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Young, Male, Experienced: What factors drive overconfidence? Empirical evidence from marathon running

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Abstract

The effects of overconfidence have substantial and far-reaching economic as well as social implications. A large body of literature has confirmed that overestimating one's own abilities hinders accurate decision-making and considerably influences the quality of decisions, thus leading to substantial negative consequences. In our study, we explore how gender, age, and prior experience affect the occurrence of overconfidence. We investigate these factors within the context of marathon races by analyzing the slowdown of runners, which is seen as a direct and inevitable reaction to the overestimation of one's initial race pace. We confirm the large body of previous studies by revealing a clear gender gap: men have a stronger tendency toward overconfidence. Furthermore, we show that age correlates with overconfidence, with particularly young and old individuals overestimating their potential performance. Moreover, the present study illustrates that the tendency for overconfident behavior increases with experience.

Keywords

overestimation; gender gap; age; experience; distance running

1. Introduction

"No problem in judgment and decision making is more prevalent and more potentially catastrophic than overconfidence"

(Plous, 1993, p.217).

The effects of overconfidence have substantial and far-reaching economic as well as social implications (Bénabou & Tirole, 2002). In previous studies, the concept of overconfidence was used not only to explain the emergence of stock crises, strikes, and wars but also to explain suboptimal decision-making in economic and entrepreneurial contexts (see e.g.: Camerer & Lovallo, 1999; Dunlosky & Rawson, 2012; Glaser & Weber, 2007; Howard, 1985; Johnson, 2004; Malmendier & Tate, 2005; Odean, 1998). Overconfidence reduces the welfare of a population because it leads to increased occurrences of disappointment (McGraw et al., 2004). However, previous studies analyzed the underlying factors and motivations that cause individuals to exhibit overconfident behavior primarily in laboratory settings. One reason for this is that the effects and consequences of overconfident behavior are challenging to isolate and measure. Furthermore, measurability of overconfidence in natural environments such as the work place is extremely difficult since the difference between confidence and overconfidence can only be observed retrospectively.

In this study, underlying factors of overconfidence are investigated by analyzing the behavior of amateur marathon runners. Endurance competitions provide an excellent opportunity to investigate overconfidence. In contrast to prior studies in academic and professional contexts, overconfidence in endurance sport causes clear, direct, and objectively measurable real-life consequences: athletes who choose an overly fast initial pace slowdown in the second half of the race. Comparing an athlete's initial pace with their pace at a later stage of the race indicates whether the athlete correctly assessed, overestimated, or underestimated their ability at the start of the race considering current conditions.

Marathon competitions are particularly suitable for slowdown analysis. Given the length of the course (42.195 km), speed must be chosen even more carefully than in half marathons (21.1 km) because the effect of an overestimated initial speed is much more evident and painful. In contrast to ultra-marathons (distances over 50 km), marathons are mass events, and the large, heterogeneous datasets they provide allow a comprehensive and differentiated analysis of the underlying factors of overconfidence. Previous research on underlying factors of overconfidence has already found overconfident behavior among male as well as younger and older marathon runners (Krawczyk & Wilamowski, 2017). This study builds upon these results and provides detailed insight into the slowdown patterns of men and women using segments of 5 km (part I and II of this project). Furthermore, previous marathon experience has been considered in our model. The influence of experience on overconfidence has been discussed with a considerable degree of controversy in previous studies. Some studies reveal high overconfidence among young, inexperienced individuals, while others have found the opposite. Part III of this project contributes to this discussion.

1.1 Overconfidence and potential influencing factors

As a well-established term in psychology, overconfidence is increasingly discussed in the context of behavioral economics. In a general sense, overconfidence can be described as the discrepancy between expectation and reality (McGraw et al., 2004). In the scientific literature, different nuances and definitions of overconfidence are used. Moore and Healy (2008) solidified the distinction by summarizing three different existing approaches: (i) overconfidence as overestimation of one's own performance, (ii) overestimation of one's own performance in relation to others (e.g. the 'better than average effect'), and (iii) excessive precision in the accuracy of the assessment of one's own performance. The present study is based on the first definition – the pure overestimation of one's own performance.

The concept of overconfidence has received considerable attention in research, largely because of its substantial economic and social implications. As Bénabou and Tirole pointed out in 2002 (p. 872): "From car accidents, failed 'dot. com' firms, and day trading to the space shuttle disaster and lost wars, the costs of overconfidence are plain for all to see." Many studies in metacognition have confirmed that overestimating one's own abilities hinders accurate decision-making and considerably influences the quality of decisions (Plous, 1993). For example, in 1998, Odean used 10,000 brokerage accounts to show that overconfident investors invested significantly more often, resulting in lower returns due to excessive trading. Furthermore, Dunlosky and Rawson (2012) suggested that overconfidence leads to underachievement in academic performance by studying the learning and retention behavior of undergraduate students. Moreover, Johnson (2004) performed four case studies to demonstrate that political leaders who overestimated their own abilities led to the outbreak of wars in the 20^{th} century (WWI and the Vietnam War) and that less positive illusions allowed leaders to find a peaceful solution (the Munich Crisis and Cuban Missile Crisis).

