ist das auf alle Fälle nicht so.
LS	Und eher die Männer, so wie das raus höre?
MW	Ja, schon auf alle Fälle. Klar gibt es auch welche, die total zweifeln und so, aber mir kommt es schon so vor größtenteils nicht so extrem wie bei den Mädels.
LS	Der nächste Themenblock wäre die Vergleichsgruppe. Gegen wen vergleichst du deine Leistung? Hast du in der Saison so zwei, drei Athleten um dich herum, wo du weißt, die sind in derselben Kategorie oder ist es im Rennen einfach wer gerade vorne ist?
MW	Also im Rennen, wenn es ein Massenstart oder Verfolger ist, dann natürlich wer vorne ist. Aber ja, die meisten Personen kennt man ja und kann nach einiger Zeit, am Anfang der Saison natürlich noch nicht so gut, aber ungefähr einschätzen, wo man sich immer so einordnet. Genauso wie es dann ist, dass manche extrem schnell laufen, wenn die einem überholen und man kommt nicht mit, dass dies einem nicht so stresst, weil man weiß, die laufen eh immer schneller. Also es gibt schon so ein paar Personen, wo man nach den ersten Wochen so ungefähr einschätzen kann, gut da kann ich jetzt mitlaufen, dann ist das ein ordentliches Tempo oder auch ein paar andere, keine Ahnung, wenn ein Verfolger mal schlechter schießt, was weiß ich, und du dann einfach da jemand vor dir siehst, den du kennst und weißt okay da bin ich schneller, da muss ich gleich vorbei gehen und gleich eine Lücke reisen, weil da bin ich einfach schneller.
LS	Und im Sprint und im Einzel, ich nehme an, das ist im IBU auch so, dass man hintereinander startet?
MW	Genau, ja.
LS	Weißt du wer vor dir schon gestartet ist?

MW	Ja, ja, das ist schon so. Da ist dann tatsächlich auch manchmal so, also man bekommt ja am Tag vorher immer die Startliste und da schaut man sich das an und wenn jemand gutes vor einem startet, und manchmal, wenn die vielleicht langsamer schießen und eine Strafrunde haben, dann kann man ja zusammenkommen, weil man dann die 30 Sekunden aufholt. Und dann ist das natürlich schon richtig cool, wenn man weiß man kann da jetzt mitgehen. Und genauso sind manchmal einfach welche vor dir, die sind um einiges schlechter, wo du dann schon weißt am Tag davor, okay vor dem Schießen will ich die schon sehen, weil ich so nah dran bin in der ersten Runde.
LS	Startest du in so einem Rennen, also jetzt im Einzel oder Sprint, lieber früh oder lieber spät?
MW	Lieber früh. Man schießt ja immer an, dann hat man noch ein bisschen Zeit, aber nicht so viel und dann ist ja Start. Und da weiß ich einfach ich schieß an und dann mache ich mich warm und dann starte ich. Und habe nicht noch ewig Zeitpuffer, wo ich dann so bin, dass ich mir Gedanken mache oder sehe was die anderen machen oder so. Ich habe auch immer Kopfhörer drinnen damit ich auch bewusst nichts höre und nichts sehe. Denn ich möchte das nicht mitbekommen, denn sonst konzentriere ich mich nicht auf mich selbst, sondern schau so auf andere und da geht es einfach zack, zack hintereinander weg und dann ist man auch fertig und hat nicht so viel Zeit sich mit was anderem zu beschäftigen was einem irgendwie negativ beeinflussen kann.
LS	Beim IBU-Cup wird auch gelost?
MW	Ja.
LS	Innerhalb der Startgruppe?
MW	Ja. Die Startgruppen haben die Jungs sicher eh schon erklärt, und da wird dann eben gelost. Also es kann auch mal sein, wenn du als erste Startgruppe bist, dass du relativ weit hinten bist, weil viele in die erste Startgruppe gehen. Aber das ist immer noch besser als ganz zum Schluss. Also ich starte eigentlich immer am liebsten in der Eins.
LS	Genau. Wenn du die Startgruppe wählen kannst, wählst du die Eins?
MW	Immer Eins.
LS	Und hoffst dann auch in der Auslosung, dass du weit nach vorne landest?
MW	Wobei die Nummer Eins, da pokere ich immer so ein bisschen, das möchte ich dann auch nicht unbedingt haben, keine Ahnung, obwohl man da ja auch ein normales Rennen läuft. Aber irgendwie so gar keinen vor sich haben das finde ich auch komisch. Aber wenn es so ist, dann macht man das auch.
LS	Das habe ich auch schon mal gehört. Der Benedikt Doll: „Die Eins, die will keiner."
MW	Ja, die will wirklich keiner.
LS	Und du bist dann unterwegs beim Sprint, kriegst du dann die Zwischenzeiten durchgesagt im Vergleich zu den Leuten, die schon vor dir gestartet sind?
MW	Ja, genau die, die vor einem gestartet sind oder manchmal, wenn man in der zweiten Runde ist und man weiß hinter einem ist eine recht gute und man ist jetzt richtig gut dabei, dann sagen einem die Trainer in der ersten Runde warst du trotzdem noch schneller als die. Also das auf alle Fälle auch. Aber meistens bekommt man nur das gesagt oder wenn man mal wirklich sehr viel schneller war oder besser, wo die wissen es motiviert einem. Aber meistens nur zu den Personen vor einem.
