Hormones in speed-dating

The role of testosterone and cortisol in attraction

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DOI
10.1016/j.yhbeh.2019.07.003

Publication date
2019

Document Version
Accepted author manuscript

Published in
Hormones and Behavior

Manuscript Details

Manuscript number	HB_2018_403_R2
Title	Hormones in speed-dating: The role of testosterone and cortisol in attraction
Article type	Research paper

Abstract

There is evidence that testosterone and cortisol levels are related to the attraction of a romantic partner; testosterone levels relate to a wide range of sexual behaviors and cortisol is a crucial component in the response to stress. To investigate this, we conducted a speed-dating study among heterosexual singles. We measured salivary testosterone and cortisol changes in men and women (n = 79) when they participated in a romantic condition (meeting opposite-sex others, i.e., potential romantic partners), as well as a control condition (meeting same-sex others, i.e., potential friends). Over the course of the romantic speed-dating event, results showed that women's but not men's testosterone levels increased and cortisol levels decreased for both men and women. These findings indicate that men's testosterone and cortisol levels were elevated in anticipation of the event, whereas for women, this appears to only be the case for cortisol. Concerning the relationship between attraction and hormonal change, four important findings can be distinguished. First, men were more popular when they arrived at the romantic speed-dating event with elevated cortisol levels. Second, in both men and women, a larger change in cortisol levels during romantic speed-dating was related to more selectivity. Third, testosterone alone was unrelated to any romantic speed-dating outcome (selectivity or popularity). However, fourth, women who arrived at the romantic speed-dating event with higher testosterone levels were more selective when their anticipatory cortisol response was low. Overall, our findings suggest that changes in the hormone cortisol may be stronger associated with the attraction of a romantic partner than testosterone is.

Keywords	testosterone; cortisol; speed-dating; attraction; popularity; selectivity; human mating; social relation model

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Suggested reviewers	James Roney, Pranjal Mehta, Peter Gray, Peter Bos

Submission Files Included in this PDF

File Name [File Type]

R2 cover letter.docx [Cover Letter]

R2 Response to reviewer.docx [Response to Reviewers]

Track changes R2 Hormones in speed-dating.docx [Response to Reviewers]

Resubmission Highlights.docx [Highlights]

R2 Hormones in speed-dating.docx [Manuscript File]

Figure 1.eps [Figure]

Figure 2.eps [Figure]

Figure 3.eps [Figure]

Figure 4.eps [Figure]

Figure 5 v2.eps [Figure]

Research Data Related to this Submission

Data set http://dx.doi.org/10.17632/bgs3fjkcnb.1#file-8ee3f62c-732f-4e5e-8a06-b6aeef3a8735

Data for: Hormones in speed-dating: The role of testosterone and cortisol in attraction

Datafile belonging to the submission "Hormones in speed-dating: The role of testosterone and cortisol in attraction."

Eindhoven, The Netherlands

June 25, 2019

Regarding: Revision Manuscript HB_2018_403_R1

Dear Kim Wallen,

We would like to submit a revision of our previous submission. We thank you for the time spent on the manuscript. We have followed your suggestions concerning the ceiling effect, effect sizes, and marginal significance. We also have tried to follow-up on the remaining points of the 2nd reviewer.

Importantly, upon preparing a talk about this study and looking at Figure 5, I found a data interpretation error in one of the four findings. In the abstract, we claimed:

- "Second, in both men and women, a larger change in cortisol levels during romantic speed-dating was related to **less** selectivity."

However, according to Figure 5 and the calculation description in 2.6 of the methods, it appears that this relationship is reversed and thus should read:

- "Second, in both men and women, a larger change in cortisol levels during romantic speed-dating was related to **more** selectivity."

This error occurred because selectivity was actually reverse coded. A higher score meant less selectivity. The relationship we found was a negative correlation and thus this result thus indicated more selectivity instead of less selectivity. This was actually correctly described in section 2.6 of the methods and in the figure legend of Figure 5. Unfortunately, our numerous data and result checks failed to spot this at an earlier stage.

As a result, we have changed "less" into "more" in our abstract. We have now changed the paragraph discussing the result to reflect this new result. We did so by keeping our previous rationale while adding a new explanation for this different result. Please see the last paragraph of the section "Cortisol and attraction" in the discussion. To avoid possible confusion for readers we have now reverse coded the selectivity variable in such a way that a higher score means more selectivity (saying "yes" less frequently) and have changed figure 5 and its legend correspondingly. We are very sorry this error occurred.

Thankfully, we did not have to change too much in the discussion as this finding was briefly discussed. Additionally, the main message of our article remains intact: cortisol may be more important in speed-dating than testosterone.

Again, we are very sorry this mistake happened but we are happy we found this error at this stage of the review process. Notwithstanding this mistake, we hope that you still find this submission fit for publication in Hormones and Behavior. If you have any comments or questions, please do not hesitate to contact us.

Kind regards,

Leander van der Meij
The authors

Response to editor

Thank you for submitting your revised manuscript to Hormones and Behavior. It has been reviewed by one of the original reviewers who has raised an issue, because your study was not preregistered, about whether analyses and dependent variables were selected in advance or after the data were collected. While I think preregistration is a good practice, I don't see a lack of preregistration as grounds for suggesting that analyses are cherry-picked. In reading your paper I don't find any of the analyses particularly unique and that they reflect what most would analyze given the design of your study. You may respond to the reviewer's comments as you think best.

1. There are a few matters that I think need addressing. In the abstract you make the claim that because some hormones did not increase over intake levels that the hormones were at ceiling. This is not an appropriate inference unless there were additional challenges that could have been expected to increase hormone levels. This is particularly important for cortisol. While one can say the hormone levels didn't change it is pure speculation as to why that is the case and a ceiling cannot be invoked.

   Response: We agree here that we were perhaps too speculative. We have now removed any mentioning of a ceiling effect from our abstract and discussion. Now we discuss that hormonal levels were elevated and did not change (see 2nd paragraph of the discussion and 1st paragraph of the section “Testosterone and attraction” in the discussion).

2. In line 737 you refer to a marginally-significant finding (p=0.056). Marginally-significant is not a meaningful term. Significance is a convention not a continuous measure. A finding is either significant or not depending upon that alpha level chosen. So the finding you describe as marginally-significant is no significant. This is the reason for effect size estimates because you can talk about the magnitude of effect whether or not a finding is statistically reliable.

   Response: We now have removed any mentioning of marginal significance and now discuss this finding as non-significant.

3. This raises another issue that I think needs to be addressed. You have provided effect size estimates for your findings (thanks!), but you don't really address effect sizes, particularly that most are small of very small. The largest you have is the decrease in CORT under the control condition, which has a Cohen's d of 1.21. The size of this effect, which is much larger than the effect in the romantic condition, suggests that the romantic condition is quite stressful. I would like the size of your effects addressed in the paper.

   Response: We now discuss effect sizes in the discussion at the following sections:

   - The beginning of the first paragraph of the discussion.
   - In the discussion, the first paragraph of the section “cortisol change”.
   - First and last paragraph “Cortisol and attraction” in the discussion.
   - Last paragraph “Cortisol and attraction” in the discussion.

Response to reviewer

I appreciate the authors' thoughtful and respectful comments, and the care they've taken in the revision. They have addressed many of my concerns and comments, though a few remain.

> **Response:** We again thank the reviewer for his/her time spent on the manuscript. We have responded to his/her suggestions below.

1. The main one is still about the analyses; I noted that there seemed to be a lot of subjectivity to the analyses that occurred as data were being analyzed, and the authors responded that they did not preregister their study, and that this would have been the only way to address this particular concern. But the authors could either honestly state that these were analyses they set out to do, or honestly state that they decided on analyses as they went through, which increases the chance of error and heightens the need for confirmatory findings. Preregistration, after all, is only a way to formally state the first (they planned these analyses) without having to hope for honesty later on. But we could still ask for it, no? So, it seems like either/or (i.e., either the authors did plan these analyses or didn't), which could be reported.

   Response: At the time of planning and executing the study, we did not have a statistical analyses plan ready. It was already a huge amount of work to make this experiment possible and, at that time, preregistration was just not something we even considered doing. In hindsight, yes, we should have preregistered, which with newer studies we now always do. Nonetheless, we performed the most appropriate statistical analyses that would test our hypotheses. We did not choose our analyses on the basis of what would produce statistically significant findings. Indeed, when comparing our hypotheses with our findings it is evident that we find things we did not hypothesize. Thus, we also do not see why we would have a "chance of error" and a heightened need for confirmatory findings". Nor do we think it will improve our manuscript (or the reputation of the journal) if we would report that we did not choose our analyses on the basis of what produced statistically significant findings.

2. Somewhat in relation, the authors note that they also measured (in addition to selectivity and popularity) ratings of long- and short-term sexual partner and potential friend ratings. Specifically, they note that "…these data were not analyzed as these ratings did not have any implications for the participants." I'm not sure what not having implications means. Were all these included as potential DVs, but only the ones that were significant were reported as DVs? These measured but not reported ones certainly sound like DVs the authors would have intended to report on given hypotheses (and, if not, why measure them?). This is a major concern, as it suggests picking and choosing which DVs to report based on post hoc decisions about significance – this of course alters the interpretation of any and all results. If the authors can clarify the above concerns, that may resolve the issue. However, it would require being explicit and very direct about whether analyses were planned or not, and whether DVs were selected (and on what basis). At present, I can only conclude that the analyses and DVs were chosen on the basis of what made for significant results and a clear story, rather than a linear exploration of the data as it was intended to be analyzed.

   Response: We also took ratings of long- and short-term sexual partner and potential friend ratings so that the three Master students working on the project could use these variables for their research projects. With this comment: "these data were not analyzed, as these ratings did not have any implications for the participants", we meant that participants could give any number on these rating scales and this would not have any consequence for the match making. Only when both participants indicate a "yes" they would get to know each other's' contact information. Thus, only saying "yes" or "no" had real behavioral outcomes.

Some smaller issues below:

3. I wonder how much having one's physicality literally measured as part of the study might have impacted how important physicalities then became to the participants, e.g., with prompting. And, now that it's clear the authors designed the speed dating (that certainly must have been a lot of work!), it would be helpful to know how it was advertised and whether participants treated it more as a research study or more as an actual speed dating event.

   Response: We have now added this information in section 2.1 of the methods.

4. It would be useful to list more limitations in the discussion related to some of the previous points raised, including hormonal contraceptive use and the gender-friend confound.

   Response: As mentioned in our previous response, friends usually participated in the same group, meaning that they would have same-sex speed-dates with people from the other group whom they did not know (see now first paragraph 2.2). Also, we have done many statistical checks for hormonal contraceptive use, see the supplementary analyses S4 and 3.2 in the results. These results showed no important influence of HC use on our results. Taken together, we feel these limitations are thus already addressed in our manuscript.

Hormones in speed-dating: The role of testosterone and cortisol in attraction

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Abstract

There is evidence that testosterone and cortisol levels are related to the attraction of a romantic partner; testosterone levels relate to a wide range of sexual behaviors and cortisol is a crucial component in the response to stress. To investigate this, we conducted a speed-dating study among heterosexual singles. We measured salivary testosterone and cortisol changes in men and women (*n* = 79) when they participated in a romantic condition (meeting opposite-sex others, i.e., potential romantic partners), as well as a control condition (meeting same-sex others, i.e., potential friends). Over the course of the romantic speed-dating event, results showed that women's but not men's testosterone levels increased and cortisol levels decreased for both men and women. These findings ~~further~~ indicate that men's testosterone and cortisol levels were ~~at ceiling level~~elevated in anticipation of the event, whereas for women, this appears to only be the case for cortisol. Concerning the relationship between attraction and hormonal change, four important findings can be distinguished. First, men were more popular when they arrived at the romantic speed-dating event with elevated cortisol levels. Second, in both men and women, a larger change in cortisol levels during romantic speed-dating was related to ~~less~~ more selectivity. Third, testosterone alone was unrelated to any romantic speed-dating outcome (selectivity or popularity). However, fourth, women who arrived at the romantic speed-dating event with higher testosterone levels were more selective when their anticipatory cortisol response was low. Overall, our findings suggest that changes in the hormone cortisol may be stronger associated with the attraction of a romantic partner than testosterone is.

Keywords: testosterone; cortisol; speed-dating; attraction; popularity; selectivity; human mating; social relation model

1 Introduction

Speed-dating events are well suited to study initial romantic attraction between individuals (Finkel et al., 2007). In speed-dating, individuals meet potential romantic partners during short “dates” of a few minutes, after which they indicate whether or not they would like to see them again. When both individuals have indicated that they would like to see each other, this is considered a match and their contact information is exchanged. Not surprisingly, there is quite some evidence concerning the psychological processes that take place during these speed-dates (e.g., Asendorpf et al., 2011) and contributing factors such as personality and ideal partner preferences (e.g., Joel et al., 2017). However, it still remains unclear if, and to what extent, physiological changes relate to dating outcomes. Of special interest are the hormones testosterone and cortisol, as a large body of research has shown that testosterone relates to sexuality (e.g., Roney, 2016) and that cortisol is a crucial component in the regulation of energy requiring processes in response to stress (e.g., Sapolsky et al., 2000).