On the other hand, a high level of self-confidence (as a preliminary stage of overconfidence) provides many advantages. High confidence promotes motivation and good performance as it encourages high aspiration levels and helps to maintain them even when hurdles are encountered (Bénabou & Tirole, 2002). Consequently, high self-confidence helps individuals not only to achieve better performances and higher motivation at school and university but also increases the probability of promotions, management positions, and other career-advancing advantages (Anderson et al., 2012). Due to the sharp contrast between the advantages of high confidence and the disadvantages of overconfidence, it is crucial to investigate the underlying factors of overconfidence to understand which mechanisms and strategies could mitigate overconfidence without hindering self-confidence.

Individuals generally tend to overestimate their actual performance (Dunning et al., 2004). Previous studies have chiefly investigated the emergence of overconfidence in specific areas of society, such as the behavior of students in exam situations at school and university or decision-making processes in professional life. However, the focus of this study is to investigate which factors cause overconfidence and, more precisely, to examine the effects of gender, age, and previous experience on the emergence of overconfidence.

1.1.1 Gender and overconfidence

Men tend to be more overconfident than women, as has already been demonstrated in numerous studies in various contexts (see, e.g., Beyer & Bowden, 1997; Lundeberg et al., 1994). Previous studies have focused primarily on the academic and professional spheres and illustrate that men overestimate their educational abilities, problem-solving skills, professional qualifications, and assessments of their own intelligence (Blanch et al., 2008; Dickerson & Taylor, 2000; Newman, 1984; Storek & Furnham, 2014). Existing studies contradictorily describe the self-assessment ability of women. Some studies indicate that women assess themselves realistically (Bench et al., 2015), while others state that women underestimate themselves (Hügelschäfer & Achtziger, 2014). A third group reports that both sexes overestimate themselves but that men do so more strongly (Lundeberg et al., 1994).

1.1.2 Age and overconfidence

There are also conflicting results in previous studies regarding the influence of age on overconfidence. In several studies, overconfidence and the miscalibration of one's own performance rises with increasing age (Hansson et al., 2008; Job, 1990; Menkhoff et al., 2013). In contrast, other studies have demonstrated that overconfidence occurs particularly among young people (Pliske & Mutter, 1996; Touron & Hertzog, 2004). Previous studies do not reveal any patterns in relation to different contexts. In a sports context, the investigation of pacing strategies in endurance competitions has also produced a wide variety of results. Krawczyk and Wilamowski (2017) described the relationship between age and overconfidence as a U-curve; in their study, very young and older marathon runners overestimated their marathon tempo. Conversely, other studies have indicated that older runners are best at estimating their pace (March et al., 2011; Nikolaidis & Knechtle, 2017). Additionally, there are some studies suggesting that age has no influence on the choice of initial pace in endurance competitions (Nikolaidis et al., 2019).

1.1.3 Experience and overconfidence

Similar to the relationship between age and overconfidence, the effect of experience on overconfidence has not yet been sufficiently investigated, and previous studies do not show consistent results. Gervais and Odean (2001) claimed that overconfidence initially increases with greater experience but then decreases at a certain point (see also Mann & Locke, 2001). Other studies, particularly in psychology, have demonstrated that experts more frequently tend toward overconfident behavior compared to non-professionals (e.g. C. Heath & Tversky, 1991). This has been confirmed by several studies in the financial market concerning the trading behavior of investors, where experience positively correlated with the occurrence of overconfidence (Kirchler & Maciejovsky, 2002). In 2013, Menkhoff et al. presented significant impact of both age and investment experience on the degree of overconfidence with surprisingly contrasting directions. In their experiment with institutional investors, investment advisors, and individual investors they found experienced investors to be less overconfident, whereas older investors performed more poorly.

The relationship between experience and overconfidence has not yet been covered extensively in the sport context. Previous studies have primarily investigated how the level of runner affects pacing behavior. The better the athletes, the more controlled and consistent the pacing (D. Breen et al., 2018). Further, Knechtle et al. (2015) confirmed the link between performance and experience in endurance competitions: on average, athletes who have participated in more races in previous years run faster.

1.2 Pacing as a measure for overconfidence in endurance competitions

The greatest difficulty in researching overconfidence is that it cannot be observed directly but only retrospectively. There are few natural environments in which overconfidence can be measured objectively and unambiguously. Moreover, it is often hard to differentiate whether a failure is solely due to an overestimation of one's own performance or to the difficulty of assessing external factors. Endurance contests are among the most genuine and severe judges one can face. There are few environments in which overconfidence or the overestimation of one's own performance is so objectively reflected. By choosing an initial speed, every athlete makes an honest assessment of their performance considering current conditions. In contrast to interviewing athletes on target times before the race, they have no motivation to deliberately over- or underestimate themselves when choosing an initial pace and the overestimation of this decision can be objectively observed at the finish line by assessing the slowdown of the athlete during the race. Regardless of an athlete's ambition – whether they want to run as fast as possible or just want to finish the race – there is no motivation for an amateur athlete to run too fast or behave tactically in relation to other athletes in the first half of the marathon. Choosing an initial pace that is too fast clearly reflects overestimation of one's abilities.

Pacing strategy in endurance competitions requires finding the balance between speed, energy expenditure, and remaining energy reserves (Tucker & Noakes, 2009). It describes the ability to divide remaining energy in such a way that the race can be completed without a major drop in performance due to premature fatigue (Nikolaidis & Knechtle, 2017). There is a clear consensus in the existing literature that constant or negative pacing[1] is the optimal racing strategy for endurance competitions that last several hours (see e.g. Abbiss & Laursen, 2008; March et al., 2011). Studies exploring different pacing strategies reveal that athletes with consistent pacing deliver the best performance. The choice of one's general pacing strategy and particularly their initial pace depends on the athlete' s decision, their appetite for risk (Konings & Hettinga, 2018), and – above all – on their ability to assess their own performance. Therefore, choosing an initial speed that is too fast is an effective measure of overconfidence.