LS	Ja. Und angenommen du hast da deine beste Konkurrentin, die ist immer so um dich herum und ihr zwei kämpft immer um den Sieg und die startet vor dir. Hat das einen anderen Einfluss auf dich und dein Rennen, als wenn sie hinter die starten würde in diesen Rennen, wo man hintereinander startet?
MW	Ja, finde ich schon.
LS	Was wäre dir lieber? Welches Szenario?
MW	Dass die vor mir startet. Das man halt die quasi aufholen kann als sie immer im Rücken zu haben und nicht so wirklich genau zu überblicken, ob die jetzt da ist, denn umdrehen tut man sich nicht im Wettkampf. Also ich habe es lieber, wenn die vor mir ist.
LS	Und in der Regel ist die dann auch in derselben Startgruppe?
MW	Ja. Meistens schon.
LS	Wo nach wählt man denn die Startgruppe? Also einmal nachdem wie du gesagt hast, dass es dir lieber ist früh zu starten und gibt es noch andere Faktoren, die diese Wahl beeinflussen?
MW	Ja, wenn dann mal die äußeren Bedingungen. Wenn es mal irgendwie schneien soll oder so, weil dass musst du ja auch am Tag davor sagen, und das ist manchmal gar nicht so einfach. Und wenn die aber sicher Schnee ansagen, dann gehst du eher weiter hinten rein, weil sonst bist du halt vorne wie so eine Art Schneepflug. In der Früh wird natürlich präpariert, aber dann ja nicht mehr kurz vor Rennen. Und wenn es richtig viel schneit, dann kann schon mal einiges an Schnee auf der Strecke liegen und da gehst du lieber hinten rein, denn da sind schon alle drüber gelaufen. Der erste Punkt ist, was man am liebsten will und dann ändert man es mal um, da gerade komische Bedingungen sind.
LS	Glaubst du es gibt Unterschiede zwischen Männer und Frauen je nachdem ob sie lieber früher oder später starten?
MW	Das glaube ich jetzt tatsächlich nicht, weil da ist wirklich jeder so individuell. Die meisten mögen zwar schon weit vorne rein, aber es gibt trotzdem welche, die sagen sie mögen hinten rein, weil sie wollen so viel Infos wie möglich bekommen. Und wenn du halt weit vorne bist, dann kannst du halt nicht ganz so viele Infos kriegen, wie wenn jemand gutes dreißig Nummern nach dir startet.
LS	Und da glaubst du, dass dieses wie viel Information ich haben will, dass das für Männer und Frauen gleich beziehungsweise bei beiden unterschiedlich ist.
MW	Ja, da gibt es bei beiden Unterschiede, da ist glaube ich jeder wirklich so individuell. Aber ich glaube, dass bekomme ich ja bei den meisten mit, dass schon die meisten am liebsten immer vorne starten. Man bekommt zwar nicht so viel Infos, aber man hat nicht so viel Wartezeit und jeder ist von der Wartezeit oftmals genervt. Wenn man ewig wartet, wenn man Startnummer Achtzig hat, da startet man ja 40 Minuten nach dem Ersten. Und klar macht man sich warm, aber das ist schon wirklich lang dann.
LS	Und zwischen Einzel und Sprint gibt es was das angeht keine Unterschiede, oder?
MW	Nein, also bei mir nicht. Ich starte am liebsten immer vorne, egal ob jetzt Einzel oder Sprint.
LS	Im Einzel kann man da anders taktieren, da man mehr Runden hat? Also beim Sprint hast du eben gesagt, da läuft man immer alles was geht. Im Einzel ist das ähnlich oder gibt es da Unterschiede?
MW	Ja, vielleicht schon. Das man versucht die ersten Runden nicht gleich Vollgas zu laufen, weil es ist halt doppelt so lange wie ein Sprint. Das muss man sich auf alle Fälle schon ein bisschen besser einteilen. Und grundsätzlich versucht man es zwar immer zu vermeiden, dass man jetzt sagt man läuft so, dass man gut schießt, weil sonst wird das ja schon wieder zu viel Druck, den man aufbaut. Aber so ein bisschen hat man das schon im Unterbewusstsein, dass man sagt, okay jetzt völlig ausgepowert und das gar nichts mehr geht will man jetzt nicht unbedingt zum Schießstand kommen, denn man bekommt ja eine Minute Strafzeit pro Fehlschuss und das ist schon wirklich richtig viel.
LS	Ja, sehr gut. Ich glaube wir sind am Ende angekommen. Ich habe noch so eine Kategorie Sonstiges. Das sind zwei große Fragen. Die erste Frage ist, gibt es noch irgendetwas was dir noch einfällt zur Rolle von Feedback im Biathlon, die Information, die du auf der Strecke bekommst? Irgendetwas, was wir nicht besprochen haben, wo du aber denkst, das ist noch interessant.

MW	Ja. Die meisten Trainer machen das ja, aber ich glaube nicht immer alle, da glaube ich sind wohl die Sportler proaktiv, dass jeder Trainer vor einer Saison oder auch während der Saison immer mal wieder die Sportler fragt, was für Infos wollt ihr denn wissen. Wollt ihr die Zeit wissen, wollt ihr eure Platzierung wissen, wollt ihr gar nichts wissen, wollt ihr nur Anfeuerung, weil ich glaube, da ist jeder unterschiedlich und ich finde auch manchmal kann sich das im Laufe einer Saison ein bisschen ändern. Wenn man eben fit ist und sich auf einmal eben nicht mehr so fit fühlt, dass man vielleicht nicht so viel Infos will, weil einem das nur verunsichert. Da ist glaube ich würde ich sagen von Trainer- bzw. Betreuerseite, alle die an der Strecke stehen, dass da öfter mal wieder nachgefragt wird. Die meisten machen das schon, aber vor allem das Nachfragen im Laufe der Saison machen glaube ich nicht so viele. Das sagen zwar die Sportler schon auch, aber ich glaube, das würde auch nicht schaden, wenn man das so als Trainer mit einbindet.