To our knowledge, no study to date has explored whether changes in these hormones relate to attraction in a real-world dating environment. This study tested this by measuring testosterone and cortisol levels before and after a speed-dating event in heterosexual men and women. Unique in this study is that participants also participated in a control condition in which they speed-dated with same-sex others to make potential friends. This control condition enabled us to control for the arousal produced by meeting new people, and to extract hormonal changes that were more specific to attracting a romantic partner. The attraction of dates can be measured in various ways, but in the current study we used *selectivity*: how many dates does an individual accept as a potential romantic partner, and *popularity*: by how many dates is an individual accepted as a potential romantic partner. The advantage of these measures is that they have real consequences for participants: when both dates said yes they would receive each other’s contact details to potentially arrange further meetings.

Testosterone

How would testosterone relate to selectivity and popularity in speed-dating? According to a broad evolutionary framework, testosterone levels promote competition for potential romantic partners at a cost to investments in other areas (Roney, 2016). More specifically, the challenge hypothesis theorizes that high levels of testosterone are an indication that resources are being allocated to mating effort (Archer, 2006). An example of such mating effort would be effort spend to acquire mates during speed-dating. On the other hand, low testosterone levels are an indication that resources are being allocated to parental effort (Archer, 2006), for example, when taking care of children. Alternatively, the steroid/peptide theory of social bonds puts forward that the distinction between mating and parental effort is not specific enough (van Anders et al., 2011). Instead, high testosterone levels may only map onto mating effort if the behavior is competitive (e.g., competing for mates) but not when mating effort is nurturing (e.g., bonding with partner; van Anders, 2013).

Indeed, in the scientific literature there is substantial evidence for the proposition that high testosterone levels are related to mate acquisition in men (i.e., high mating effort or competitive behavior). For example, men with higher basal testosterone levels had a greater number of lifetime sexual partners in a large sample of American elderly men (Pollet et al., 2011) and Australian male students (Peters et al., 2008). Furthermore, in North-American male students, those who were single had higher basal testosterone levels than those in a relationship (van Anders and Goldey, 2010; van Anders and Watson, 2006). Also, basal testosterone levels were higher in English male students when they were in a new relationships (< 12 months) as compared to a longer relationship (≥ 12 months; Farrelly et al., 2015), and basal testosterone levels were higher in male Harvard Business School students who were single than those in a committed relationship (Burnham et al., 2003). In addition, polygynous men had higher basal testosterone levels then monogamous men in a sample of agriculturists in rural Senegal (Alvergne et al., 2009) and in Swahili men of Kenya (Gray, 2003), but not in Ariaal men of Northern Kenya (Gray et al., 2007). Of special interest is a study showing that a more masculine facial width-to-height ratio (fWHR), which is shaped by testosterone in adolescence (Verdonck, 1999), was related to more popularity during speed-dating in a sample of young male Germans (Valentine et al., 2014).

In addition, there is also evidence that low basal levels of testosterone relate to nurturing parental behavior/effort. For example, fathers had lower basal testosterone levels than unmarried men in a sample of Chinese students (Gray et al., 2006) and men from the Boston area (Gray et al., 2002). Also, testosterone levels were lower in expectant Canadian fathers compared to a control group (Berg and Wynne-Edwards, 2001). Furthermore, when making the distinction between competitive and nurturing parental behaviors, there is research showing that in a polygynous population of agriculturists in rural Senegal, the more parental care fathers provided the lower their basal testosterone levels (Alvergne et al., 2009). If parental care involves infant defense, such as when hearing a crying baby without being able to provide a nurturing response, testosterone levels actually increase (van Anders et al., 2012).

Although most scientific literature on testosterone and social behavior is on men, for women too, there is evidence that testosterone levels are related to mate acquisition. Basal testosterone levels were higher in North American women who were single than for those who were in casual relationships (van Anders and Goldey, 2010), although in a sample of American female students, basal testosterone levels were comparable between single women and women who reported frequent uncommitted sexual behavior (Edelstein et al., 2011). In addition, in a sample of North American women, those with multiple committed relationships had higher basal testosterone levels than those with only one committed relationship (van Anders et al., 2007). Finally, other studies showed that motherhood was associated with lower basal testosterone levels in Norwegian women (Barrett et al., 2013) and Philippine women (Kuzawa et al., 2010).

Changes in testosterone levels over time in mating contexts have been studied less. Nevertheless, studies have shown that testosterone levels increase when talking to a potential romantic partner, in both American male students (Roney et al., 2010, 2007, 2003) and Dutch male students (van der Meij et al., 2008). Also, the more Spanish male students responded with a testosterone increase after competition the more affiliation they showed towards women afterwards during a brief social contact (van der Meij et al., 2012). Despite evidence suggesting the relevance of testosterone in mating contexts, to our knowledge, only one study has attempted to explore whether levels change over the course of a speed-dating event. Interestingly, this study showed that in men testosterone levels did not change before and after speed-dating (Lefevre et al., 2013).

In sum, based on the available literature demonstrating a link between testosterone and mate acquisition, we expected that testosterone levels would be elevated in anticipation of the speed-dating event and would increase further during the event. We also explored whether participants with overall higher testosterone levels would be less selective. If their primary motivation is to form short-term relationships, then saying "yes" to more of their interaction partners (lower selectivity) would increase their chances of seeing an interaction partner again and thus increase their chances to form short-term relationships. However, if they are primarily motived to find a long-term relationship partner, then high testosterone levels could lead to both higher or lower selectivity. Being selective means participants avoid spending time and energy on unsuitable people, which they are able to invest in potential partners more worthy of a long-term relationship. On the other hand, being too selective will leave them with fewer people to explore long-term relationship possibilities with. Taken together, we expected that participants' motive for participation in speed-dating would vary, but that — on average — people who are focused on mate acquisition would be less selective and would thus have higher testosterone levels.

Concerning popularity, we expected that participants with higher testosterone levels would be more popular overall. According to the challenge hypothesis and the steroid/peptide theory of social bonds, men and women with elevated testosterone levels are more motivated to find a romantic partner and thus put more effort in impression management. This extra effort will make them appear more favorable as a potential romantic partner and as such they may receive more "yeses" from their interaction partners (i.e., higher popularity). Indeed, one study showed that testosterone levels may actually relate to positive social behaviors such as smiling and showing interest in a mating context (van der Meij et al., 2012). Furthermore, several authors have proposed that high testosterone levels can lead to prosocial behavior as long as the social context rewards prosocial behavior with an increase in social status (Bos et al., 2012; Eisenegger et al., 2011).

Cortisol

How would cortisol relate to selectivity and popularity in speed-dating? The hormone cortisol is one of the key players in the response to psychosocial stress: cortisol release sharpens cognition and diverts energy to muscles to cope with stressors (Sapolsky et al., 2000). The largest release in cortisol has been shown in situations that are uncontrollable and pose a social-evaluative threat (Dickerson and Kemeny, 2004). Speed-dating is a situation that appears to match these criteria: how dates will respond is not within one's complete control, and participants are being evaluated by their dates, which may result in rejections and few matches.

Even though the literature on romantic attraction and cortisol is scarcer than for the hormone testosterone, studies suggest that meeting a potential romantic partner increases cortisol levels. For example, previous research has shown that cortisol levels increased in American male students when talking to a potential romantic partner (Roney et al., 2010, 2007). Furthermore, cortisol levels increased in Spanish male students when they talked to a potential female partner they perceived as attractive (van der Meij et al., 2010). Conversely, lower cortisol levels seem associated with parental effort/nurturing behaviors and not mating effort/competitive behaviors. For example, Canadian fathers had lower cortisol concentrations than non-fathers (Berg and Wynne-Edwards, 2001), and "parenting oriented" (pair bonded and/or fathers) Philippine men had lower cortisol levels than "mating oriented" (non-pairbonded, non-fathers) Philippine men (Gettler et al., 2011).

Interestingly, there are also several studies indirectly investigating if cortisol is related to mating effort or competitive behaviors by studying cortisol changes in response to viewing sexual images. Results from such studies are mixed. In American and Canadian women cortisol levels decreased when seeing sexual images (respectively: Hamilton and Meston, 2011; Van Anders et al., 2009), whereas another study showed that cortisol increased in a sample of American women (Hamilton et al., 2008), and cortisol levels did not change in German community samples (Exton et al., 2000), American women (Heiman et al., 1991), and female American students (Goldey and van Anders, 2011). Finally, in a sample of mostly American students, cortisol levels did not increase when men were instructed to imagine a sexual situation, although higher cortisol levels did correlate with more self-reported sexual arousal (Goldey and van Anders, 2012).

Considering the above findings, we concluded that there may be a link between elevated cortisol levels and more mate acquisition, as shown by studies investigating cortisol in relation to contact with potential romantic partners and fatherhood. Similar to the rationale we applied to testosterone, we expected that cortisol levels would be elevated in anticipation of the speed-dating event and would increase further during the event. We also expected that larger cortisol changes would show a higher focus on mate acquisition and thus less selectivity (more "yeses" given) and more popularity (more "yeses" received). Furthermore, from the perspective of the psychosocial stress literature, speed-dating can be considered a stressful experience, since there is the distinct possibility of a negative outcome by having very few matches. When considering this perspective, we would expect that elevated cortisol levels are related to less selectivity and more popularity, as this strategy would decrease the chances of no match.

Testosterone × cortisol

Does the interaction between testosterone and cortisol levels relate to selectivity and popularity in speed-dating? Recent developments in theoretical models have predicted that testosterone and cortisol may actually jointly regulate behavior (Mehta and Josephs, 2010; Terburg et al., 2009). The dual-hormone hypothesis predicts specifically that high basal testosterone levels stimulate status seeking only when basal cortisol levels are low (Mehta and Prasad, 2015). This is in contrast to basal cortisol levels being high, which combined with high basal testosterone levels may inhibit or block status-seeking behavior (Mehta and Prasad, 2015). Indeed, there is some support for this hypothesis, as several studies have shown that higher basal testosterone levels were related to more risk-taking (Mehta et al., 2015; Ronay et al., 2018), more overbidding (van den Bos et al., 2013), and less empathy (Zilioli et al., 2015) only when basal cortisol levels were low. However, there are also studies showing the opposite result as expected from the dual-hormone hypothesis. For example, female aggression and male psychopathy were related to higher basal testosterone levels only for high basal cortisol levels (respectively Denson et al., 2013; Welker et al., 2014). These mixed findings are also illustrated by a recent meta-analysis showing that there is marginal support for the dual-hormone hypothesis (Dekkers et al., 2019).

Of special relevance to our study is research showing that male rugby athletes' popularity (i.e., more teammates reported to like hanging out with them) was related to higher basal testosterone levels only for athletes that also had low basal cortisol levels (Ponzi et al., 2016). This last finding could also indicate that these men were more popular among women as, according to Sexual Strategies Theory, women are attracted to men with more social status (Buss and Schmitt, 1993). In line with this finding, we investigated if the dual-hormone hypothesis also applied to the mating domain (i.e., in speed-dating).

For popularity the prediction is straightforward: more social status seeking should lead to more popularity. Participants seeking social status may be motivated to show off their high desirability as a potential romantic partner by receiving many "yeses" from other dates and subsequently making this public. Thus, high testosterone levels should be related to more popularity when cortisol levels are low. However, it is unclear how selectivity relates to status seeking. On the one hand, both men and women may gain social status by getting many successful matches, as this may demonstrate that they are desirable as a potential romantic partner. In this case, the best strategy would be to say “yes” to many other dates (low selectivity) in order to increase the potential number of matches. On the other hand, both men and women may gain social status by demonstrating that the other people present at the speed-dating were not good enough for them. Thus, they may say “yes” to very few dates (high selectivity).

Hypotheses

To investigate the relationship between romantic attraction and hormonal levels we performed a speed-dating study. In this study, we compared salivary testosterone and cortisol levels (pre and post) in heterosexual men and women attending both a romantic condition (opposite sex dates) and a control condition in which they dated same-sex partners (*n* = 79). We assessed popularity and selectivity by having each participant indicate if they wanted to exchange contact details with their date. Based on the previously mentioned literature we hypothesized the following:

1. Testosterone and cortisol levels are elevated in anticipation of romantic speed-dating and increase further during the event.
2. Higher testosterone levels are related to less selectivity and more popularity in romantic speed-dating.
3. Higher cortisol levels are related to less selectivity and more popularity in romantic speed-dating.
4. Only when cortisol levels are low, higher testosterone levels are related to more popularity in romantic speed-dating. For selectivity, we explored whether higher testosterone levels are related to *more* or *less* selectivity in romantic speed-dating when cortisol levels were low.