In our study, we investigated overconfidence by measuring how much athletes deviate from their initially chosen pace. Krawczyk and Wilamowski already investigated overconfidence in a sample of one million marathon runners in 2017 by comparing runners' speed in the first half of the marathon with their speed in the second half. The results showed

[1] Negative pacing (or negative splitting) describes a pacing strategy that involves running the first half of a race slower than the second half.

that men as well as younger and older athletes exhibit overconfident behavior. Our study constitutes a further extension of Krawczyk and Wilamowski's study. Firstly, we used detailed 5 km split times of the athletes, which allows a more differentiated view of the athletes' changes in speed. In addition, we explored not only the influence of age and gender but also the effect of previous marathon experience on the occurrence of overconfidence.

2 Materials & Methods

Study data was collected over four consecutive years from two large, annual marathons in Germany (Hamburg 2016-2019; Frankfurt 2015-2018). We selected these races because of data availability, the flat and even routes and, their timing in the spring (Hamburg) and autumn (Frankfurt). Both races have large, heterogeneous athlete fields. Table 1 provides the distribution of athletes by marathon and gender. The percentage of women in our sample is 28% and the athletes are evenly distributed among the 8 races. Only athletes with complete datasets were considered. Individual outliers with unrealistic split times (most likely due to a shortcut or accident) have been excluded.

Table 1.
Number of participants by marathon and gender

	Men	Women	Sum
Frankfurt 2015	8,893	2,271	11,164
Frankfurt 2016	9,392	2,467	11,859
Frankfurt 2017	8,750	2,368	11,118
Frankfurt 2018	8,315	2,304	10,619
Hamburg 2016	9,376	2,701	12,077
Hamburg 2017	9,143	2,787	11,930
Hamburg 2018	7,651	2,360	10,011
Hamburg 2019	7,772	2,326	10,098
	69,292	**19,584**	**88,876**

Table 2 depicts the distribution of athletes according to their age groups (AGs). AGs have been amalgamated to obtain equally sized groups. There was no differentiation between amateurs and professional athletes. The proportion of professional athletes in this sample is <

0.5%. Thus, this study builds on previous research focused primarily on pacing in elite or sub-elite races (see e.g. Abbiss & Laursen, 2008; Frick & Prinz, 2007).

Table 2.
Number of participants by age and gender

	Men	Women	Sum
AG 1 | < 30 years	7,957	3,487	11,444
AG 2 | 30 - 34 years	8,696	2,765	11,461
AG 3 | 35 - 39 years	9,551	2,733	12,284
AG 4 | 40 - 45 years	10,542	3,051	13,593
AG 5 | 45 - 49 years	11,902	3,200	15,102
AG 6 | 50 - 54 years	10,873	2,491	13,364
AG 7 | ≥ 55 years	9,771	1,857	11,628
	69,292	**19,584**	**88,876**

Previous studies examined athlete overconfidence by comparing athletes' speeds in the first and second halves of the race (Krawczyk & Wilamowski, 2017). Our dataset consists of 5 km split times, thereby allowing for a much more granular analysis of the data and deeper insight into athletes' race behavior. Our analyses are divided into three parts. In Part I, we examined athlete overconfidence by comparing initial pace with slowdown later in the race. In Part II, we compared the athletes' detailed race patterns using 5 km segments. Finally, in Part III, we studied the influence of prior marathon experience on athletes' overconfidence.

Part I: Exploring overconfidence by analyzing slowdown over the course of the race

In Part I, as in previous studies, we investigated athletes' overconfidence by comparing their speed in the second half of the race with their initial pace.

In addition to Krawczyk & Wilamowski`s (2017) overconfidence definition ($OC1 = \frac{\text{Net time 2nd half of the marathon}}{\text{Net time 1st half of the marathon}}$), our dataset allows further operationalizations of overconfidence. Large marathon races like those held in Frankfurt and Hamburg are crowded events, especially during the first kilometers, and do not allow runners to choose their pace independently. From kilometers 5–10 onwards, the pack of runners becomes less concentrated and athletes can run at their intended pace, which – if they have chosen their pace appropriately – they can maintain for the rest of the race. Hence, we also examined runners' overconfidence as OC2 = $\frac{\text{pace 30−40km}}{\text{pace 5−15km}}$ and OC_3 = $\frac{\text{pace 30−40km}}{\text{pace 10−20km}}$. These additional overconfidence measures exclude not only the effect of crowding in the first kilometers but also the sprint in the final kilometers (40km–42.195km). In this way, additional effects such as a particularly competitive spirit during the initial crowding or the final kilometers are omitted, such that slowdown in the later parts of the race can be attributed to an overestimated initial pace and thus to overconfidence. The following table displays the distribution of $OC_{1\text{-}3}$ by age and gender.