LS	Ja. Und die allerletzte Frage: Gibt es irgendwelche Situationen oder Herangehensweisen an so ein Rennen, die sich stark zwischen Männern und Frauen unterscheiden? Wo du sagst, das ist dir irgendwie aufgefallen. Ich weiß nicht, ihr habt vielleicht Trainingsgruppen, die irgendwie gemischt sind, wo du dann denkst, die Männer, die legen viel mehr Wert aufs Schießen oder die haben immer weniger Sorgen und die Frauen sind verkopfter? Was sind irgendwelche Unterschiede zwischen Männern und Frauen, die dir allgemein auffallen?
MW	Ja, ich würde schon sagen, dass die Frauen eher mehr verkopfter sind. Klar gibt es da auch Individuelle, die sehr selbstbewusst sind. Aber im Allgemeinen haben Frauen glaube ich von Haus aus nicht ganz so viel Selbstbewusstsein wie die meisten Männer und zweifeln eher mal an sich selbst als wie Männer. Es ist gar nicht, dass die Männer so über selbstbewusst sind, aber die denken gar nicht so viele Szenarien was passiert könnte, was dann Frauen schon haben. Und ich glaube das liegt irgendwie daran, weil das Selbstbewusstsein eben nicht ganz so hoch ist wie im Schnitt bei den Männern. Das würde ich auf alle Fälle sagen. Da wird viel mehr gedacht, was passieren könnte und sämtliche Szenarien durchgedacht. Das beobachte ich, das haben die Jungs oftmals nicht so, denn die wissen halt sie sind fit, dann läuft es schon oder sie sind nicht so fit, ja dann kann ich gerade auch nichts machen. Dann ist das halt so. So kommt mir das schon oft vor.
LS	Und Verhalten auf der Laufstrecke?
MW	Ja, da gibt es echt einen Riesenunterschied. Vor allem beim Massenstart, das haben vielleicht die Jungs eh schon gesagt. Bei den Männern ist so ein Massenstart trotzdem noch geregelter, weil z.B. in der ersten Runde Massenstart durch das, dass man im Windschatten laufen kann, da kann man eigentlich keine Zeit gut machen. Da kommen selbst die schlechten Läufer ganz gut mit. Ich bin ja nicht so oft im Weltcup, aber vor zwei Jahren, da bin ich Weltcup-Massenstart gelaufen, das erste Mal. Da war ich auch sehr aufgeregt davor, aber die erste Runde war überhaupt kein Problem. Denn da kommt man schon mit im Windschatten. Und bei den Männern ist es dann so, das weiß jeder. Also versucht da auch keiner irgendwie von ganz hinten nach ganz vorne oder recht aggressiv zu laufen. Und bei den Frauen ist das irgendwie immer ein Drama, ich weiß auch nicht. Also ich würde das nicht so sehen, aber da meinen die mit Startnummer achtundzwanzig sie müssten jetzt nach ganz vorne, wo sie ja sowieso keine Zeit gut machen. Und das ist immer so. Also die Männer sind da immer eher entspannter in der ersten Runde. Bei den Frauen ist es immer hektisch. Man muss immer aufpassen, dass einem der Stock nicht abgetreten wird. Also das ist wirklich immer so. Das ist einfach immer anstrengend und auch immer Vollgas die ersten Meter, dass ist ein Vollsprint, wo die Männer schon auch Gas geben, aber vielleicht jetzt nicht Vollgas, da sie wissen nach einhundert Meter läuft eh jeder wieder sein Tempo. Keine Ahnung, das ist

	einfach immer Chaos. Aber das ist immer so. Und da gibt es aber auch schon so die gewissen Personen, wo du immer weißt, oh wenn die neben einem sind, das ist richtig nervig.
LS	Ja, jetzt muss ich überlegen, aber ich glaube das war auch der Benedikt, der meinte, wenn die Strecke unendlich breit wäre, dann würden die Frauen alle nebeneinander laufen.
MW	Ja, das ist so. Ja, klar, das ist wirklich so. Also keine Ahnung. Ich würde schon sagen, doch mich stresst das eigentlich immer nicht, wo ich da jetzt lauf, ob ich jetzt hinten oder vorn lauf. Aber manche, die sind da wirklich so und das ist ganz, ganz anstrengend. Ich bin da auch so, dass ich schon mal dann rüber schrei was das soll, weil gerade manche so wild da rum hauen, wo du denkst es laufen gerade drei vor dir, die Strecke ist nicht breit, wo willst du da hin und die versuchen trotzdem, am besten Doppelstock, daran vorbeizuschieben. Ich verstehe es auch nicht.
LS	Ich muss mal darauf achten. Ich schaue es mir im Winter mal wieder an.
MW	Ich glaube von außen fällt das gar nicht so auf. Doch wenn man darauf achtet, das ist wirklich extrem bei den Damen. Ganz, ganz schlimm.
LS	Spannend. Ja, ich guck mal was ich da in den Daten dazu finde.