2 Methods

2.1 Participants

The final sample consisted of 79 single participants (41 women: 19-28 yrs., *M* = 22.1, *SD* = 2.2; 38 men: 18-28 yrs., *M* = 23.2, *SD* = 2.2). Participants were recruited in the Netherlands from undergraduate classes at the Vrije Universiteit Amsterdam, the student dorms, social network websites, and from the social networks of the researchers. The event was advertised as a real speed-dating event that formed part of a study. Many of these students were foreign students and thus the event was hosted in English. Participants first completed an online survey to determine eligibility. Criteria of inclusion were that they had to be heterosexual (to make the study design simpler), single, and not older than 30 years.

Women during romantic speed-dating had between 12 and 17 dates (*M* = 15.2, *SD* = 1.1) and in the control condition they had between 14 and 17 dates (*M* = 15.9, *SD* = .6). Men had in both the romantic speed-dating and control condition between 14 and 17 dates (respectively: *M* = 16.4 *SD* = 0.6; *M* = 15.6, *SD* = 0.8).

Participants were asked not to engage in any recreational drug use or excessive alcohol consumption up to 24 hours prior to each event they attended, and not to consume anything but water up to two hours prior to each event.

In the final sample size, the following substances were used that could alter hormonal levels: (i) 2 men and 1 woman used medication (Euthyrox, Letrox, Escitalopram), (ii) 1 man used hard drugs on a weekly basis (XTC, 4FMP, Speed, MDMA), (iii) 2 men used more than 0.5 g of marihuana daily, (iv) 9 men consumed 21 or more alcoholic units weekly and 6 woman consumed 14 or more alcoholic units weekly, (v) 5 men and 6 women smoked more than 5 cigarettes daily, (vi) 11 women used hormonal contraceptives and 29 women did not. See the Supplementary material Table S3 for the effect on the statistical conclusions when controlling for these substances.

2.2 Procedure

A total of four events were organized by the authors of this article: two romantic speed-dating events where participants met opposite-sex interaction partners, and two control conditions where participants met same-sex interaction partners. The events were counterbalanced, such that approximately half the participants first attended the romantic speed-dating condition followed by the control condition, and approximately the other half attended first the control condition followed by romantic speed-dating. Some men and women participated with a same-sex friend. However, friends usually participated in the same group, meaning that they would have same-sex speed-dates with people from the other group whom they did not know.

Twenty men attended first the romantic speed-dating event and eighteen of these men also participated in the following control condition (men group one). Another fifteen men attended first the control condition and then the romantic speed-dating condition (men group two). For group two we recruited three extra male participants who only participated in the romantic speed-dating event because at this event we needed more male participants. Twenty-three women attended first the romantic speed-dating event and twenty of these women also participated in the following control condition (women group one). Another eighteen women attended first the control condition and then the romantic speed-dating event (women group two).

The events took place at a local bar at the same time on each day. Experimenters led men and women to separate rooms in order to prevent social interaction prior to the event. Experimenters handed participants a packet that contained a consent form, an initial questionnaire, the “match” card which contained items to be completed after each speed date, and a tube for their first saliva sample. After signing the consent form, participants began completing the initial questionnaire. Experimenters called participants one at a time, to measure their height and weight, and to take photographs of their faces. At approximately the same time at each event, experimenters gave instructions to participants on how to properly provide a saliva sample. Participants then provided their first (pre) saliva sample and completed any remaining items on the questionnaires. They were subsequently directed to the room where the romantic speed-dating event took place. Pairs of participants were seated at small tables facing each other. After each interaction, participants rated their interaction partner, and then all participants moved one seat to the left.

At the conclusion of speed-dating, men and women were once again separated. Exit questionnaires were completed and participants provided their second (post) saliva sample. Afterward, participants were paid €20 if it was their 2nd event and were thanked for their cooperation. After each event, they also received a token for one drink to be redeemed at the bar. Within 48 hours of the event, participants received an email containing photos and participant numbers of their matches. Participants could then respond with whether they would like to have their contact details sent to each match. All participants were debriefed via email.

The study was approved by the Ethics Committee of the Faculty of Psychology and Pedagogy of the VU University Amsterdam (Vaste Commissie Wetenschap en Ethiek van de Faculteit der Psychologie en Pedagogiek: VCWE) and was registered under E1404.

2.3 Questionnaires

Registration survey Participants registered for the study via an online survey. The survey screened for: 1) use of recreational drugs, 2) physical and/or mental illness', 3) relationship status (e.g. single, in a relationship), and 4) sexual orientation (e.g. heterosexual, homosexual, bisexual, other). Respondents indicated their use of recreational and medicinal substances in terms of frequency and amount per month. In addition, participants indicated whether they used contraceptives and indicated the type and amount. Participants also completed an initial survey, which was used for the research projects of three authors (AD, MT, and IM) as part of their master education. In this survey, we measured the following: self-control, socio-sexual orientation, self-perceived mating success, personal attributes, and cultural orientation.

Match card Participants rated their interaction partners on a "match" booklet, immediately following each interaction (see Appendix A). The card was twice the length of a piece of A4 paper folded in half, such that participants could hold one end upright and prevent interaction partners from seeing their responses. Participants indicated on the card if they would like to see this person again (yes/no). A "match" occurred when both participants indicated a yes. During romantic speed-dating, participants indicated how they would rate their interaction person as a short-term sexual partner and as a long-term romantic partner (low = 1 to high = 7). In the control condition, participants indicated how they would rate their interaction person as a potential friend (low = 1 to high = 7). Participants were also asked by the researchers at the event to write "yes" or "no" on the card next to the interaction partner's participant number to indicate if they had ever met prior to the event.

Exit questionnaire Participants answered several questions after the speed-dating event concerning their previous experience with speed-dates, how they felt about the use of the English language throughout the event, and how they evaluated the event.

2.4 Hormonal analyses

To measure hormonal levels participants deposited 2 ml of saliva in small plastic vials through a straw at approximately 10 min before the beginning of each session (pre-sample) and approximately 10 min after the last interaction (post-sample). The time between saliva samples was approximately 1h. Saliva samples were subsequently stored in a freezer and sent frozen to the laboratory of Biological Psychology at the Dresden University of Technology.

Salivary testosterone and cortisol levels were determined in duplicate with a high performance liquid chromatography–tandem mass spectrometry (LC–MS/MS) with Atmospheric Pressure Chemical Ionization (APCI) coupled with on-line solid phase extraction (SPE) by the laboratory of Biological Psychology at the Dresden University of Technology (Gao et al., 2015). For cortisol, this method features an inter-assay variation of 7.7% at 0.01 ng/mL, 7.4% at 1 ng/mL, and 6.8% at 10 ng/mL. For testosterone, this method features an inter-assay variation of 8.6% at 0.01 ng/mL, 6.2% at 1 ng/mL, and 8.1% at 10 ng/mL (Gao et al., 2015). The lower limit of quantification (LOQ) of this method was 1 pg/ml for testosterone and 5 pg/ml for cortisol (Gao et al., 2015). See Table 1 for the average intra-assay coefficients for each hormone and sample in this study.

Testosterone and cortisol values were log transformed for all statistical analyses because the raw values and residuals did not follow a normal distribution (see Table S4 and S5 in the Supplementary analysis).

Table 1: Average intra-assay coefficients (%) per hormone and pre and post-sample.

	Romantic speed-dating				**Control condition**			
	Pre		Post		Pre		Post	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Testosterone	7.98	4.51	7.05	4.16	7.59	4.42	5.90	4.31
Cortisol	8.32	2.16	7.95	2.08	8.28	2.45	8.30	2.18

2.5 Statistical analyses: social relation model

We performed a social relation model (Kenny, 1994; Kenny and La Voie, 1984) to investigate the relationships between selectivity and popularity in romantic speed-dating (see section 3.1) and how they related to hormonal levels (see section 3.3). The advantage of the social relation model over models that average speed-dating outcomes, is that it takes into account variance at the date level by specifying actor, partner, and relationship effects. Actor effects refer to the general tendency of a rater to respond “yes” to the question “Would you like to see this person again?” (i.e., selectivity, where more yes responses indicate low selectivity). Partner effects refer to the general tendency of a target to receive a “yes” from their date (i.e., popularity, where more “yes” responses indicate high popularity), and the relationship effect refers to the unique dyadic component of a date plus error variance (people may be attracted to specific individuals, i.e., exclusivity). For effect sizes, we reported partial eta squared (Lakens, 2013) and odds ratios.

We adapted the procedure in SPSS as described by Ackerman et al. (2015) to GENLINMIXED (with logit-link) as we had a dichotomous date outcome variable (yes or no). As fixed effects, we included Sex and the anticipatory hormonal responses. We calculated this response as follows: (log of hormonal level pre-sample romantic speed-dating) minus (log of hormonal level pre-sample control condition). According to this operationalization of anticipatory hormonal response, in men, 53.1% experienced a positive testosterone response and 66.7% experienced a positive cortisol response, and in women, 38.9% experienced a positive testosterone response and 48.6% experienced a positive cortisol response. We also included a repeated measures effect to asses relationship effects, and we included random effects to asses men’s and women’s actor and partner effects, see Supplementary material Table S2 for a more detailed description. For the analyses concerning cortisol, we first assessed if the partner and actor effect interacted with Sex, whereas we separated the analyses for testosterone, as men and women had different testosterone levels (see Table 2). See the Supplementary material for more information on the used procedure and the code we used in SPSS to run the analyses (i.e., syntax).

2.6 Statistical analyses: hormonal changes and attraction

We used linear mixed models to investigate whether hormonal changes occurred over the course of the romantic speed-dating and control condition (see section 3.2 for results). As the dependent variable, we included the log-transformed testosterone or cortisol values. As fixed effects, we included: Moment (pre or post), Condition (romantic speed-dating or control condition), and Sex (man or woman). We also specified a subject variable. As a repeated factor we included the four saliva sampling moments (pre and post for each condition) and selected an unstructured correlation metric as the covariance structure. As effect size, we reported partial eta squared and Cohen's d_{rm} for repeated measures (Lakens, 2013).

We chose not to analyze the hormonal changes in relation to selectivity and popularity with the social relation model since the overall hormonal changes may be in response to one specific date, some specific dates, or all dates. Thus, we could not specify at the individual date level whether hormonal levels were changing in response to that particular date. Also, we did not use linear mixed models because we wanted to control for elevated baseline levels in our study. How much hormonal levels can change depends on how high levels are at baseline, and thus hormonal levels in the post-sample are sensitive to regression to the mean (see also Mehta et al., 2008; van der Meij et al., 2012). To control for this we used the unstandardized residuals when regressing the pre-sample on the post-sample in each condition.

Thus, to investigate if hormonal changes during romantic speed-dating were related to overall selectivity and popularity we performed the following analyses (for results see section 3.4): (i) for cortisol change, moderator regression analyses change to investigate the moderation of Sex and partial correlations controlling for Sex to investigate the cortisol change across sexes, (ii) for testosterone change, Pearson correlations separate for each sex, since men and women had different testosterone levels (see Table 2), and (iii) for the interaction between testosterone and cortisol change, a moderator regression analyses (with Process, Hayes, 2017) separate for each sex, with testosterone change as predictor and cortisol change as the moderator. Additionally, following a reviewer's suggestion, we also explored if the relationship between the testosterone change and popularity and selectivity was moderated by the anticipatory cortisol response (pre-sample Romantic speed-dating – pre-sample Control condition). As effect size, we reported the adjusted *r* squared change.

For the above analyses, we defined selectivity as 1-the number of the total given "yeses" divided by the total number of completed dates, and we defined popularity as the number of the total received "yeses" divided by the total number of completed dates. To obtain a hormonal change score more specific to attracting a romantic partner we calculated the final hormonal change variable for each hormone by subtracting the unstandardized residuals in romantic speed-dating from the unstandardized residuals in the control condition. According to this operationalization of hormonal change, in men, 45.2% experienced an increase in testosterone levels and 50.0% experienced an increase in cortisol levels, and in women, 36.1% experienced an increase in testosterone levels and 54.1% experienced an increase in cortisol levels.

2.7 Statistical analyses: outliers, measurement errors, and covariates

We followed the guidelines by Pollet and van der Meij (2016) for outlier detection. For the cortisol analyses, four outliers were detected (one woman and three men) as one or more of their raw cortisol levels measurements differed by more than three standard deviations from the mean and were more than three interquartile ranges above the third quartile.

For one male participant, only his first testosterone measurement during romantic speed-dating was removed from hormonal analyses due to its extremely low value, which indicated a measurement error (pre-sample: 2.02 pg/mg, 2.40 SD away from the mean, other samples same participant: ≥ 48.93). Subsequently, we detected five outliers for testosterone (assessed separately for each sex). The raw testosterone samples of two women and two men differed by more than three standard deviations from the mean and were more than three interquartile ranges above the third quartile. One other raw testosterone sample of one male participant was three interquartile ranges above the third quartile but did not differ more than three standard deviations from the mean.