Table 3.
OC1-3 distribution by age and gender

	OC1		OC2		OC3	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
AK 1 | < 30 years	1.10	1.08	1.15	1.11	1.15	1.10
AK 2 | 30 - 34 years	1.09	1.07	1.14	1.10	1.14	1.10
AK 3 | 35 - 39 years	1.09	1.07	1.14	1.11	1.13	1.10
AK 4 | 40 - 45 years	1.09	1.07	1.13	1.10	1.13	1.09
AK 5 | 45 - 49 years	1.09	1.07	1.13	1.11	1.13	1.10
AK 6 | 50 - 54 years	1.09	1.08	1.14	1.11	1.13	1.10
AK 7 | ≥ 55 years	1.11	1.09	1.15	1.12	1.14	1.11
	1.09	**1.08**	**1.14**	**1.11**	**1.13**	**1.10**

The descriptive overview of the slowdown effects in Table 3 clearly reveals that athletes of both sexes and all AGs overestimate themselves and are not able to maintain their initial pace. Furthermore, a gender-specific difference is evident: regardless of the OC definition, men deviate more from their initial pace and thus show a greater level of overconfidence. In contrast, Table 4 illustrates the slowdown of the top 1% of runners[2]. These professional runners can assess themselves much better and therefore deviate much less from their initial race pace.

[2] The 1% fastest runners in each of the eight races; separated by gender.

Moreover, in the sample of the top 1% of runners, no gender effect is apparent. Once again, this underlines that starting too fast is not a calculated tactic but rather a clear sign of overconfidence.

Table 4.
OC distribution by age for the top 1% of runners

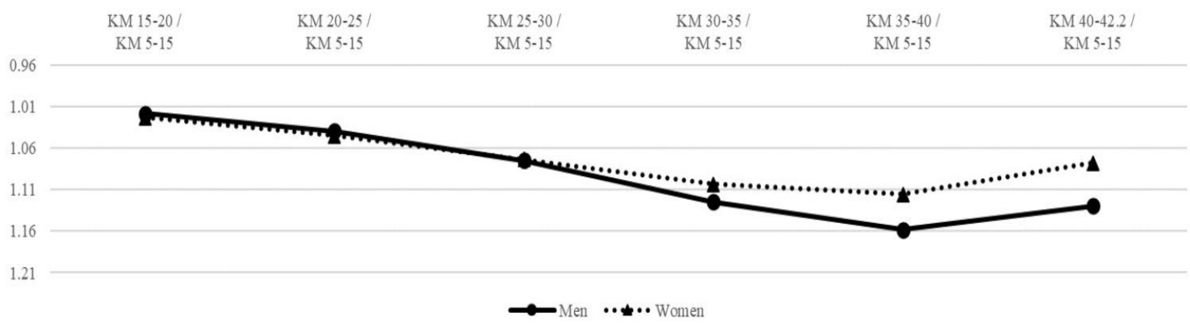
	OC1		OC2		OC3	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Top 1%	1.04	1.04	1.06	1.06	1.06	1.06

Part II: Analysis of the evolution of athletes' pace using 5-km segments

In Part II, we analyzed the effect of initial race pace on the rest of the race in 5-km segments. We referred to the pace between 5km–15km as the initial pace and set the following 5-km segments in relation to it. Figure 1 displays the evolution of athletes' speed in relation to their initial race pace. For both genders, a successive slowdown and deviation from the initial pace is shown in the graph. From kilometer 30, a gender effect becomes visible, with men deviating more strongly than women from their initial pace.

Figure 1.

Speed change per 5 km-segment in relation to initial pace (km 5-15)



Part III: Effect of prior marathon experience

Previous literature presents inconsistent results regarding the impact of prior experience on the occurrence of overconfidence. For this reason, we created a subset of data and added supplementary information on prior marathon experience for 1,890 athletes; as the additional information had to be manually mapped and reviewed, this could not be done for the complete dataset of 88,876 athletes. To ensure an even distribution, 135 athletes were selected per each of the 14 age-sex clusters. The selection of these 1,890 athletes was random using a random number generator. The additional information was obtained via the freely accessible Internet database “marathon-ergebnis.de”[3], which contains the results of all German marathon races in the last 10 years. It can be assumed that women participate in international races in equal proportions which justifies the exclusive consideration of German races in the evaluation of previous experience[4].

Tables 5a provides an overview of the percentage share of athletes who completed at least one previous marathon. The percentage of athletes with prior marathon experience inevitably increases for older athletes and is on average 70.1% (women=68.3%, men=71.9%). As shown in Table 5b, the average number of previous marathon races of the athletes in our sample is 3.3 (women= 3.1 men=3.9).

[3] Sample requirements: athletes must be clearly identifiable via the database marathon-ergebnis.de. Criteria for being included in the data are German nationality and unambiguous attributability via name, age and/or club (e.g. not “Michael Smith, 30 years, no club”).

[4] The proportion of women among German starters in the international 2019 Boston Marathon was 27% and 25% in the 2019 London Marathon (compared to 23% in our sample of the 2019 Hamburg Marathon).

Table 5a.
Percentage share of participants that completed at least one marathon in the last 10 years

	Men	Women
Age Group 1 | < 30 years	42.2%	45.2%
Age Group 2 | 30 - 34 years	64.4%	56.3%
Age Group 3 | 35 - 39 years	65.2%	61.5%
Age Group 4 | 40 - 45 years	78.7%	68.9%
Age Group 5 | 45 - 49 years	80.6%	82.2%
Age Group 6 | 50 - 54 years	86.7%	74.8%
Age Group 7 | ≥ 55 years	85.2%	88.9%
	71.9%	**68.3%**

Table 5b.
Average number of previous races by gender and age

	Men	Women
Age Group 1 | < 30 years	0.9	1.0
Age Group 2 | 30 - 34 years	2.1	1.5
Age Group 3 | 35 - 39 years	2.9	2.1
Age Group 4 | 40 - 45 years	3.7	2.7
Age Group 5 | 45 - 49 years	4.5	4.7
Age Group 6 | 50 - 54 years	5.9	3.9
Age Group 7 | ≥ 55 years	7.1	6.0
	3.9	**3.1**

3 Results

Fourteen dummy variables were introduced to test for differences between the genders and AGs. The dummy variable "Male + 40–44years" was used as a base group to measure the effects on females as well as younger and older athletes. Post-estimation Wald tests were conducted to test for differences between other categories. Previous papers used runners' absolute speed as a control variable To prevent multicollinearity, we controlled for athletes' relative speed[5]. In addition, we controlled for race (location and year) to account for effects such as extreme weather conditions.