MW	Ja. Aber ich glaube, wenn du jetzt zweihundert Athleten und zweihundert Athletinnen dazu fragen würdest, das würden alle bestätigen.
LS	Ja, ihr zwei seid euch zumindest schon mal sehr einig. Gibt es sonst noch etwas, was du gerne loswerden möchtest?
MW	Nein.
LS	Sehr gut. Dann beende ich jetzt die Aufnahme.

Appendix 3.9f – Interview with Juliane Frühwirth

Date of the interview	**15.08.2022**
Duration of the interview	**26 minutes**
Interview format	**Video call (MS Teams)**
Name of interview partner	**Julian Frühwirth (JF) – active athlete of DSV**
Name of interviewer	**Leo Schmallenbach (LS)**

Table A3.14 Interview Transcript – Juliane Frühwirth

LS	Also der erste Themenblock heißt Leistungstreiber im Biathlon. Und die erste Frage ist, ob du bitte einmal beschreiben könntest mit welcher Motivation und welchem Ziel du in ein Rennen gehst?
JF	Ganz unabhängig davon in welcher Leistungsklasse das ist, auf jeden Fall mit dem Ziel, meine persönliche Bestleistung an dem jeweiligen Tag abzuliefern. Also aus dem wie ich mich psychisch und physisch fühle, wie das Material ist, eben das beste rauszuholen. Und ganz klar meine Trainingsleistung umzusetzen.
LS	Und dann setzt du dir ein Ziel wie eine Zeit oder eine Position, die du erreichen willst?
JF	Ja, das ist so eine Mischung. Also je nachdem, wie gesagt, wie ich das jetzt einschätzen kann, ob ich in der Leistungsklasse - also ich bin jetzt immer zwischen IBU Cup und Weltcup geswitched - vorne mitlaufen möchte und dass mein Anspruch ist oder ob ich eben mir quasi nur Handlungsziele setze. Aber Ich versuche auch immer einfach ein Großteil an Handlungszielen dabei zu haben, weil man die eben selbst in der Hand hat. Es bringt mir jetzt nichts zu sagen, ich möchte unbedingt jedes Rennen gewinnen. Also klar, man möchte das, sonst ist man als Sportler fehl am Platz. Aber wenn ich jetzt am Schießstand meine Leistung zeige, 100% schieße und auf der Loipe alles aus mir raushole, dann kann ich mir in dem Moment nichts vorwerfen. Und wenn ich dann 20. werde oder 25. oder 10. oder 1., das muss man dann so akzeptieren wie es gerade im Moment eben ist.
LS	Was meinst du mit Handlungszielen?
JF	Also ebenso Sachen, die ich beeinflussen kann. Wie habe ich mich technisch bewegt auf der Runde? Bin ich an mein absolutes Laufmaximum rangekommen? Habe ich am Schießstand sauber gearbeitet? So Sachen.
LS	Ich bin mir jetzt nicht sicher, wie lange du schon dabei bist. Wenn du jetzt mal zurück guckst ein paar Jahre, haben sich die Ziele bei dir verändert?
JF	Ja, schon denke ich. Also so als kleines Kind geht man halt klar in die Schülerwettkämpfe und will da jedes Rennen gewinnen. Das ist ja irgendwie normal so als Kind. Aber irgendwann muss man sich dann eine gewisse Frustrationstoleranz anlernen, weil es in den höheren Leistungsklassen dann nicht mehr üblich ist, dass man jedes Rennen gewinnt. Ich würde schon sagen, dass auch durch mein Studium – also ich bin bald mit dem Master in Sportwissenschaften fertig -, dass man da auch merkt. Okay, über den Tellerrand hinausgeschaut, vielleicht sind Handlungsziele auch Sachen, die ich beeinflussen kann, auch zielführend und gehören ein Stück weit dazu.
LS	Und gibt es unterschiedliche Ziele je nachdem in der welcher Disziplin du läufst?
JF	Nein.
LS	Also, dass du sagst bei der einen Disziplin, da konzentriere ich mich mehr auf das schießen und bei der anderen mehr auf das Laufen?
JF	Nein. Das ist bei uns im Endeffekt auch nicht so, dass man in einer unterschiedlichen Disziplin etwas völlig anderes machen muss. Also ist ja genau das gleiche.
LS	In den unterschiedlichen Leistungsklassen – also, wenn du jetzt im IBU Cup startest oder Weltcup – setzt du dir da unterschiedliche Ziele?
JF	Also vom Ergebnis her, klar. Und vom Handlungsziel nicht, weil ich möchte ja bei jedem Wettkampf einfach das zeigen, was ich kann für den Moment.
LS	Dann kommen wir zum nächsten Ziel: und zwar die Einflussfaktoren auf deine Leistung. Fangen wir mal mit der Motivation an. Welchen Einfluss hat Motivation auf das was da am Ende rauskommt?
JF	Also für mich ein sehr sehr großen, weil das schon limitierend ist, inwieweit man auf der Loipe an seine Grenzen geht. Und auch, inwieweit man bereit ist, die ganzen kleinen Sachen, die zu so einer Wettkampfleistung dazugehören, dann auch zu machen am jeweiligen Tag.
LS	Gibt es andere Dinge, wo du denkst, die beeinflussen deine Laufleistung besonders?