We also tested how robust statistical conclusions were. To this end we investigated whether the significant statistical conclusions differed according to the following: (i) excluding participants that used medication that can alter hormonal levels, (ii) excluding hormonal outliers, (iii) adding as a covariate hormonal contraception, (iv) adding as a covariate recreational drug use, (v) adding as a covariate if they participated first in the romantic speed-dating or the control condition. These analyses showed that the statistical conclusions concerning the anticipatory cortisol and testosterone × cortisol response remained the same, whereas these analyses lead to *p* values between .046 and .066 for the cortisol changes (see Supplementary material Table S3).

3 Results

3.1 Preliminary analysis: romantic dating outcomes

The social relation model showed that men and women differed in how often they said yes to their date ($F_{1,1223}$ = 5.69, *p* = 0.017, η_p^2 < .01). Men on average said yes to 72% (*se* = .06) of their dates and women on average said yes to 48% (*se* =.07) of their dates. Men differed to whom they said yes; some men said yes to some dates whereas other men did not say yes to those dates (i.e., male relationship effect, male exclusivity: *Z* = 15.94, *p* < .001, *b* = .75, *se* = .047). Also women differed to whom they said yes (i.e., female relationship effect, female exclusivity: *Z* = 16.01, *p* < .001, *b* = .80, *se* = .05). Furthermore, when a particular man or woman said yes to a date, that same date was more likely to yes to them (i.e., there was a click, or dyadic reciprocity: *Z* = 2.15, *p* = .031, *b* = .07, *se* = .03, *r* = .094). See the supplementary information for male and female actor and partner variances.

3.2 ~~Preliminary analysis: h~~Hormonal changes during speed dating

Testosterone In the linear mixed model with testosterone as dependent variable, the results showed that there was a significant interaction between Sex, Moment, and Condition ($F_{1,68.51}$ = 12.61, *p* = .001, η_p^2 = .16). Results showed that men did not experience a change in their testosterone levels during romantic speed-dating ($t_{76.31}$ = .74, *p* = .462, d_{rm} = .07) nor during the control condition ($t_{64.66}$ = -.40, *p* = .689, d_{rm} = .04). Also, male testosterone levels in the pre- and post-sample were not different between the romantic speed-dating and control condition (respectively: $t_{68.19}$ = .40, *p* = .691, d_{rm} = .05; $t_{75.34}$ = -.51, *p* = .620, d_{rm} = .06). However, women did experience an increase in their testosterone levels during romantic speed-dating ($t_{75,48}$ = -3.34, *p* = .001, d_{rm} = .32), and experienced a decrease in their testosterone levels during the control condition ($t_{63.83}$= 2.55, *p* =

.012, d_{rm} = .26). Furthermore, in women, the pre testosterone sample did not differ between the romantic speed-dating and control condition ($t_{67.67}$ = -0.98, p = .332, d_{rm} = .13), but the post testosterone sample was higher after romantic speed-dating than in the control condition ($t_{73.23}$ = 3.81, p < .001, d_{rm} = .47). Additionally, the testosterone change was not different between women taking hormonal contraceptives and women who did not ($F_{1,32.38}$ = .13, p = .721, η_p^2 < .01). See table 2 and Figure 1 for the testosterone means.

-- figure 1 here –

Cortisol In the linear mixed model with cortisol as the dependent variable, the results showed that there was no interaction between Sex, Moment, and Condition ($F_{1,74.96}$ = 1.90, p = .173, η_p^2 = .02). Also, there was no interaction between Sex and Condition, nor between Moment and Sex (all $p \geq$ .128). However, there was an interaction between Condition and Moment ($F_{1,74.96}$ = 24.21, p < .001, η_p^2 = .24). Results showed that cortisol levels decreased from the pre-sample to the post-sample during romantic speed-dating ($t_{76.00}$ = 3.05, p = .003, d_{rm} = .33) and in the control condition ($t_{69.90}$ = 9.91, p < .001, d_{rm} = 1.21). Furthermore, cortisol levels were not different between ~~to a marginally significant extent higher in~~ the pre-sample of the romantic speed-dating condition ~~than~~ and~~in~~ ~~the in~~ the pre-sample of the control condition ($t_{71.98}$ = 1.92, p = .056, d_{rm} = .22), and cortisol levels were higher in the post-sample after romantic speed-dating than in the post-sample of the control condition ($t_{75.79}$ = 7.41, p < .001, d_{rm} = .87). Additionally, the cortisol change was not different between women taking hormonal contraceptives and women who did not ($F_{1,36.57}$ = .21, p = .649, η_p^2 = .01). See table 2 and Figure 2 for the cortisol means.

-- figure 2 here --

Table 2. Mean and standard deviations of testosterone and cortisol levels (pg/mg) separated per condition, pre or post saliva sample, and sex.

	Romantic speed-dating				**Control condition**			
	Pre		Post		Pre		Post	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Men								
Testosterone	76.51	27.95	74.03	36.35	81.97	57.41	74.49	29.61
Cortisol	5.66	3.67	4.46	3.39	4.37	5.28	2.04	1.80
Women								
Testosterone	6.79	8.24	8.37	7.62	5.98	2.58	4.92	1.79
Cortisol	4.85	4.17	4.43	5.96	4.15	2.39	1.69	1.01

3.3 Anticipatory hormonal response and attraction

Testosterone The social relation model showed that for both men and women their own anticipatory testosterone response was unrelated to how often they said “yes” to their interaction partner, i.e. selectivity (sel. men: $F_{1,902}$ = 3.16, p = .076, η_p^2 < .01, sel. women: $F_{1,902}$ = .06, p = .806, η_p^2 < .01). Furthermore, how often they said “yes” was also unrelated to the anticipatory testosterone response of their interaction partner, i.e. popularity (pop. women: $F_{1,902} = .68$, $p = .411$, $\eta_p^2 < .01$; pop. men: $F_{1,902} = .06$, $p = .806$, $\eta_p^2 < .01$).

Cortisol The social relation model showed that there were no sex differences in the relationship between participants saying "yes" to their interaction partner and their own anticipatory cortisol response, i.e. selectivity ($F_{1,956} = 0.15$, $p = .701$, $\eta_p^2 < .01$). Also, when excluding the interactions with Sex, the model showed that how often participants said "yes" was unrelated to their own anticipatory cortisol response ($F_{1,958} = .01$, $p = .947$, $\eta_p^2 < .01$).

However, the social relation model showed that there were sex differences in the relationship between participants saying "yes" to a date and the anticipatory cortisol response of their interaction partner, i.e. popularity ($F_{1,956} = 4.90$, $p = .027$, $\eta_p^2 = .01$), see Figure 3. Results showed that women more often said "yes" when their interaction partner experienced a higher anticipatory cortisol response, i.e. male popularity ($F_{1,956} = 8.54$, $p =.004$, $\eta_p^2 = .01$, odds ratio = 1.91). Women said "yes" to 34% of their dates when their interaction partner experienced an anticipatory cortisol response that was 1SD below the mean, whereas they said "yes" to 65% of their dates when their interaction partner experienced an anticipatory cortisol response that was 1SD above the mean. However, in men, saying "yes" to a date was unrelated to the anticipatory cortisol response of their interaction partner, i.e. female popularity ($F_{1,956} = .15$, $p = .698$, $\eta_p^2 < .01$).

-- figure 3 here --

Testosterone × Cortisol (T×C) The social relation model showed that for men their own anticipatory T×C response was unrelated to how often they said "yes" to their interaction partner, i.e. male selectivity ($F_{1,894} = .01$, $p = .919$, $\eta_p^2 < .01$), but for women their own anticipatory T×C response was related to how often they said "yes", i.e. female selectivity ($F_{1,894} = 5.76$, $p = .017$, $\eta_p^2 = .01$), see figure 4. Results showed that when women's anticipatory cortisol response was high, saying "yes" to their interaction partner was not related to their own anticipatory testosterone response ($F_{1,894} = .23$, $p = .629$, $\eta_p^2 < .01$, -1SD testosterone = 47% yeses, +1SD testosterone = 52% yeses). However, when women's anticipatory cortisol response was low, a higher anticipatory testosterone response was related to less often saying "yes" ($F_{1,894} = 4.98$, $\eta_p^2 = .01$, $p = .026$, -1SD testosterone = 62% yeses, +1SD testosterone = 21% yeses).

Furthermore, how often men and women said "yes" was unrelated to the anticipatory T×C response of their interaction partner, i.e., popularity (pop. women: $F_{1,894} = .19$, $\eta_p^2 < .01$, $p = .665$; pop. men: $F_{1,894} = .11$, $p = .739$, $\eta_p^2 < .01$).

-- figure 4 here --

3.4 Hormonal change and attraction

Cortisol The moderator regression analyses showed that sex did not moderate the relationship between cortisol change and selectivity ($F_{1,65} = .76$, $p = .386$, $r^2\Delta = .01$) and popularity ($F_{1,65} = .57$, $p = .452$, $r^2\Delta = .01$). Follow-up analyses with partial correlations (controlling for sex) showed that the ~~less~~ more selective participants were the larger their cortisol change during romantic speed-dating (r_{66} = ~~-~~.24, $p = .047$), see Figure 5. Popularity was unrelated to cortisol change ($r_{66} = -.06$, $p = .656$).

Testosterone The partial correlations analyses showed that for both men and women selectivity/popularity was unrelated to a change in testosterone levels (sel. men r_{31} = -.034, p = .855; sel. women: r_{36} = .~~-~~229, p = .180; pop. men: r_{31} = -.211, p = .255, pop. women: r_{36} = -.041, p = .814).

Testosterone × Cortisol (T×C) moderator cortisol change In men, the moderator regression analyses showed that the cortisol change did not moderate the relationship between the testosterone change and selectivity ($F_{1,27}$ = 1.46, p = .238, $r^2\Delta$ = .05) and popularity ($F_{1,27}$ = 1.74, p = .198, $r^2\Delta$ = .06). In women, the moderator regression analyses showed that the cortisol change did not moderate the relationship between the testosterone change and selectivity ($F_{1,32}$ = 1.12, p = .298, $r^2\Delta$ = .03) and popularity ($F_{1,32}$ = .44, p = .511, $r^2\Delta$ = .01).

Testosterone × Cortisol (T×C) moderator anticipatory cortisol response In men, the moderator regression analyses showed that the anticipatory cortisol response did not moderate the relationship between testosterone change and selectivity ($F_{1,27}$ = .17, p = .684, $r^2\Delta$ = .01) and popularity ($F_{1,27}$ = .25, p = .621, $r^2\Delta$ = .01). In women, the moderator regression analyses showed that the anticipatory cortisol response did not moderate the relationship between testosterone change and selectivity ($F_{1,32}$ = 2.40, p = .131, $r^2\Delta$ = .07) and popularity ($F_{1,32}$ = .30, p = .589, $r^2\Delta$ = .01).

-- figure 5 here –

Discussion

Testosterone change

Our findings showed that testosterone levels increased in women during romantic speed-dating ~~but~~ and decreased in women~~not~~ during the control condition. Although these changes were small-medium effect sizes, they are~~. This is~~ in line with theoretical models predicting that high testosterone levels relate to more mate~~ing~~ acquisition (Archer, 2006; Roney, 2016; Zilioli and Bird, 2017) and more competitive behavior (van Anders et al., 2011). However, surprisingly, in men, testosterone levels did not change during romantic speed-dating and remained high throughout the event. This is not in line with some previous research, as numerous studies have shown that men experience an increase in testosterone levels when talking to a potential mate in a waiting room situation (Roney et al., 2010, 2007, 2003; van der Meij et al., 2008), although one other study also showed that testosterone levels did not change during romantic speed-dating (Lefevre et al., 2013). A speculative explanation for these divergent findings is that romantic speed-dating is a much more arousing social context than a waiting room situation. Unlike a waiting room situation, a romantic speed-dating is an unambiguous dating context where individuals scan each other as potential mates. While the waiting room situation is unlikely to trigger prior expectations because participants do not know that they will be waiting together, participants of a romantic speed-dating do know that they will be evaluated as a potential romantic partner.

Thus, it could be that, in contrast to women's testosterone levels, men's testosterone levels ~~were at ceiling levels and could not~~did not increase further due to negative feedback from already high testosterone levels on the hypothalamus-pituitary-gonadal (HPG) axis. This may also have held true for the control condition, as testosterone levels were similar in this condition. In both conditions, men may have experienced greater amounts of social evaluative stress than women, as they were being evaluated on either suitability as a romantic partner or were checking the competition in the control condition. This finding is in line with other recent studies showing that testosterone levels increase in men during stress tasks with a social evaluative component (Bedgood et al., 2014; Lennartsson et al., 2012; Phan et al., 2017; Turan et al., 2015), although some older studies found no change in testosterone levels after psychosocial stress (Gerra et al., 2000; Heinz et al., 2003; Schoofs and Wolf, 2011) and one other study showed a decrease (Schulz et al., 1996). This increase in testosterone levels may be part of an adaptive response that assists an individual to cope with social challenges (Salvador, 2005; Salvador and Costa, 2009). Indeed, previous research has shown that the more men experienced a testosterone increase the more they affiliated with women (van der Meij et al., 2012).