Part I: Exploring overconfidence by analyzing slowdown over the course of the race

The impact of gender and age on overconfidence was first analyzed using linear regressions with operationalized overconfidence OC1, OC2, and OC3 as continuous dependent variables. Table 6 shows the results of the OLS regression.

As shown in Table 6, all three models reveal a clear gender-specific effect: women run a significantly more consistent race and are far less likely to overestimate their initial pace. Post-estimation Wald tests confirmed that these gender differences are significant in all AGs. With respect to age, there are also significant effects: compared to middle-aged men, younger athletes (< 40 years) and older athletes (> 50 years) particularly overestimate themselves.

[5] $\frac{\text{overall finishing time}}{\text{Median overall finishing time in the respective age X gender X race cluster}}$

Table 6.

Linear regression: Explaining overconfidence with gender and age

	Model 1	Model 2	Model 3
Dependent Variable	$OC_1 = \frac{\text{pace 2nd half}}{\text{pace 1st half}}$	$OC = \frac{\text{pace km } 30-40}{\text{pace km } 5-15}$	$OC = \frac{\text{pace km } 30-40}{\text{pace km } 10-15}$
Independent Variable			
Gender x Age			
(Male + 40-44 years)			
Male + <30 years	**.0159** (.0013)***	**.0244** (.0018)***	**.0231** (.0017)***
Male + 30-34 years	**.0062** (.0012)***	**.0100** (.0017)***	**.0105** (.0016)***
Male + 35-39 years	**.0032** (.0012)**	**.0052** (.0017)**	**.0056** (.0016)***
Male + 45-49 years	**.0013** (.0011)	**.0013** (.0016)	**.0008** (.0015)
Male + 50-54 years	**.0053** (.0012)***	**.0048** (.0016)**	**.0031** (.0015)*
Male + >54 years	**.0152** (.0012)***	**.0168** (.0017)***	**.0111** (.0016)
Female + <30 years	**-.0103** (.0017)***	**-.0171** (.0023)***	**-.0213** (.0022)***
Female + 30-34 years	**-.0165** (.0018)***	**-.0265** (.0025)***	**-.0300** (.0024)***
Female + 35-49 years	**-.0162** (.0018)***	**-.0260** (.0025)***	**-.0287** (.0024)***
Female + 40-44 years	**-.0168** (.0017)***	**-.0282** (.0024)***	**-.0318** (.0023)***
Female + 45-49 years	**-.0150** (.0017)***	**-.0262** (.0024)***	**-.0305** (.0023)***
Female + 50-54 years	**-.0081** (.0019)***	**-.0173** (.0026)***	**-.0236** (.0025)***
Female + >54 years	**.0029** (.0021)	-**.0059** (.0030)*	-**.0155** (.0028)***
Speed			
Speed compared to Median	**.2721** (.0018)***	**.3630** (.0024)***	**.3118** (.0023)***
Constant	**.8242** (.0021)***	**.7851** (.0029)***	**.8314** (.0028)***
Race-Year Dummies	YES	YES	YES
Observations	88,780	88,580	88,580
Adjusted R-squared	0.2457	0.2371	0.2086

Legend: *** denotes significance <1% ** denotes significance at 1%. * denotes significance at 5%. Robust standard errors are in parentheses.

Table 20 provides the results of an OLS regression of the fastest 1% of women and men in each race. There are no significant gender differences among these top runners, which provides further evidence that the sex difference in the main sample (Models 1–3) is not due to physiological differences in men but due to men's general overestimation, which is absent among top runners who understand the importance of consistent pacing.

Table 7.
Top 1%: Explaining overconfidence with gender and age

	Model 2a
Dependent Variable	$\frac{pace\ km\ 30-40}{pace\ km\ 5-15}$
Independent Variable	
Gender	
(Men)	
Women	**-.0024** (.0013)
Speed	
Speed compared to Median	**-.0041** (.0591)
Constant	**1.0618** (.0379)***
Race-Year Dummies	YES
Observations	896
R-squared	0.0289

Legend: *** denotes significance <1% ** denotes significance at 1%. * denotes significance at 5%. Robust standard errors are in parentheses.

The results of the probit regressions in Table 8 clearly confirm previous findings: Women of all AGs deviate significantly less frequently by more than 20% (or 30% or 40%) from the initial race pace in the last quarter of the race. Additionally, with regard to the effect of age, the results from Model 1–3 are confirmed: athletes in the lower (< 34 years) and upper (> 55 years) AGs overestimate themselves significantly more when choosing their initial race pace. However, a particularly strong deviation in pace of >40% (Model 6) can be only found for younger athletes. Model 7 illustrates athletes who deviate at most 5% from their initial pace. Here, too, younger and older male athletes tend to deviate more than 5%, while younger women typically run a consistent race.