JF	Das Material auf jeden Fall. Das muss man schon mal ganz klar so sagen. Dann das eigene Leistungsvermögen am Tag X. Also die Form. Und auch der Gesundheitszustand. Also das ist mir jetzt im letzten Winter besonders deutlich geworden. Wenn es gesundheitlich nicht passt, dann funktioniert das nicht. Oder nicht so, wie man es sich vorstellt. Und natürlich auch das Training im Vorfeld. So ein Wettkampf ist die Momentaufnahme am Tag X, aber die wird ja determiniert durch wie hat man sich auf das ganze vorbereitet die ganzen letzten Jahre.
LS	Das betrifft jetzt deine Laufleistung. Was beeinflusst deine Schießleistung besonders?
JF	Ich würde sagen zum großen Stück weit man auch selber. Wie ist man aktiviert? Wie fokussiert ist man an dem Tag? Wie gut gelingt es einem so destruktive Gedanken auszuschalten. Und natürlich auch so Sachen wie Wind und äußere Umstande. So ein bisschen Glück gehört beim Biathlon auch immer dazu. Da darf man glaube ich auch die Augen nicht davor verschließen.
LS	Und was meinst du mit destruktiven Gedanken?
JF	Ja, man hat manchmal solche Tage, wenn man sich denkt: oh gott, heute darf ich keinen Fehler schießen. Und das sind so Sachen, wo ich mir versucht habe zu sagen: stopp, das bringt nichts. Schluss und abarbeiten. Weil wenn man an den Fehler denkt, ist das so wie mit dem großen dicken Elefanten. Dann kann es schon passieren, dass er auch dann eintritt.
LS	Und was für Strategien gibt es dann in so Momenten, wo man diese Gedanken hat. Du hast gesagt, du versuchst dir dann einfach einzureden: denk da nicht dran. Gibt es sonst noch irgendwelche?
JF	Also ich mach seit Jahren viel Mentaltraining. Also für mich ist zum Beispiel so eine probate Strategie, dass ich einfach einen Ablauf im Training einstudiert habe. Da gibt es für mich dann ein Wort – es ist souverän. Das sag ich mir dann, um in meine Zone quasi zu kommen beim Schießen. Und man merkt so Tage, wo man besonders aufgeregt ist. Eine Quali oder irgendein Rennen, wo man wirklich absolut performen möchte. Da gibt es dann auch so Kniffe, um einfach ein bisschen die Aufmerksamkeit zu binden. Also ich zähle zum Beispiel von 70 rückwärts beim Schießstandeinflauf, dass ich die ganze Zeit am Zählen bin und mein Ablauf machen muss. Und eben nicht noch irgendwelche Gedanken hab für – Oh Gott, wenn ich jetzt treffe, was passiert dann. Ich bin dann einfach beschäftigt. Und was jetzt bei mir auch ist – und das gehört auch ein bisschen als Talent dazu – in Situation Mann gegen Mann, das macht mir einfach Spaß. Da habe ich einfach Bock drauf. Wenn ich merke ein Verfolger oder im Massenstart stehe ja Leute nehmen mir, das ist einfach cool.
LS	Interessant mit den Strategien. Du hast ja beschrieben, dass es Situationen gibt, wo es besonders drauf ankommt, wie eine Quali oder das erste Weltcup Rennen. Hat das auch einen Einfluss auf deine Zeit, die du dir am Schießstand nimmst?

JF	Ich glaube nicht, nein. Also klar, es kann schon mal sein, wenn man sich jetzt irgendwie besonders unruhig fühlt oder so. Man hat ja verschiedene Tage. Es ist ja im Leben genauso, das man mal einen schlechten Tag hat. Und dann vielleicht einfach ein bisschen länger braucht, um sich sicher zu fühlen am Stand. Aber die Zeit muss man sich dann eben nehmen. Es bringt ja nichts, wenn man dann sagt: okay, ich schieße jetzt meinen ganz normalen Rhythmus durch und es bleiben drei Scheiben hängen. Wenn ich dann 3 Sekunden länger da lag und es bleiben keine Scheiben hängen, ist das irgendwie produktiver unterm Strich. Also ich versuch da einfach flexibel zu sein vom Kopf.
LS	Gibt es Unterschiede in den Einflussfaktoren zwischen dem Liegen- und dem Stehendschießen?
JF	Nein. Also für mich persönlich jetzt nicht. Ich habe jetzt auch kein Lieblingsanschlag oder so.
LS	Ich habe irgendwo gelesen, dass das Stehendschießen so ein Reaktionsschießen ist und das Liegenschießen eher so ein fokussiertes Schießen ist. Ist das Quatsch?
JF	Es stimmt schon ein Stück weit. Weil man im Stehen niemals so ruhig ist. Aber über so Haltetraining und Trockentraining entwickelt man ja schon eine gewisse Haltefähigkeit. Das wird dann immer besser mit der Zeit.
LS	Sehr interessant. Du hast eben gesagt, dass man in manchen Situationen die Leute neben sich hat. Kriegt man mit was die schießen?
JF	Wenn man das mitkriegen möchte, kriegt man das auf jeden Fall mit. Für mich ist das so eine Situation, dass ich einen inneren Drang habe schneller fertig zu sein und weniger zu schießen als der neben mir. Dann ist mir das eigentlich egal. In dem Moment bin ich eigentlich so mit meiner Serie beschäftigt, dass ich es eigentlich nicht mitbekomme. Und das ist auch besser so auf jeden Fall. Weil wenn man sich damit beschäftigt, dann ist man irgendwie abgelenkt und nicht bei sich.