Testosterone and attraction

An important finding is that testosterone levels were unrelated to popularity and selectivity in both men and women. This null finding for men may be related to the previously discussed ~~ceiling~~ elevated hormonal levels. Male testosterone levels may have been too ~~reached their maximum~~elevated for most participants even before the romantic speed-dating began, which reduced ~~any~~ variance ~~in the relationship between~~ in testosterone ~~levels~~ levels such that we were unable to detect a relationship with ~~and~~ their behavior (either in selectivity or popularity). However, it is important to note that we may have lacked the power to detect smaller effect sizes, since men and women have different testosterone levels, and thus we had to analyze their testosterone data separately. In men, we did find an indication that a larger anticipatory testosterone response was related to less selectivity, although this effect was statistically not significant. Future studies with larger sample sizes may untangle if ~~in men a ceiling effect~~heightened testosterone levels during romantic speed-dating makes the relationship between attraction and testosterone undetectable in men.

For women, there was also no relationship between attraction and testosterone levels. This null finding is more difficult to explain, as testosterone levels in women did increase during romantic speed-dating. Additionally, previous research shows that, in a lab setting, an increase in testosterone levels was related to more sexual arousal in women (Tuiten et al., 2000), which suggests that increased testosterone levels could decrease selectivity. A speculative explanation for this null finding in women is that temporal changes in their testosterone levels had less of an effect on their behavior in an ecologically valid environment such as romantic speed-dating. Perhaps women more rationally deliberated the pros and cons of a potential romantic partner and were not so much affected by their own bodily and psychological state. Also interesting was that female popularity was unaffected by their testosterone levels. A possible explanation here could be that that men's selectivity is not so much influenced by female behavior during these speed dates. Men may largely determine beforehand if they will say yes to a date based on physical appearance. For example, in one particular study, BMI predicted 25% of female popularity alone (Kurzban and Weeden, 2005). Another explanation could be that variance in female popularity was limited and this reduced the power to detect an effect of anticipatory testosterone. Indeed, men said yes to 72% of their dates whereas women said yes to 48% of their dates.

Cortisol change

Results showed that both men and women arrived at both the romantic speed-dating and control condition with elevated cortisol levels and that during the course of both conditions their cortisol levels decreased. Furthermore, this decrease was a very large effect size in the control condition and less so in the romantic speed-dating condition (small-medium effect size). Also, cortisol levels were higher at the end of romantic speed-dating than at the end of the control condition. This Together these finding indicates that participants perceived the romantic speed-dating as more challenging and stressful than friendship dating. This implies that being judged as a potential romantic partner is more stressful, and requires more impression management than when being judged as a potential friend. Furthermore, results showed that cortisol levels decreased during the course of romantic speed-dating and control condition. These results contrast with other studies showing that a brief social contact with a potential romantic partner produces an increase in cortisol levels in heterosexual men (Roney et al., 2010, 2007), although another study showed that cortisol levels only increased when in such encounters men perceived their potential partner as attractive (van der Meij et al., 2010).

There are two speculative explanations for these different results. First, our speed-dating study took over an hour to complete, thus cortisol levels may have started decreasing towards more normal values due to negative feedback from high cortisol levels on the hypothalamus-pituitary-adrenal (HPA) axis. Second, unlike these other studies, our participants probably arrived with relatively high cortisol levels in excited anticipation of the event. Thus, after having experienced several speed dates they may have habituated. Adding to this, social affiliation may have reduced anxiety through the release of oxytocin (for a review see Heinrichs et al., 2009). Indeed, previous research has shown that oxytocin administration reduces cortisol secretion during social evaluative stress (Heinrichs et al., 2003).

Cortisol and attraction

There are two interesting findings concerning cortisol and attraction. First, only in men, cortisol release in anticipation of romantic speed-dating was related to more popularity. This effect was substantial as women said “yes” to 34% of their dates when men experienced a small anticipatory cortisol response, whereas they said “yes” to 65% of their dates when men experienced a high anticipatory cortisol response. A possible explanation is that men who arrived with these high levels were more interested in dating women. Consequently, they may have put more energy into making positive impressions during the speed-dates. Additionally, they may have had more energy at their disposal since cortisol secretion increases local cerebral glucose utilization and cardiovascular tone (Sapolsky et al., 2000). However, it is important to note that a causal effect of cortisol on mate attraction could not be established in the current study. Other third variables, such as a high speed-dating motivation, may have produced more mate attraction behaviors as well as a rise in cortisol levels in anticipation of the event. Why women with elevated cortisol levels were not more popular may have to do with the small variance in female popularity. Similar to the function of testosterone, the function of these elevated cortisol levels in men may help them cope with social challenges (Salvador, 2005; Salvador and Costa, 2009). Furthermore, it could also reflect an effort to affiliate, as it has been shown that, in men, increased cortisol secretions during social evaluative stress predicted their feelings of closeness to a stranger in a subsequent interaction (Berger et al., 2016). Thus, our finding lends support for a “tend and befriend response” in men during stressful times (Geary and Flinn, 2002). Finally, this finding is in line with the Physiology of Romantic Pair Bond Initiation and Maintenance Model, as this model posits that HPA-axis activation in mating contexts is necessary to improve evaluations by potential mates (Mercado and Hibel, 2017).

Second, contrary to our hypothesis, in both men and women, a larger cortisol change during romantic speed-dating was related to ~~lower~~ more selectivity (controlling for baseline and cortisol change in the control condition), although this effect was small to medium.~~.~~ A speculative explanation is that romantic speed-dating was not a positive experience for all participants. Those men and women that experienced an increase in cortisol levels may have been worried that they would end up with no or very few matches. ~~In such a scenario the best strategy is to be less selective and say "yes" to many dates.~~ This would be in line with the stress literature as cortisol release is more prominent in social situations that are uncontrollable and pose a social-evaluative threat (for a review see Dickerson and Kemeny, 2004). Romantic speed-dating has both these elements: participants can only guess whether their interaction partner likes them (low control) and they are being evaluated as a potential partner at each date (high social-evaluative threat). In such a scenario, two different effects can be argued. The most rational strategy would be to say "yes" to many dates (low selectivity), to increase the chances of a match. However, our data shows the opposite: a larger cortisol change was related to more selectivity. This shows that a different process may have been going on. Perhaps those participants who experienced a larger increase in cortisol levels during speed-dating were more preoccupied with impression management and found it, therefore, more difficult to connect with their dates. As a result, they could have subjectively experienced fewer matches and said "yes" to fewer dates.

Testosterone × Cortisol

Our results showed overall weak support for the dual-hormone hypothesis (Mehta and Josephs, 2010) in a mating context. The most direct prediction from this hypothesis would be that popularity in romantic speed-dating was related to the interaction between testosterone and cortisol levels, yet we did not find evidence for this. These null findings could mean that the dual-hormone hypothesis is limited to social contexts in which social status can be gained more openly, for example in competition with others (Zilioli and Watson, 2012) or in leadership positions (Sherman et al., 2016). A potential alternative explanation for these null findings is that saying yes or no to other dates may depend on unique conversation dynamics for which we could not control. Perhaps this reduced our power to detect the interaction between both hormones. Indeed, many of the studies showing support for the dual-hormone hypothesis use laboratory tasks (Mehta et al., 2015) in which it is far easier to control for confounding variables.

Nonetheless, we did find support for one of our mutually exclusive predictions based on the dual-hormone hypothesis. Only in women, a higher anticipatory testosterone response was related to more selectivity when their anticipatory cortisol response was low. Women with this hormone profile may not have been motivated to gain social status by going for more matches (thus by being less selective). Instead, these women may have been motivated to gain social status by appearing exclusive. This finding would also be in line with the sexual double standard (Sagebin Bordini and Sperb, 2013). Women feel they are being valued more highly as a partner when they are restrictive in their sexual contacts, whereas for men this is less of a concern.

Future directions

An interesting avenue for future research would be to assess how hormones relate to specific behaviors during individual dates, as opposed to the accumulation of many speed-dates.

Unfortunately, this was not possible in our current design as the hormonal changes captured the total experience of all the speed dates that had occurred between the pre and post measurement. Assess how hormones relate to specific behaviors is interesting because multiple studies have shown that specific behaviors do lead to more dating success. For example, it has been shown that when participants occupied more physical space, they were more popular, and this effect was stronger for men than for women (Vacharkulksemsuk et al., 2016). Also, video analyses show that being flirtatious leads to higher popularity, but that being flirted with does not lead to being chosen more (Back et al., 2011). Finally, research has also shown that dates that match each other's language style have an increased chance of mutual romantic interest (Ireland et al., 2011), and speed-dates were more likely to result in a match when men show alignment to women (McFarland et al., 2013). To test if these behaviors also relate to hormonal changes, future studies could use a single dating paradigm such that hormonal measurements reflect the experience of one particular date.

In addition, a serious limitation of using a speed-dating paradigm to investigate romantic attraction is that attraction frequently develops over time in response to repeated exposure (the familiarity effect). It would thus be very interesting to investigate whether changes in testosterone and cortisol levels relate to successful bonding in the beginning stages of romantic relationship forming.

General conclusion

Our study highlights the importance of controlling for anticipatory effects when studying the role of hormones in naturalistic stressors, such as participation in a romantic speed-dating event. Only with the inclusion of a control condition were we able to distinguish hormonal changes produced by meeting new people from hormonal changes associated with the attraction of romantic partners. Finally, our findings showed that compared to cortisol, testosterone was less strongly associated with attraction in romantic speed-dating. This suggests that cortisol may be more influential than testosterone in real-world situations in which people find romantic partners.

Acknowledgments

This work was supported by the equipment fund of the Vrije Universiteit Amsterdam.

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Supplementary material

S1 Male and female actor and partner variances

Men Results also showed that some men more frequently said yes to their dates than other men (i.e., male actor variance, variance in male selectivity: $Z = 3.28$, $p = .001$, estimate = 1.80, $se = .55$). Also, some men in general received a yes more frequently from their dates than other men (i.e., male partner variance, variance in male popularity: $Z = 3.24$, $p = .001$, estimate = 1.46, $se = .45$). Furthermore, men who frequently said yes to women in general did not receive a yes more frequently from all their dates (i.e., male generalized reciprocity: $Z = -.41$, $p = .680$, $r = -.081$, estimate = -.13, $se = .32$).

Women Results also showed that some women more frequently said yes to their dates than other women (i.e., female actor variance, variance in female selectivity: $Z = 3.23$, $p = .001$, estimate = 1.13, $se = .35$). Also, some women in general received a yes more frequently from their dates than other women (i.e., female partner variance, variance in female popularity: $Z = 3.40$, $p = .001$, estimate = 1.68, $se = .49$). Furthermore, women who frequently said yes to men in general did not receive a yes more frequently from all their dates (i.e., female generalized reciprocity: $Z = -.72$, $p = .471$, $r = -.14$, estimate = -.20, $se = .27$.

Table S1: The relative percentage of how much a given yes was due to general features of two individuals involved (selectivity of actor and popularity of partner) versus something unique to their relationship (exclusivity) separated by sex.

	Selectivity of actor	Popularity of Partner	Exclusivity (relationship effect plus error)	Total variance (log odds)
Man-to-woman ratings	42.54**	39.76**	17.70	4.220
Woman-to-man ratings	33.23**	43.17**	23.61	3.389

Note. **$p = 0.001$

S2 GENLINMIXED: Anticipatory hormonal response and attraction

To investigate the relationships between selectivity and popularity in speed-dating and how they relate to hormonal levels, we performed a social relation model by adapting the procedure in SPSS described by Ackerman et al. (2015) to GENLINMIXED (with logit-link), as we had a dichotomous outcome variable (yes or no). As a consequence, we chose an unstructured covariance matrix type for the random and repeated measures effects, since a heterogeneous compound symmetry matrix is unavailable for this analysis. We chose not to code for Group (there were three groups with each > 20 dates) since we assumed no substantial group differences due to random allocation.

The data matrix was coded in such a way that each date in the dataset was included as an individual row entry twice: one entry for a date in which a 1st individual within a date is the actor (and the 2nd individual the partner) and one entry for the same date in which the 2nd individual is the actor (and the 1st individual the partner). See Table S2 for the variables we included in the analyses.

Table S2: The included variables in the GENLINMIXED.