Table 8. *Probit regression: Explaining overconfidence with Gender and Age*

	Model 4	**Model 5**	**Model 6**	**Model 7**
Dependent Variable	$OC_2 > 1,2$	$OC_2 > 1,3$	$OC_2 > 1,4$	$0,95 < OC_2 < 1,05$
Independent Variable				
Gender x Age				
(Male + 41-45 years)				
Male + <30 years	**.0562** (.0055)***	**.0460** (.0039)***	**.0295** (.0026)***	**-.0184** (.0063)***
Male + 30-34 years	**.0286** (.0054)***	**.0215** (.0039)***	**.0129** (.0026)***	**.0121** (.0061)***
Male + 35-40 years	**.0151** (.0053)***	**.0078** (.0039)***	**.0038** (.0027)***	**.0003** (.0059)***
Male + 46-50 years	**-.0001** (.0051)***	**-.0058** (.0037)***	**-.0032** (.0026)***	**-.0146** (.0056)***
Male + 51-55 years	**.0077** (.0051)***	**-.0028** (.0038)***	**-.0051** (.0027)***	**-.0343** (.0058)***
Male + >55 years	**.0370** (.0052)***	**.0102** (.0038)***	**.0005** (.0027)***	**-.0806** (.0061)***
Female + <30 years	**-.0522** (.0078)***	**-.0434** (.0061)***	**-.0214** (.0044)***	**.0260** (.0081)***
Female + 30-34 years	**-.0810** (.0087)***	**-.0719** (.0073)***	**-.0312** (.0052)***	**.0299** (.0088)***
Female + 35-40 years	**-.0923** (.0089)***	**-.0615** (.0070)***	**-.0332** (.0053)***	**.0294** (.0081)***
Female + 41-45 years	**-.1040** (.0086)***	**-.0858** (.0073)***	**-.0505** (.0060)***	**.0155** (.0084)***
Female + 46-50 years	**-.0980** (.0084)***	**-.0821** (.0072)***	**-.0471** (.0057)***	**.0044** (.0084)***
Female + 51-55 years	**-.0641** (.0089)***	**-.0694** (.0076)***	**-.0039** (.0060)***	**-.0269** (.0094)***
Female + >55 years	**-.0294** (.0098)***	**-.0536** (.0082)***	**-.0452** (.0072)***	**-.0706** (.0110)***
Speed				
Speed compared to Median	**.9511** (.0068)***	**.5333** (.0056)***	**.2597** (.0044)***	**-.8281** (.0088)***
Constant	-	-	-	-
Race-Year Dummies	YES	YES	YES	YES
Observations	88,580	88,580	88,580	88,876
Pseudo R2	0.1831	0.1937	0.1904	0.0988

Legend: *** denotes significance <1% ** denotes significance at 1%. * denotes significance at 5%. Robust standard errors are in parentheses.

Part II: Analysis of the evolution of athletes' pace using 5-km segments

In the second part of the analysis, the individuals' initial race pace (kilometers 5–15) was compared with the subsequent 5-km segments. We used the OC definition of the second model (OC_2) as a baseline in order to exclude the effects of crowding in the opening kilometers. As such, the initially chosen speed can be compared with later speed without the influence of these special race effects. Table 9 presents the results of the OLS regression models for the respective sections.

As can be seen in Table 9, the analysis of the 5-kilometer segments reveals clear gender-specific differences in pace development. In the first half of the marathon (models 8 and 9), women of all AGs deviate more strongly from their initial pace and become successively slower compared to the comparison group of middle-aged men. From kilometer 30 (model 11), the picture reverses: in the last 10 kilometers of the race, male athletes decelerate significantly more than women. A look at the coefficients reveals that the slowdown of male athletes in the last quarter of the race is significantly more pronounced than the pace deviation of the female athletes in the first half. The difference is particularly evident in the final kilometers (Model 13) where, for example, women in the 41–45 AG deviate 5.09 percentage points less from their initial pace than the male comparison group. The models clearly show the inevitable slowdown in the final kilometers in response to an overestimated initial pace among male athletes. Female athletes, in contrast, adjust and down-regulate their pace significantly stronger than men in the first part of the race. Although women also overestimate themselves, they seem to become aware of this earlier and take measures to counteract it or adjust their pace earlier than men. Furthermore, the models confirm the findings in Part I that younger (< 30 years) and older (> 55 years) athletes in particular tend to overestimate themselves. Post-estimation Wald tests show that this age-based differentiation is less pronounced among women. Although the significant slowdown of older athletes (> 55 years) is also confirmed in women, unlike in the male groups, younger female athletes (< 30 years) barely differ from female athletes in the middle AGs.