LS	Ist man eher abgelenkt, wenn es um Mann gegen Mann geht als wenn man im Sprint oder Einzel unterwegs ist? Und man weiß ja vielleicht gar nicht wer neben einem ist.
JF	Das würde ich jetzt gar nicht so sagen. Im Sprint oder Einzel hat man natürlich viel mehr Zeit für sich, um sich Gedanken zu machen. Man kriegt dann schon noch von der Anzeigetafel mit, was die anderen machen. Im Mann gegen Mann Rennen ist einfach viel mehr los am Schießstand. Da ist man einfach von der Aufmerksamkeit viel mehr gefordert die Sachen ordentlich zu machen und auf dem richtigen Stand zu liegen etc. Ist oftmals gar nicht so relevant für mich persönlich.
LS	So wie du es eben beschrieben hast im Einzel und im Sprint, da hat man mehr Zeit sich Gedanken zu machen?
JF	Die Zeit, die man dann eben hat, muss man mit irgendwas Sinnvollem füllen.
LS	Und da hast du dann auch Tricks, die du dann anwendest?
JF	Ja, eben zum Beispiel das Rückwärtszählen oder auf der Runde nochmal eine gute Serie visualisieren oder so.
LS	Der nächste Themenblock bezieht sich auf das Feedback, das du über deine Leistung bekommst. Also während des Rennens, wie gut wirst du da über deine eigene Leistung informiert?
JF	Das kommt drauf an, wie viele Betreuer wir an der Strecke haben. Also es kann schon mal sein, dass man eben nur die Zwischenzeit bekommt und sonst relativ wenig. Aber im Weltcup ist eigentlich so abgesichert, dass du an jeder Kurve wissen kannst, wo du stehst. Besonders wichtig ist im Biathlon ja eigentlich, dass man die Trefferbilder angezeigt bekommt. Besonders bei den 4x Schießen Sachen.
LS	Also das ist eine Information auf die du besonders achtest?
JF	Ja, weil im Endeffekt läuft man sowieso so schnell man kann und klar ist das auf der letzten Runde mal ganz schön. Es geht jetzt um ein oder zwei Sekunden, aber im Endeffekt läuft man deswegen jetzt nicht 10 Sekunden schneller, wenn man ständig eine Zwischenzeit bekommt. Es kann sogar manchmal eher ein bisschen hinderlich sein, wenn man merkt: okay, ich hab jetzt schon so viel verloren und bin aber schon völlig am Limit. Das kommt auf den Tag an. Oder wenn man in Führung liegt, möchte man es manchmal gar nicht so genau wissen. Wenn einer sagt, du hast 3 Strafrunden Vorsprung. Das ist jetzt auch nicht so besonders förderlich.
LS	Gibt es auch da Unterschiede zwischen den Disziplinen? Das man bei bestimmten Disziplinen auf andere Sachen achtet? Du hattest ja eben gesagt beim 4x Schießen halt auf das Trefferbild?
JF	Ja, genau. Das ist wie gesagt besonders wichtig. Klar im Sprint ist die letzte Runde schon wichtig. Weil es da einfach die kürzesten Abstände hat und es zur Sache geht.
LS	Und wie gut bist du während des Rennens über deine eigene Position informiert? Massenstart und Verfolgung denke ich mal ganz gut oder wie ist es da?
JF	Ist eigentlich in allen Disziplinen gut. Es gibt ja die Zwischenzeiten bei uns überall.
LS	Auch im IBU Cup?
JF	Ja, das geben einem die Trainer dann schon durch.
LS	Wenn du jetzt so eine Information bekommst, wie: du liegst sehr gut im Rennen. Was macht das dann mit dir?
JF	Das pusht einen schon nochmal. Oder bestätigt einen. Man hat ja dann meistens auch selbst ein gutes Gefühl und bestätigt einen dann, so dass man zügig weiter machen kann.
LS	Und wenn es jetzt anders rum ist? Du kriegst eine Info, dass du deutlich schlechter bist als du es dir vorgenommen hast?
JF	Ja, dann muss man damit auch irgendwie umgehen und weiter machen. Das ist das Schöne am Biathlon. Meistens kommt dann noch ein Schießen. Und wenn man da mit 0 raus geht, ist man meistens nicht so weit hinten, wie man an der Zwischenzeit war.
LS	Nächster Themenblock ist die relevante Vergleichsgruppe. Mit wem vergleichst du dich im Rennen? Suchst du dir vorher die 5-6 Athletinnen aus mit denen du dich vergleichen willst? Oder ergibt sich das während des Rennens? Oder wie geht man da vor?
JF	Im Rennen selber vergleich ich mich eigentlich mit niemandem. Da bekommt man die Zahl und die ist ja relativ personenunabhängig. Wenn man mir jetzt sagt, du bist 5. dann bist du halt 5. Und dann interessiert mich nicht, wer 4. oder 6. ist. Sondern der, der 4. ist, den möchte ich einfach einholen oder die Zeit einfach gut machen. Das ist mir eigentlich völlig egal, wer das ist.
LS	Das heißt, wenn du jetzt wüsstest 17 Sekunden hinter dir ist jemand, der läuft extrem schnell – du kennst die Läufer ja und es sind immer dieselben?
JF	Das sagt uns aber keiner. Also es ist ganz selten, dass uns da wirklich jemand Namen durchgibt. Da muss man schon sehr weit vorne sein. Nein, eigentlich ist das nicht üblich. Außer es ist jetzt ein Mannschaftskamerad, dann sagen sie es uns manchmal. Meistens ist aber die Zwischenzeit: du bist jetzt 5.,6 Sekunden auf Platz 4 und 10 auf 3.