Variable	Description
Outcome variable (YesNo)	If they wanted to see the other person again (yes = 1, no = 0).
Repeated measures effect	To investigate relationship effects for each sex we included the interaction term between male rating female target (mf, man = 1, woman =0) and female rating male target (fm, man =0, woman =1). To code for each date we added the interaction term between male and female ID as subject variable.
Random effects	To investigate actor and partner effects for men we included as random effects mf (men's actor variance) and fm (men's partner variance) with male ID as a subject variable. To investigate actor and partner effects for women we included as random effects fm (women's actor variance) and MF (women's partner variance) with female ID as a subject variable.
Fixed effects	Sex (1 = man, -1 = woman), actor and partner anticipatory hormonal response (testosterone or cortisol), and the interactions between the latter variables.

S3 Syntax GENLINMIXED

Atar = Actor testosterone anticipatory response
Ptar = Partner testosterone anticipatory response

Investigating if there is an interaction between attraction and sex:

```
GENLINMIXED
  /DATA_STRUCTURE SUBJECTS=Male_ID*Female_ID REPEATED_MEASURES=mf*fm COVARIANCE_TYPE=UNSTRUCTURED
  /FIELDS TARGET=YesNo TRIALS=NONE OFFSET=NONE
  /TARGET_OPTIONS REFERENCE=0 DISTRIBUTION=BINOMIAL LINK=LOGIT
  /FIXED EFFECTS= Sex Atar Ptar Sex*Atar Sex*Ptar USE_INTERCEPT=TRUE
  /RANDOM EFFECTS=mf fm SUBJECTS= Male_ID  COVARIANCE_TYPE=UNSTRUCTURED
  /RANDOM EFFECTS=fm mf SUBJECTS= Female_ID COVARIANCE_TYPE=UNSTRUCTURED
  /BUILD_OPTIONS TARGET_CATEGORY_ORDER=ASCENDING INPUTS_CATEGORY_ORDER=ASCENDING
MAX_ITERATIONS=100
    CONFIDENCE_LEVEL=95 DF_METHOD=RESIDUAL COVB=MODEL PCONVERGE=0.000001(ABSOLUTE) SCORING=0
    SINGULAR=0.000000000001.
```

Investigating male and female actor and partner variances in relation to attraction:

```
GENLINMIXED
  /DATA_STRUCTURE SUBJECTS=Male_ID*Female_ID REPEATED_MEASURES=mf*fm COVARIANCE_TYPE=UNSTRUCTURED
  /FIELDS TARGET=YesNo TRIALS=NONE OFFSET=NONE
  /TARGET_OPTIONS REFERENCE=0 DISTRIBUTION=BINOMIAL LINK=LOGIT
  /FIXED EFFECTS= man woman Atar*man Atar*woman Ptar*man Ptar*woman USE_INTERCEPT=FALSE
  /RANDOM EFFECTS=mf fm SUBJECTS= Male_ID  COVARIANCE_TYPE=UNSTRUCTURED
  /RANDOM EFFECTS=fm mf SUBJECTS= Female_ID COVARIANCE_TYPE=UNSTRUCTURED
  /BUILD_OPTIONS TARGET_CATEGORY_ORDER=ASCENDING INPUTS_CATEGORY_ORDER=ASCENDING
MAX_ITERATIONS=100
    CONFIDENCE_LEVEL=95 DF_METHOD=RESIDUAL COVB=MODEL PCONVERGE=0.000001(ABSOLUTE) SCORING=0
    SINGULAR=0.000000000001.
```

S4 Supplementary analyses

Table S3. The impact on the significant *p*-values reported in section 3.3 and 3.4 of the main manuscript when excluding several participants (outliers and medication use) and when adding several covariates to the analyses (contraceptive use, recreational drug use, condition order).

	Original result	Exclusion of:		Controlling for:		
		Hormonal out-liers (SD/IQR)	Medication use	Contra-ceptives[1]	Recreational drug use[2]	Condition order[3]
Anticipatory response: male popularity & cortisol	.004	.010	.001	.004	.041	.003
Anticipatory response: female selectivity & T×C	.017	.014/.017	.024	.029	.028	.020
Hormonal change: selectivity & cortisol	.047	.058	.063	.052	.066	.047

[1] Use of hormonal contraceptives (yes/no)
[2] The following dummy variables were added: smoking more than 5 cigarettes a day (yes/no), regular hard drug use (once a week or more MDMA/Exctacy/Mushrooms etc.) (yes/no), regular marihuana user (more than 0.5 g a day) (yes/no), heavy alcohol user (3 or more alcoholic units a day for men and 2 or more alcoholic units a day for women) (yes/no).
[3] Speed-dating or control condition first

Table S4. Skewness and kurtosis of the residuals when regression the raw pre-sample on the post-sample separated per condition and for testosterone also per sex.

Residuals (post-pre)	**Skewness**		**Kurtosis**	
	Statistic	*se*	Statistic	*se*
Testosterone men				
Romantic condition	1.99	.39	6.43	.77
Control condition	.73	.41	.49	.81
Testosterone women				
Romantic condition	3.65	.37	16.55	.72
Control condition	.94	.39	.87	.77
Cortisol				
Romantic condition	1.58	.27	6.43	.54
Control condition	3.52	.29	15.85	.57

Table S5. Skewness and kurtosis of the raw variables.

Raw variables		**Skewness**		**Kurtosis**	
		Statistic	*se*	Statistic	*se*
Testosterone men	**Moment**				
Romantic condition	Pre	.54	.39	-.31	.77
	Post	1.76	.39	4.44	.76
Control condition	Pre	1.88	.41	3.14	.80
	Post	.87	.41	1.45	.81
Testosterone women					
Romantic condition	Pre	4.69	.37	25.63	.72
	Post	2.56	.37	7.14	.72
Control condition	Pre	1.05	.39	.37	.77
	Post	.79	.38	.40	.75
Cortisol					
Romantic condition	Pre	1.86	.27	5.54	.54
	Post	4.22	.27	25.58	.54
Control condition	Pre	4.51	.29	28.23	.57
	Post	3.21	.29	13.83	.57

Figure legends

Figure 1. Mean testosterone levels per sample, condition, and sex. Errors bars represent 1 standard error.

Figure 2. Mean cortisol levels per sample, condition, and sex. Errors bars represent 1 standard error.

Figure 3. The percentage of men and women saying yes according to the anticipatory cortisol response of their interaction partner.

Figure 4. The percentage of people saying yes to their dates according to the interaction between their own anticipatory cortisol response and their own testosterone response.

Figure 5: Scatterplot showing the relationship between cortisol change during romantic speed-dating (minus the control condition change) and selectivity. A higher score on selectivity means that participants said less frequently yes to their dates. Selectivity was coded as a percentage: (1-~~(~~((number of given “yeses” divided by the number of completed dates)) × 100~~)~~. Plotted are the regression line (solid line) and its corresponding 95% confidence intervals (dashed lines).

Highlights

- Testosterone and cortisol levels are probably related to romantic attraction
- We conducted a study with a romantic speed-dating condition and control condition
- We found strong anticipatory hormonal responses
- In women, but not in men, testosterone levels increased during speed-dating
- Cortisol was related more to the attraction of a romantic partner than testosterone

Hormones in speed-dating: The role of testosterone and cortisol in attraction

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Abstract

There is evidence that testosterone and cortisol levels are related to the attraction of a romantic partner; testosterone levels relate to a wide range of sexual behaviors and cortisol is a crucial component in the response to stress. To investigate this, we conducted a speed-dating study among heterosexual singles. We measured salivary testosterone and cortisol changes in men and women (n = 79) when they participated in a romantic condition (meeting opposite-sex others, i.e., potential romantic partners), as well as a control condition (meeting same-sex others, i.e., potential friends). Over the course of the romantic speed-dating event, results showed that women's but not men's testosterone levels increased and cortisol levels decreased for both men and women. These findings indicate that men's testosterone and cortisol levels were elevated in anticipation of the event, whereas for women, this appears to only be the case for cortisol. Concerning the relationship between attraction and hormonal change, four important findings can be distinguished. First, men were more popular when they arrived at the romantic speed-dating event with elevated cortisol levels. Second, in both men and women, a larger change in cortisol levels during romantic speed-dating was related to more selectivity. Third, testosterone alone was unrelated to any romantic speed-dating outcome (selectivity or popularity). However, fourth, women who arrived at the romantic speed-dating event with higher testosterone levels were more selective when their anticipatory cortisol response was low. Overall, our findings suggest that changes in the hormone cortisol may be stronger associated with the attraction of a romantic partner than testosterone is.

Keywords: testosterone; cortisol; speed-dating; attraction; popularity; selectivity; human mating; social relation model

1 Introduction

Speed-dating events are well suited to study initial romantic attraction between individuals (Finkel et al., 2007). In speed-dating, individuals meet potential romantic partners during short "dates" of a few minutes, after which they indicate whether or not they would like to see them again. When both individuals have indicated that they would like to see each other, this is considered a match and their contact information is exchanged. Not surprisingly, there is quite some evidence concerning the psychological processes that take place during these speed-dates (e.g., Asendorpf et al., 2011) and contributing factors such as personality and ideal partner preferences (e.g., Joel et al., 2017). However, it still remains unclear if, and to what extent, physiological changes relate to dating outcomes. Of special interest are the hormones testosterone and cortisol, as a large body of research has shown that testosterone relates to sexuality (e.g., Roney, 2016) and that cortisol is a crucial component in the regulation of energy requiring processes in response to stress (e.g., Sapolsky et al., 2000).

To our knowledge, no study to date has explored whether changes in these hormones relate to attraction in a real-world dating environment. This study tested this by measuring testosterone and cortisol levels before and after a speed-dating event in heterosexual men and women. Unique in this study is that participants also participated in a control condition in which they speed-dated with same-sex others to make potential friends. This control condition enabled us to control for the arousal produced by meeting new people, and to extract hormonal changes that were more specific to attracting a romantic partner. The attraction of dates can be measured in various ways, but in the current study we used *selectivity*: how many dates does an individual accept as a potential romantic partner, and *popularity*: by how many dates is an individual accepted as a potential romantic partner. The advantage of these measures is that they have real consequences for participants: when both dates said yes they would receive each other's contact details to potentially arrange further meetings.

Testosterone

How would testosterone relate to selectivity and popularity in speed-dating? According to a broad evolutionary framework, testosterone levels promote competition for potential romantic partners at a cost to investments in other areas (Roney, 2016). More specifically, the challenge hypothesis theorizes that high levels of testosterone are an indication that resources are being allocated to mating effort (Archer, 2006). An example of such mating effort would be effort spend to acquire mates during speed-dating. On the other hand, low testosterone levels are an indication that resources are being allocated to parental effort (Archer, 2006), for example, when taking care of children. Alternatively, the steroid/peptide theory of social bonds puts forward that the distinction between mating and parental effort is not specific enough (van Anders et al., 2011). Instead, high testosterone levels may only map onto mating effort if the behavior is competitive (e.g., competing for mates) but not when mating effort is nurturing (e.g., bonding with partner; van Anders, 2013).

Indeed, in the scientific literature there is substantial evidence for the proposition that high testosterone levels are related to mate acquisition in men (i.e., high mating effort or competitive behavior). For example, men with higher basal testosterone levels had a greater number of lifetime sexual partners in a large sample of American elderly men (Pollet et al., 2011) and Australian male students (Peters et al., 2008). Furthermore, in North-American male students, those who were single had higher basal testosterone levels than those in a relationship (van Anders and Goldey, 2010; van Anders and Watson, 2006). Also, basal testosterone levels were higher in English male students when they were in a new relationships (< 12 months) as compared to a longer relationship (≥ 12 months; Farrelly et al., 2015), and basal testosterone levels were higher in male Harvard Business School students who were single than those in a committed relationship (Burnham et al., 2003). In addition, polygynous men had higher basal testosterone levels then monogamous men in a sample of agriculturists in rural Senegal (Alvergne et al., 2009) and in Swahili men of Kenya (Gray, 2003), but not in Ariaal men of Northern Kenya (Gray et al., 2007). Of special interest is a study showing that a more masculine facial width-to-height ratio (fWHR), which is shaped by testosterone in adolescence (Verdonck, 1999), was related to more popularity during speed-dating in a sample of young male Germans (Valentine et al., 2014).

In addition, there is also evidence that low basal levels of testosterone relate to nurturing parental behavior/effort. For example, fathers had lower basal testosterone levels than unmarried men in a sample of Chinese students (Gray et al., 2006) and men from the Boston area (Gray et al., 2002). Also, testosterone levels were lower in expectant Canadian fathers compared to a control group (Berg and Wynne-Edwards, 2001). Furthermore, when making the distinction between competitive and nurturing parental behaviors, there is research showing that in a polygynous population of agriculturists in rural Senegal, the more parental care fathers provided the lower their basal testosterone levels (Alvergne et al., 2009). If parental care involves infant defense, such as when hearing a crying baby without being able to provide a nurturing response, testosterone levels actually increase (van Anders et al., 2012).