Table 9. *Linear regression: Analysis of the evolution of pace per 5-km segment*

Dependent Variable	Model 8 $\frac{pace\ km\ 15-20}{pace\ km\ 5-15}$	Model 9 $\frac{pace\ km\ 20-25}{pace\ km\ 5-15}$	Model 10 $\frac{pace\ km\ 25-30}{pace\ km\ 5-15}$	Model 11 $\frac{pace\ km\ 30-35}{pace\ km\ 5-15}$	Model 12 $\frac{pace\ km\ 35-40}{pace\ km\ 5-15}$	Model 13 $\frac{pace\ km\ 40-42.2}{pace\ km\ 5-15}$
Independent Variable						
Gender x Age						
(Male + 41-45 years)						
Male + <30 years	**.0021** (.0005)***	**.0058** (.0008)***	**.0174** (.0013)***	**.0258** (.0017)***	**.0231** (.0020)***	**.0098** (.0022)***
Male + 30-34 years	**-.0008** (.0005)	**-.0002** (.0008)	**.0042** (.0012)**	**.0087** (.0017)***	**.0114** (.0020)***	**.0087** (.0022)***
Male + 35-40 years	**-.0005** (.0005)	**-.0005** (.0007)	**.0025** (.0012)*	**.0055** (.0016)**	**.0053** (.0019)**	**.0032** (.0021)
Male + 46-50 years	**.0007** (.0004)	**.0005** (.0007)	**.0013** (.0011)	**.0021** (.0051)	**.0007** (.0018)	**.0003** (.0020)
Male + 51-55 years	**.0021** (.0004)***	**.0052** (.0007)***	**.0066** (.0012)***	**.0071** (.0016)	**.0024** (.0018)	**.0022** (.0021)
Male + >55 years	**.0084** (.0005)***	**.0145** (.0007)***	**.0179** (.0012)***	**.0203** (.0016)***	**.0136** (.0019)***	**.0111** (.0021)***
Female + <30 years	**.0061** (.0006)***	**.0087** (.0010)***	**.0097** (.0016)***	**-.0051** (.0023)*	**-.0292** (.0026)***	**-.0513** (.0029)***
Female + 30-34 years	**.0042** (.0007)***	**.0058** (.0011)***	**.0024** (.0018)	**-.0144** (.0025)***	**-.0384** (.0029)***	**-.0530** (.0032)***
Female + 35-40 years	**.0040** (.0007)***	**.0061** (.0011)***	**.0010** (.0018)	**-.0140** (.0025)***	**-.0379** (.0029)***	**-.0521** (.0032)***
Female + 41-45 years	**.0051** (.0007)***	**.0067** (.0011)***	**.0015** (.0017)	**-.0167** (.0024)***	**-.0396** (.0028)***	**-.0509** (.0031)***
Female + 46-50 years	**.0066** (.0007)***	**.0079** (.0011)***	**.0025** (.0017)	**-.0133** (.0023)***	**-.0392** (.0027)***	**-.0448** (.0031)***
Female + 51-55 years	**.0096** (.0007)***	**.0134** (.0012)***	**.0092** (.0019)***	**-.0044** (.0026)	**-.0301** (.0030)***	**-.0402** (.0034)***
Female + >55 years	**.0144** (.0008)***	**.0218** (.0013)***	**.0194** (.0021)***	**.0065** (.0029)*	**-.0180** (.0034)***	**-.0236** (.0038)***
Speed						
Speed compared to Median	**.0736** (.0007)***	**.1641** (.0011)***	**.2851** (.0017)***	**.3796** (.0024)***	**.3462** (.0028)***	**.2194** (.0031)***
Constant	**.9409** (.0008)***	**.8676** (.0013)***	**.7859** (.0021)***	**.7547** (.0017)***	**.8158** (.0017)***	**.9047** (.0037)***
Race-Year Dummies	YES	YES	YES	YES	YES	YES
Observations	88,580	88,580	88,580	88,580	88,580	88,580
Adjusted R-squared	0.2182	0.2283	0.2617	0.2571	0.1861	0.0827

Legend: *** denotes significance <1% ** denotes significance at 1%. * denotes significance at 5%. Robust standard errors are in parentheses.

Part III: Effect of prior marathon experience

To test the correlation of experience and overconfidence, information concerning prior marathon experience was collected for a subset of 1,890 athletes. Given that the number of previous races correlates with AG, to avoid multicollinearity, the number of previous races was set in relation to the respective AG and expressed in quartiles with athletes in 4th quartile depicting greatest experience.

Table 10. *Linear regression: Effect of prior race experience*

Dependent Variable	**Model 14** $\frac{pace\ km\ 30-40}{pace\ km\ 5-15}$
Independent Variable	
Gender	
Women	**-.0246** (.0051)***
Age	
('Age Group 4 | 40 - 45 years)	
Age Group 1 | < 30 years	**-.0005** (.0098)
Age Group 2 | 30 - 34 years	**.0066** (.0096)
Age Group 3 | 35 - 39 years	**-.0085** (.0096)
Age Group 5 | 45 - 49 years	**-.0132** (.0095)
Age Group 6 | 50 - 54 years	**-.0068** (.0095)
Age Group 7 | ≥ 55 years	**-.0041** (.0095)
Speed	
Speed compared to Median	**.3831** (.0174)***
Experience | Number of previous races	
(1st Quartile per respective age group)	-
2nd Quartile " "	**.0258** (.0079)**
3rd Quartile " "	**.0285** (.0069)***
4th Quartile " "	**.0344** (.0070)***
Constant	**.7499** (.0221)***
Race-Year Dummies	YES
Observations	1,890
Adjusted R-squared	0.2446

Legend: *** denotes significance <1% ** denotes significance at 1%. * denotes significance at 5%. Robust standard errors are in parentheses.