LS	Ist die Konkurrenz innerhalb der Mannschaft größer als außerhalb?
JF	Nein. Also ja klar, wir haben eine Konkurrenz, aber die würde ich als sehr gesund einordnen.
LS	Das war auch nicht wertend gemeint, sondern ihr kämpft ja dann auch um limitierte Startplätze und so weiter.
JF	Ich versuch mich da mehr auf mich zu konzentrieren. Also wenn man dann unterm Rennen schon denkt: Oh Gott, Startplätze, IBU Cup und Weltcup. Das bringt’s am Ende dann nicht. Wenn man seine Leistung zeigt und auch ordentlich zeigt, ist man auch international dabei. Und wenn man das nicht macht, ist man auch nicht dabei.
LS	Und so ein Traum ist Olympia oder was?

JF	Ja, definitiv.
LS	Und das gilt eigentlich für jeden Athleten?
JF	Ich gehe davon aus.
LS	Wenn du die verschiedenen Klassen durchgehen würdest, was wäre da das Ranking von der Bedeutung her?
JF	Also der Gesamt-Weltcup-Sieg, finde ich, würde bei mir noch vor Olympia kommen, weil man da einfach über eine Gesamtsaison seine Leistung gebracht hat und auch konstant der beste war. So eine Heim-WM in Oberhof ist natürlich auch vom Stellenwert sehr hoch einzuordnen. Also das ist ja Fakt definitiv.
LS	Also Gesamt-Weltcup, dann als nächstes Olympia, dann WM, dann Weltcup?
JF	Ja, genau. Und darunter muss ich sagen gibt es jetzt für mich nicht so ein Ranking.
LS	Die Wettkämpfe auf Schalke: haben die irgendeinen Stellenwert außer Marketing?
JF	Ich muss ganz ehrlich sagen, dass ich hinter dieser Veranstaltung gar nicht dahinter stehe, weil das für mich aus Nachhaltigkeitsgründen einfach nicht geht. Also muss man jetzt auch nicht drum rumreden: wir sind eine Sportart, die von Kunstschnee abhängig ist. Es wird immer wärmer. Ich war jetzt letzte Woche wieder zu Hause in der Nähe von Oberhof. Es ist nur noch trocken, es schaut alles steppig aus und die IBU meint dann ein Event zwischen Weihnachten und Neujahr auf Schalke zu machen, wo ich weiß nicht wie viele LKW Kunstschnee dahintransportiert werden. Wo man jetzt die letzten zwei Jahre in Ruhpolding gesehen hat, da liegt Schnee. Es wäre auch so gegangen. Das wäre für mich jetzt nichts wo ich sagen würde, da müsste ich nochmal an den Start gehen. Ich habe es als Junior mal erlebt, aber finde ich jetzt kein besonders nachhaltiges Konzept. Und ich weiß auch nicht, ob dass das richtige Bild ist, was wir da vermitteln.
LS	Die nächsten Fragen beziehen sich auf ein paar Regularien. Gibt es Begrenzungen auf der Strecke, wo man informiert werden darf? Also wo Betreuer stehen dürfen oder können die sich überall hinstellen?
JF	Also wir haben bestimmte Coaching-Zonen. Und eben Zonen, wo auf Grund der Kameraführung keiner stehen darf.
LS	Jetzt warst du wieder kurz weg: also es gibt diese Coaching-Zonen, Kameraführungszonen wo keiner stehen darf, aber sonst ist egal oder?
JF	Ja, sonst ist wurscht.
LS	Beim Einzel und beim Sprint, da werden ja die Startnummern gelost. Welchen Einfluss hat man? Man kann nur die Startgruppe wählen oder hat man noch einen anderen Einfluss?
JF	Genau, nur die Startgruppe. Weiter nicht.
LS	Und das macht man im Team? Oder der Trainer?
JF	Also wir machen es nach Weltcup-Gesamtranking. Es ist schon so üblich, dass die besten dann in die 1 gehen oder in die 2.
LS	Und die dürfen zuerst wählen? Also wer am besten gerankt ist?
JF	Ja, genau.
LS	Und was bestimmt die Größe einer Startgruppe? Gibt es da auch Regeln? Also wie viele Leute in einer Startgruppe starten?
JF	Achso, jetzt pro Nation. Also quasi die ersten 15 im Gesamt-Weltcup dürfen frei wählen und sonst maximal 2 pro Gruppe.
LS	Wenn du dann so eine Startgruppe gewählt hast, weißt du dann auch schon wo die anderen Konkurrenten sich einsortieren werden?
JF	Also es ist relativ oft, dass die meisten besseren in die 1 und die 2 gehen. Also es geht jetzt selten jemand freiwillig in die 3 oder 4.

LS	Warum?
JF	Weil die Streckenverhältnisse meistens nicht besser werden. Also gut, wenn jetzt neu Neuschnee ist, das ist so die einzige Ausnahme und dann vielleicht schon. Aber sonst nicht.
LS	Das heißt, wenn du wählen könntest, würdest du auch lieber früh starten?
JF	Ja, definitiv.
LS	Und wenn du dann ausgelost wirst und die 1 bekommst, ist das dann etwas worüber du dich freust?
JF	Also das ist mir eigentlich egal. Es ist jetzt nicht besser oder schlechter als jede andere Startnummer.