Although most scientific literature on testosterone and social behavior is on men, for women too, there is evidence that testosterone levels are related to mate acquisition. Basal testosterone levels were higher in North American women who were single than for those who were in casual relationships (van Anders and Goldey, 2010), although in a sample of American female students, basal testosterone levels were comparable between single women and women who reported frequent uncommitted sexual behavior (Edelstein et al., 2011). In addition, in a sample of North American women, those with multiple committed relationships had higher basal testosterone levels than those with only one committed relationship (van Anders et al., 2007). Finally, other studies showed that motherhood was associated with lower basal testosterone levels in Norwegian women (Barrett et al., 2013) and Philippine women (Kuzawa et al., 2010).

Changes in testosterone levels over time in mating contexts have been studied less. Nevertheless, studies have shown that testosterone levels increase when talking to a potential romantic partner, in both American male students (Roney et al., 2010, 2007, 2003) and Dutch male students (van der Meij et al., 2008). Also, the more Spanish male students responded with a testosterone increase after competition the more affiliation they showed towards women afterwards during a brief social contact (van der Meij et al., 2012). Despite evidence suggesting the relevance of testosterone in mating contexts, to our knowledge, only one study has attempted to explore whether levels change over the course of a speed-dating event. Interestingly, this study showed that in men testosterone levels did not change before and after speed-dating (Lefevre et al., 2013).

In sum, based on the available literature demonstrating a link between testosterone and mate acquisition, we expected that testosterone levels would be elevated in anticipation of the speed-dating event and would increase further during the event. We also explored whether participants with overall higher testosterone levels would be less selective. If their primary motivation is to form short-term relationships, then saying “yes” to more of their interaction partners (lower selectivity) would increase their chances of seeing an interaction partner again and thus increase their chances to form short-term relationships. However, if they are primarily motived to find a long-term relationship partner, then high testosterone levels could lead to both higher or lower selectivity. Being selective means participants avoid spending time and energy on unsuitable people, which they are able to invest in potential partners more worthy of a long-term relationship. On the other hand, being too selective will leave them with fewer people to explore long-term relationship possibilities with. Taken together, we expected that participants’ motive for participation in speed-dating would vary, but that — on average — people who are focused on mate acquisition would be less selective and would thus have higher testosterone levels.

Concerning popularity, we expected that participants with higher testosterone levels would be more popular overall. According to the challenge hypothesis and the steroid/peptide theory of social bonds, men and women with elevated testosterone levels are more motivated to find a romantic partner and thus put more effort in impression management. This extra effort will make them appear more favorable as a potential romantic partner and as such they may receive more “yeses” from their interaction partners (i.e., higher popularity). Indeed, one study showed that testosterone levels may actually relate to positive social behaviors such as smiling and showing interest in a mating context (van der Meij et al., 2012). Furthermore, several authors have proposed that high testosterone levels can lead to prosocial behavior as long as the social context rewards prosocial behavior with an increase in social status (Bos et al., 2012; Eisenegger et al., 2011).

Cortisol

How would cortisol relate to selectivity and popularity in speed-dating? The hormone cortisol is one of the key players in the response to psychosocial stress: cortisol release sharpens cognition and diverts energy to muscles to cope with stressors (Sapolsky et al., 2000). The largest release in cortisol has been shown in situations that are uncontrollable and pose a social-evaluative threat (Dickerson and Kemeny, 2004). Speed-dating is a situation that appears to match these criteria: how dates will respond is not within one’s complete control, and participants are being evaluated by their dates, which may result in rejections and few matches.

Even though the literature on romantic attraction and cortisol is scarcer than for the hormone testosterone, studies suggest that meeting a potential romantic partner increases cortisol levels. For example, previous research has shown that cortisol levels increased in American male students when talking to a potential romantic partner (Roney et al., 2010, 2007). Furthermore, cortisol levels increased in Spanish male students when they talked to a potential female partner they perceived as attractive (van der Meij et al., 2010). Conversely, lower cortisol levels seem associated with parental effort/nurturing behaviors and not mating effort/competitive behaviors. For example, Canadian fathers had lower cortisol concentrations than non-fathers (Berg and Wynne-Edwards, 2001), and “parenting oriented” (pair bonded and/or fathers) Philippine men had lower cortisol levels than “mating oriented” (non-pairbonded, non-fathers) Philippine men (Gettler et al., 2011).

Interestingly, there are also several studies indirectly investigating if cortisol is related to mating effort or competitive behaviors by studying cortisol changes in response to viewing sexual images. Results from such studies are mixed. In American and Canadian women cortisol levels decreased when seeing sexual images (respectively: Hamilton and Meston, 2011; Van Anders et al., 2009), whereas another study showed that cortisol increased in a sample of American women (Hamilton et al., 2008), and cortisol levels did not change in German community samples (Exton et al., 2000), American women (Heiman et al., 1991), and female American students (Goldey and van Anders, 2011). Finally, in a sample of mostly American students, cortisol levels did not increase when men were instructed to imagine a sexual situation, although higher cortisol levels did correlate with more self-reported sexual arousal (Goldey and van Anders, 2012).

Considering the above findings, we concluded that there may be a link between elevated cortisol levels and more mate acquisition, as shown by studies investigating cortisol in relation to contact with potential romantic partners and fatherhood. Similar to the rationale we applied to testosterone, we expected that cortisol levels would be elevated in anticipation of the speed-dating event and would increase further during the event. We also expected that larger cortisol changes would show a higher focus on mate acquisition and thus less selectivity (more "yeses" given) and more popularity (more "yeses" received). Furthermore, from the perspective of the psychosocial stress literature, speed-dating can be considered a stressful experience, since there is the distinct possibility of a negative outcome by having very few matches. When considering this perspective, we would expect that elevated cortisol levels are related to less selectivity and more popularity, as this strategy would decrease the chances of no match.

Testosterone × cortisol

Does the interaction between testosterone and cortisol levels relate to selectivity and popularity in speed-dating? Recent developments in theoretical models have predicted that testosterone and cortisol may actually jointly regulate behavior (Mehta and Josephs, 2010; Terburg et al., 2009). The dual-hormone hypothesis predicts specifically that high basal testosterone levels stimulate status seeking only when basal cortisol levels are low (Mehta and Prasad, 2015). This is in contrast to basal cortisol levels being high, which combined with high basal testosterone levels may inhibit or block status-seeking behavior (Mehta and Prasad, 2015). Indeed, there is some support for this hypothesis, as several studies have shown that higher basal testosterone levels were related to more risk-taking (Mehta et al., 2015; Ronay et al., 2018), more overbidding (van den Bos et al., 2013), and less empathy (Zilioli et al., 2015) only when basal cortisol levels were low. However, there are also studies showing the opposite result as expected from the dual-hormone hypothesis. For example, female aggression and male psychopathy were related to higher basal testosterone levels only for high basal cortisol levels (respectively Denson et al., 2013; Welker et al., 2014). These mixed findings are also illustrated by a recent meta-analysis showing that there is marginal support for the dual-hormone hypothesis (Dekkers et al., 2019).

Of special relevance to our study is research showing that male rugby athletes' popularity (i.e., more teammates reported to like hanging out with them) was related to higher basal testosterone levels only for athletes that also had low basal cortisol levels (Ponzi et al., 2016). This last finding could also indicate that these men were more popular among women as, according to Sexual Strategies Theory, women are attracted to men with more social status (Buss and Schmitt, 1993). In line with this finding, we investigated if the dual-hormone hypothesis also applied to the mating domain (i.e., in speed-dating).

For popularity the prediction is straightforward: more social status seeking should lead to more popularity. Participants seeking social status may be motivated to show off their high desirability as a potential romantic partner by receiving many "yeses" from other dates and subsequently making this public. Thus, high testosterone levels should be related to more popularity when cortisol levels are low. However, it is unclear how selectivity relates to status seeking. On the one hand, both men and women may gain social status by getting many successful matches, as this may demonstrate that they are desirable as a potential romantic partner. In this case, the best strategy would be to say “yes” to many other dates (low selectivity) in order to increase the potential number of matches. On the other hand, both men and women may gain social status by demonstrating that the other people present at the speed-dating were not good enough for them. Thus, they may say “yes” to very few dates (high selectivity).

Hypotheses

To investigate the relationship between romantic attraction and hormonal levels we performed a speed-dating study. In this study, we compared salivary testosterone and cortisol levels (pre and post) in heterosexual men and women attending both a romantic condition (opposite sex dates) and a control condition in which they dated same-sex partners (*n* = 79). We assessed popularity and selectivity by having each participant indicate if they wanted to exchange contact details with their date. Based on the previously mentioned literature we hypothesized the following:

1. Testosterone and cortisol levels are elevated in anticipation of romantic speed-dating and increase further during the event.
2. Higher testosterone levels are related to less selectivity and more popularity in romantic speed-dating.
3. Higher cortisol levels are related to less selectivity and more popularity in romantic speed-dating.
4. Only when cortisol levels are low, higher testosterone levels are related to more popularity in romantic speed-dating. For selectivity, we explored whether higher testosterone levels are related to *more* or *less* selectivity in romantic speed-dating when cortisol levels were low.

2 Methods

2.1 Participants

The final sample consisted of 79 single participants (41 women: 19-28 yrs., *M* = 22.1, *SD* = 2.2; 38 men: 18-28 yrs., *M* = 23.2, *SD* = 2.2). Participants were recruited in the Netherlands from undergraduate classes at the Vrije Universiteit Amsterdam, the student dorms, social network websites, and from the social networks of the researchers. The event was advertised as a real speed-dating event that formed part of a study. Many of these students were foreign students and thus the event was hosted in English. Participants first completed an online survey to determine eligibility. Criteria of inclusion were that they had to be heterosexual (to make the study design simpler), single, and not older than 30 years.

Women during romantic speed-dating had between 12 and 17 dates (*M* = 15.2, *SD* = 1.1) and in the control condition they had between 14 and 17 dates (*M* = 15.9, *SD* = .6). Men had in both the romantic speed-dating and control condition between 14 and 17 dates (respectively: *M* = 16.4 *SD* = 0.6; *M* = 15.6, *SD* = 0.8).

Participants were asked not to engage in any recreational drug use or excessive alcohol consumption up to 24 hours prior to each event they attended, and not to consume anything but water up to two hours prior to each event.

In the final sample size, the following substances were used that could alter hormonal levels: (i) 2 men and 1 woman used medication (Euthyrox, Letrox, Escitalopram), (ii) 1 man used hard drugs on a weekly basis (XTC, 4FMP, Speed, MDMA), (iii) 2 men used more than 0.5 g of marihuana daily, (iv) 9 men consumed 21 or more alcoholic units weekly and 6 woman consumed 14 or more alcoholic units weekly, (v) 5 men and 6 women smoked more than 5 cigarettes daily, (vi) 11 women used hormonal contraceptives and 29 women did not. See the Supplementary material Table S3 for the effect on the statistical conclusions when controlling for these substances.

2.2 Procedure

A total of four events were organized by the authors of this article: two romantic speed-dating events where participants met opposite-sex interaction partners, and two control conditions where participants met same-sex interaction partners. The events were counterbalanced, such that approximately half the participants first attended the romantic speed-dating condition followed by the control condition, and approximately the other half attended first the control condition followed by romantic speed-dating. Some men and women participated with a same-sex friend. However, friends usually participated in the same group, meaning that they would have same-sex speed-dates with people from the other group whom they did not know.

Twenty men attended first the romantic speed-dating event and eighteen of these men also participated in the following control condition (men group one). Another fifteen men attended first the control condition and then the romantic speed-dating condition (men group two). For group two we recruited three extra male participants who only participated in the romantic speed-dating event because at this event we needed more male participants. Twenty-three women attended first the romantic speed-dating event and twenty of these women also participated in the following control condition (women group one). Another eighteen women attended first the control condition and then the romantic speed-dating event (women group two).

The events took place at a local bar at the same time on each day. Experimenters led men and women to separate rooms in order to prevent social interaction prior to the event. Experimenters handed participants a packet that contained a consent form, an initial questionnaire, the "match" card which contained items to be completed after each speed date, and a tube for their first saliva sample. After signing the consent form, participants began completing the initial questionnaire. Experimenters called participants one at a time, to measure their height and weight, and to take photographs of their faces. At approximately the same time at each event, experimenters gave instructions to participants on how to properly provide a saliva sample. Participants then provided their first (pre) saliva sample and completed any remaining items on the questionnaires. They were subsequently directed to the room where the romantic speed-dating event took place. Pairs of participants were seated at small tables facing each other. After each interaction, participants rated their interaction partner, and then all participants moved one seat to the left.

At the conclusion of speed-dating, men and women were once again separated. Exit questionnaires were completed and participants provided their second (post) saliva sample. Afterward, participants were paid €20 if it was their 2nd event and were thanked for their cooperation. After each event, they also received a token for one drink to be redeemed at the bar. Within 48 hours of the event, participants received an email containing photos and participant numbers of their matches. Participants could then respond with whether they would like to have their contact details sent to each match. All participants were debriefed via email.