The results of the linear regression models that are illustrated in Table 23 reveal that previous marathon experience has a significant impact on racing pattern. Independent of age, overconfidence was more likely to occur in experienced athletes. Athletes who ran a larger number of marathons in the last 10 years compared to peers of their age group are more likely to overestimate themselves and start the race with a too fast initial pace. In this model, we also controlled for athlete speed and demonstrated at the same time that faster athletes are in turn better able to estimate their speed and are less likely to experience a severe slowdown. One reason for this finding could be that athletes who have gained positive experience with their race tactics in previous races are more likely to participate in a marathon again and to approach the race with increased self-confidence or even overconfidence. In particular, our data show that the likelihood of overconfidence increases with the number of previous races. A further reason for this is that athletes who have already completed a large number of marathons have particularly little to lose. They have already ticked off the mere finishing of a marathon which is considered a primary goal of many endurance athletes. With an increasing number of marathons and experience, personal goals grow and require not only increased performance but also greater risk.

4 Discussion and Conclusion

4.1 Gender and Overconfidence

This study confirms previous scientific findings: Men are significantly more prone to overconfidence than women. In our study, men tend to overestimate their abilities when choosing their initial pace and deviate relatively more from their initial pace over the course of the race. The analysis of 5-km segments provided detailed insight into the behavior of athletes during the races. Over the first half of the race, women gradually slowed down and adjusted their initial pace downwards significantly more than men. Compared to women, male athletes maintained their initial pace in the first half of the race, but then started to rapidly slowdown from kilometer 30 onwards. The results of the detailed analysis of the 5km splits clearly reveal that the behavior of male runners is not a matter of race tactics, but the slowdown in the last quarter of the race is a strong sign of overestimation and a clear reaction to excessive speed during the early kilometers of the race. In addition, future studies could explore varying behavior during a competition in more detail. For example, previous studies have shown that athletes tend to redefine their goals during the race and thus adjust their speed repeatedly (Allen et al., 2017). It would be instructive to investigate the extent to which this applies to both genders and, more specifically, whether women are more willing to deviate from their initial goal and if they are more defensive when formulating new goals during the race. The highly competitive environment of the sports context and the self-selection of athletes is also very similar to the conditions in the labor market. In a professional environment, the choice of occupations is likewise not random, but occurs as a self-selection of employees based on their preferences and abilities (Lazear, 2018). We see in the data that gender differences in overconfidence are limited to amateur athletes and disappear among professional athletes. This confirms previous research showing that gender-specific behavioral differences such as overconfidence and risk-aversion that are evident in the general population completely disappear in the professional context, which is explained in particular by self-selection and socialization (Hardies et al., 2013). The modification of gender differences in the professional context, which is also evident in our sample, is an important step in explaining and resolving the underrepresentation of women in leadership positions. Further studies should build on these findings and, in particular, investigate gender differences in different settings. Furthermore, we know from prior studies that men behave differently when competing against women and are particularly more competitive (Booth and Yamamura, 2018; Gneezy et. al, 2003). Further analyses of single-sex competitions would offer additional insight into the extent to which the presence of women in competitions affects men and leads to overconfidence (e.g. the Ironman 70.3 World Championships are held on separate days for men and women). Moreover, future studies should investigate which factors and measures could help to lower the overconfidence level of amateur runners of both sexes. Previous studies suggest that regular feedback helps people to assess their performance more realistically (Kluger & DeNisi, 1996). For this purpose, it would be crucial to analyze how athletes behave if they receive constant feedback concerning their performance, effort, and remaining energy reserves during a competition (e.g. via a watt meter in cycling competitions or triathlons). A potential limitation of the sports context considered in the present study is that it is unclear to what extent the more pronounced slowdown of men is due to physiological factors, such as gender differences in susceptibility to muscle glycogen depletion (see e.g. Hunter, 2014; Roepstorff et al., 2002). However, the analysis with data of top 1% athletes, where no gender-specific difference in slowdown behavior could be found, indicates that physiological factors play only a minor role.

4.2 Age and Overconfidence

Previous studies did not provide a consistent picture of the correlation between age and overconfidence. Some studies have stated that older athletes assess their performance more accurately, while other studies have found that old and young athletes overestimate themselves. Our large sample of almost 90,000 athletes yields the following results: athletes in AGs < 30 years and > 55 years are most likely to choose a too-fast initial speed. For older athletes, this overestimation could be due to the temptation to start with a speed that was normal when the athlete was younger but who is then confronted with the natural limitations that come with advancing age. Our results indicate that the increased overconfidence in younger and older athletes applies equally to both genders. However, the overconfidence of younger athletes is more pronounced in males. Further studies should investigate whether age-related overconfidence is due to different motivations and objectives or whether biological factors such as metabolic processes play a role.

4.3 Experience and Overconfidence

Previous findings on the influence of experience on overconfidence have been inconsistent. Kahneman and Klein (2009) already discussed extensively under which conditions experience has a positive effect on decision making through improved intuition and when instead experience leads to disadvantages due to biases and overconfidence. Using our subsample of 1,890 athletes, we showed that athletes who have completed a larger number of races compared to other athletes in their AG tend to overestimate themselves. Previous experience thus seems to cause athletes to be more exuberant and overconfident.

One reason for this could be that previous marathon experience encourages athletes to be more ambitious and motivated to take a higher risk in order to push themselves further to their limit and with each additional race, athletes accept a higher risk in order to discover their limit. Further studies should explore why previous studies arrive at such inconsistent conclusions regarding the interplay of experience and overconfidence. What circumstances must prevail for people to learn from past experiences? To what extent do the quality of and the reflection on previous experience play a role (e.g. in the form of feedback)? Detailed investigation of these questions and underlying factors is crucial for overconfidence prevention – particularly in the business context, where increased experience is accompanied by increased responsibility and decision-making power, thus increasing the potential extent of damage caused by overconfidence.

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