LS	Also wenn du jetzt als erster startest, hast du ja relativ wenig Informationen dann darüber wie du im Rennen liegst. Das macht dir aber erstmal nichts?
JF	Im Verfolger finde ich es besser als im Sprint. Aber ich nehme es auch im Sprint.
LS	Glaubst du die Startnummer hat dann einen Einfluss auf deine Leistung?
JF	Also wenn man jetzt ganz hinten startet und die Strecke schon völlig durchpflügt und durchwühlt ist, dann sicher. Also dann hat man laufzeitmäßig klar einen Nachteil. Wenn man mal Glück hat und mit einem besonders schnellen Läufer eine Runde laufen kann, dann schon. Aber jetzt nicht großartig.
LS	Auf deine Schiessleistung?
JF	Ich wüsste es nicht. Für mich persönlich nicht.
LS	Glaubst du da gibt es Unterschiede mit deinen Kollegen? Gibt es manche die gerne immer früher starten und andere die gerne später starten?
JF	Ja, das gibt es schon. So individuelle Präferenzen gibt es schon.
LS	Aber du würdest da jetzt kein Muster erkennen?
JF	Es gibt halt Leute, die einfach gerne vorm Anschießen dann schnell einlaufen und es hinter sich haben wollen. Ich bin jetzt auch so der Typ und habe nichts dagegen in den Wachs-Container zu gehen und mich 5 Minuten aufzuwärmen. Ich persönlich versuche da auch sehr flexibel zu sein, weil man es einfach nicht immer in der Hand hat.
LS	Gibt es sonst noch irgendwelche Faktoren, die wir nicht besprochen haben? Wo du denkst, hier spielt irgendwie Feedback im Biathlon eine Rolle und das hat einen großen Einfluss darauf, wie du dich im Rennen fühlst und du das Rennen angehst?
JF	So das Anschießen würde ich schon sagen. Also, dass der Trainer einem da nochmal gute Tipps mitgibt, wie die Windsituation so ist. Wenn man jetzt nicht gleich Startnummer 1 hat, sondern vielleicht schon 3,4 Leute beim Liegenschiessen waren und man sieht: okay, der Trainer funkt nochmal an den Start. Es hat sich jetzt irgendwie eine dauerhafte Linkstendenz entwickelt. Das ist schon etwas, was auf jeden Fall leistungsbeeinflussend ist.
LS	Dürfen die Trainer dir auf der Strecke sagen, wie du da drehen musst an dem Diopter?
JF	Ja, nur am Schießstand nicht. Da ist quasi Schweigezone. Da darf keiner etwas sagen. Aber auf der Strecke schon – das müssen sie ja auch.
LS	Man kann ja dann rechts und links drehen und wie viele Rasten. Das dürfen dir die konkret ansagen?
JF	Ja, genau. Man muss es dann halt selbst entscheiden, wie die Situation dann ist, wenn man wieder an dem Schießstand ist.
LS	Interessant. Losgelöst von dem, was wir gerade besprochen haben. Gibt es irgendwelche großen Unterschiede, die dir über die Zeit aufgefallen sind zwischen Männern und Frauen, wie die das Rennen angehen? Oder allgemein im Sport?
JF	Das einzige was bei uns ist: im Massenstart kriegen die Jungs es eher hin eine gechillte erste Runde zu laufen und bei den Frauen oftmals schon von Anfang an das Messer zwischen den

	Zähnen ist. Aber ansonsten eigentlich nicht. Wir haben beim Biathlon glaube ich das Privileg, dass wir sehr gleichberechtigt sind.
LS	Okay – also die erste Runde Massenstart geht es bei den Frauen schon etwas intensiver zur Sache? Woran liegt das?
JF	Ich weiß es auch nicht. Vielleicht weil die Unterschiede noch größer sind und das Leistungsniveau noch ein bisschen stärker schwangt und sich da eben die guten Läuferinnen schon absetzen möchten.
LS	Du hast ja eben so Situationen beschrieben mit den destruktiven Gedanken. Glaubst du da gibt es Unterschiede zwischen Männern und Frauen?
JF	Ehrlich gesagt, keine Ahnung. Ich habe mich damit jetzt noch nicht beschäftigt, ob ein Mann da anders denkt beim Schießen. Keine Ahnung. Aber ich glaube, dass was man in der Trainingsgruppe so mitbekommt, gibt es genauso dieselben Probleme. Dass man mal längerfristig schlechter schießt und irgendwelche Fehlerbilder nicht rausbekommt. Ich glaube, wir sind uns da schon sehr ähnlich.
LS	Alles klar. Damit sind wir auch schon am Ende des Interviews angekommen. Vielen Dank. Ich beende jetzt die Aufnahme.
JF	Alles klar.

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Leo Schmallenbach

Academic Experience

2017 – 2022	**University of Mannheim**, Germany Chair for Organization and Innovation, Prof. Dr. Karin Hoisl Center for Doctoral Studies in Business, Graduate School of Economics and Social Science Doctoral Student and Research Associate
2021	**University of California, Los Angeles**, United States of America Visiting Researcher (Host: Prof. Olav Sorenson)
2015 – 2017	**University of Mannheim**, Germany Mannheim Master of Management (M.Sc.)
2016	**EM Lyon**, France Semester abroad
2012 – 2015	**Ludwig Maximilian University of Munich**, Germany Business Administration (B.Sc.)
2015	**Bond University**, Gold Coast, Australia Semester abroad