The study was approved by the Ethics Committee of the Faculty of Psychology and Pedagogy of the VU University Amsterdam (Vaste Commissie Wetenschap en Ethiek van de Faculteit der Psychologie en Pedagogiek: VCWE) and was registered under E1404.

2.3 Questionnaires

Registration survey Participants registered for the study via an online survey. The survey screened for: 1) use of recreational drugs, 2) physical and/or mental illness', 3) relationship status (e.g. single, in a relationship), and 4) sexual orientation (e.g. heterosexual, homosexual, bisexual, other). Respondents indicated their use of recreational and medicinal substances in terms of frequency and amount per month. In addition, participants indicated whether they used contraceptives and indicated the type and amount. Participants also completed an initial survey, which was used for the research projects of three authors (AD, MT, and IM) as part of their master education. In this survey, we measured the following: self-control, socio-sexual orientation, self-perceived mating success, personal attributes, and cultural orientation.

Match card Participants rated their interaction partners on a "match" booklet, immediately following each interaction (see Appendix A). The card was twice the length of a piece of A4 paper folded in half, such that participants could hold one end upright and prevent interaction partners from seeing their responses. Participants indicated on the card if they would like to see this person again (yes/no). A "match" occurred when both participants indicated a yes. During romantic speed-dating, participants indicated how they would rate their interaction person as a short-term sexual partner and as a long-term romantic partner (low = 1 to high = 7). In the control condition, participants indicated how they would rate their interaction person as a potential friend (low = 1 to high = 7). Participants were also asked by the researchers at the event to write "yes" or "no" on the card next to the interaction partner's participant number to indicate if they had ever met prior to the event.

Exit questionnaire Participants answered several questions after the speed-dating event concerning their previous experience with speed-dates, how they felt about the use of the English language throughout the event, and how they evaluated the event.

2.4 Hormonal analyses

To measure hormonal levels participants deposited 2 ml of saliva in small plastic vials through a straw at approximately 10 min before the beginning of each session (pre-sample) and approximately 10 min after the last interaction (post-sample). The time between saliva samples was approximately 1h. Saliva samples were subsequently stored in a freezer and sent frozen to the laboratory of Biological Psychology at the Dresden University of Technology.

Salivary testosterone and cortisol levels were determined in duplicate with a high performance liquid chromatography–tandem mass spectrometry (LC–MS/MS) with Atmospheric Pressure Chemical Ionization (APCI) coupled with on-line solid phase extraction (SPE) by the laboratory of Biological Psychology at the Dresden University of Technology (Gao et al., 2015). For cortisol, this method features an inter-assay variation of 7.7% at 0.01 ng/mL, 7.4% at 1 ng/mL, and 6.8% at 10 ng/mL. For testosterone, this method features an inter-assay variation of 8.6% at 0.01 ng/mL, 6.2% at 1 ng/mL, and 8.1% at 10 ng/mL (Gao et al., 2015). The lower limit of quantification (LOQ) of this method was 1 pg/ml for testosterone and 5 pg/ml for cortisol (Gao et al., 2015). See Table 1 for the average intra-assay coefficients for each hormone and sample in this study.

Testosterone and cortisol values were log transformed for all statistical analyses because the raw values and residuals did not follow a normal distribution (see Table S4 and S5 in the Supplementary analysis).

Table 1: Average intra-assay coefficients (%) per hormone and pre and post-sample.

	Romantic speed-dating				**Control condition**			
	Pre		Post		Pre		Post	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Testosterone	7.98	4.51	7.05	4.16	7.59	4.42	5.90	4.31
Cortisol	8.32	2.16	7.95	2.08	8.28	2.45	8.30	2.18

2.5 Statistical analyses: social relation model

We performed a social relation model (Kenny, 1994; Kenny and La Voie, 1984) to investigate the relationships between selectivity and popularity in romantic speed-dating (see section 3.1) and how they related to hormonal levels (see section 3.3). The advantage of the social relation model over models that average speed-dating outcomes, is that it takes into account variance at the date level by specifying actor, partner, and relationship effects. Actor effects refer to the general tendency of a rater to respond “yes” to the question “Would you like to see this person again?” (i.e., selectivity, where more yes responses indicate low selectivity). Partner effects refer to the general tendency of a target to receive a “yes” from their date (i.e., popularity, where more “yes” responses indicate high popularity), and the relationship effect refers to the unique dyadic component of a date plus error variance (people may be attracted to specific individuals, i.e., exclusivity). For effect sizes, we reported partial eta squared (Lakens, 2013) and odds ratios.

We adapted the procedure in SPSS as described by Ackerman et al. (2015) to GENLINMIXED (with logit-link) as we had a dichotomous date outcome variable (yes or no). As fixed effects, we included Sex and the anticipatory hormonal responses. We calculated this response as follows: (log of hormonal level pre-sample romantic speed-dating) minus (log of hormonal level pre-sample control condition). According to this operationalization of anticipatory hormonal response, in men, 53.1% experienced a positive testosterone response and 66.7% experienced a positive cortisol response, and in women, 38.9% experienced a positive testosterone response and 48.6% experienced a positive cortisol response. We also included a repeated measures effect to asses relationship effects, and we included random effects to asses men’s and women’s actor and partner effects, see Supplementary material Table S2 for a more detailed description. For the analyses concerning cortisol, we first assessed if the partner and actor effect interacted with Sex, whereas we separated the analyses for testosterone, as men and women had different testosterone levels (see Table 2). See the Supplementary material for more information on the used procedure and the code we used in SPSS to run the analyses (i.e., syntax).

2.6 Statistical analyses: hormonal changes and attraction

We used linear mixed models to investigate whether hormonal changes occurred over the course of the romantic speed-dating and control condition (see section 3.2 for results). As the dependent variable, we included the log-transformed testosterone or cortisol values. As fixed effects, we included: Moment (pre or post), Condition (romantic speed-dating or control condition), and Sex (man or woman). We also specified a subject variable. As a repeated factor we included the four saliva sampling moments (pre and post for each condition) and selected an unstructured correlation metric as the covariance structure. As effect size, we reported partial eta squared and Cohen's d_{rm} for repeated measures (Lakens, 2013).

We chose not to analyze the hormonal changes in relation to selectivity and popularity with the social relation model since the overall hormonal changes may be in response to one specific date, some specific dates, or all dates. Thus, we could not specify at the individual date level whether hormonal levels were changing in response to that particular date. Also, we did not use linear mixed models because we wanted to control for elevated baseline levels in our study. How much hormonal levels can change depends on how high levels are at baseline, and thus hormonal levels in the post-sample are sensitive to regression to the mean (see also Mehta et al., 2008; van der Meij et al., 2012). To control for this we used the unstandardized residuals when regressing the pre-sample on the post-sample in each condition.

Thus, to investigate if hormonal changes during romantic speed-dating were related to overall selectivity and popularity we performed the following analyses (for results see section 3.4): (i) for cortisol change, moderator regression analyses change to investigate the moderation of Sex and partial correlations controlling for Sex to investigate the cortisol change across sexes, (ii) for testosterone change, Pearson correlations separate for each sex, since men and women had different testosterone levels (see Table 2), and (iii) for the interaction between testosterone and cortisol change, a moderator regression analyses (with Process, Hayes, 2017) separate for each sex, with testosterone change as predictor and cortisol change as the moderator. Additionally, following a reviewer's suggestion, we also explored if the relationship between the testosterone change and popularity and selectivity was moderated by the anticipatory cortisol response (pre-sample Romantic speed-dating – pre-sample Control condition). As effect size, we reported the adjusted *r* squared change.

For the above analyses, we defined selectivity as 1-the number of the total given "yeses" divided by the total number of completed dates, and we defined popularity as the number of the total received "yeses" divided by the total number of completed dates. To obtain a hormonal change score more specific to attracting a romantic partner we calculated the final hormonal change variable for each hormone by subtracting the unstandardized residuals in romantic speed-dating from the unstandardized residuals in the control condition. According to this operationalization of hormonal change, in men, 45.2% experienced an increase in testosterone levels and 50.0% experienced an increase in cortisol levels, and in women, 36.1% experienced an increase in testosterone levels and 54.1% experienced an increase in cortisol levels.

2.7 Statistical analyses: outliers, measurement errors, and covariates

We followed the guidelines by Pollet and van der Meij (2016) for outlier detection. For the cortisol analyses, four outliers were detected (one woman and three men) as one or more of their raw cortisol levels measurements differed by more than three standard deviations from the mean and were more than three interquartile ranges above the third quartile.

For one male participant, only his first testosterone measurement during romantic speed-dating was removed from hormonal analyses due to its extremely low value, which indicated a measurement error (pre-sample: 2.02 pg/mg, 2.40 SD away from the mean, other samples same participant: ≥ 48.93). Subsequently, we detected five outliers for testosterone (assessed separately for each sex). The raw testosterone samples of two women and two men differed by more than three standard deviations from the mean and were more than three interquartile ranges above the third quartile. One other raw testosterone sample of one male participant was three interquartile ranges above the third quartile but did not differ more than three standard deviations from the mean.

We also tested how robust statistical conclusions were. To this end we investigated whether the significant statistical conclusions differed according to the following: (i) excluding participants that used medication that can alter hormonal levels, (ii) excluding hormonal outliers, (iii) adding as a covariate hormonal contraception, (iv) adding as a covariate recreational drug use, (v) adding as a covariate if they participated first in the romantic speed-dating or the control condition. These analyses showed that the statistical conclusions concerning the anticipatory cortisol and testosterone × cortisol response remained the same, whereas these analyses lead to *p* values between .046 and .066 for the cortisol changes (see Supplementary material Table S3).

3 Results

3.1 Preliminary analysis: romantic dating outcomes

The social relation model showed that men and women differed in how often they said yes to their date ($F_{1,1223}$ = 5.69, p = 0.017, η_p^2 < .01). Men on average said yes to 72% (*se* = .06) of their dates and women on average said yes to 48% (*se* =.07) of their dates. Men differed to whom they said yes; some men said yes to some dates whereas other men did not say yes to those dates (i.e., male relationship effect, male exclusivity: Z = 15.94, p < .001, b = .75, *se* = .047). Also women differed to whom they said yes (i.e., female relationship effect, female exclusivity: Z = 16.01, p < .001, b = .80, *se* = .05). Furthermore, when a particular man or woman said yes to a date, that same date was more likely to yes to them (i.e., there was a click, or dyadic reciprocity: Z = 2.15, p = .031, b = .07, *se* = .03, r = .094). See the supplementary information for male and female actor and partner variances.

3.2 Hormonal changes during speed dating

Testosterone In the linear mixed model with testosterone as dependent variable, the results showed that there was a significant interaction between Sex, Moment, and Condition ($F_{1,68.51}$ = 12.61, p = .001, η_p^2 = .16). Results showed that men did not experience a change in their testosterone levels during romantic speed-dating ($t_{76.31}$ = .74, p = .462, d_{rm} = .07) nor during the control condition ($t_{64.66}$ = -.40, p = .689, d_{rm} = .04). Also, male testosterone levels in the pre- and post-sample were not different between the romantic speed-dating and control condition (respectively: $t_{68.19}$ = .40, p = .691, d_{rm} = .05; $t_{75.34}$ = -.51, p = .620, d_{rm} = .06). However, women did experience an increase in their testosterone levels during romantic speed-dating ($t_{75,48}$ = -3.34, p = .001, d_{rm} = .32), and experienced a decrease in their testosterone levels during the control condition ($t_{63.83}$= 2.55, p =

.012, d_{rm} = .26). Furthermore, in women, the pre testosterone sample did not differ between the romantic speed-dating and control condition ($t_{67.67}$ = -0.98, p = .332, d_{rm} = .13), but the post testosterone sample was higher after romantic speed-dating than in the control condition ($t_{73.23}$ = 3.81, p < .001, d_{rm} = .47). Additionally, the testosterone change was not different between women taking hormonal contraceptives and women who did not ($F_{1,32.38}$ = .13, p = .721, η_p^2 < .01). See table 2 and Figure 1 for the testosterone means.

-- figure 1 here –

Cortisol In the linear mixed model with cortisol as the dependent variable, the results showed that there was no interaction between Sex, Moment, and Condition ($F_{1,74.96}$ = 1.90, p = .173, η_p^2 = .02). Also, there was no interaction between Sex and Condition, nor between Moment and Sex (all p ≥ .128). However, there was an interaction between Condition and Moment ($F_{1,74.96}$ = 24.21, p < .001, η_p^2 = .24). Results showed that cortisol levels decreased from the pre-sample to the post-sample during romantic speed-dating ($t_{76.00}$ = 3.05, p = .003, d_{rm} = .33) and in the control condition ($t_{69.90}$ = 9.91, p < .001, d_{rm} = 1.21). Furthermore, cortisol levels were not different between the pre-sample of the romantic speed-dating condition and the pre-sample of the control condition ($t_{71.98}$ = 1.92, p = .056, d_{rm} = .22), and cortisol levels were higher in the post-sample after romantic speed-dating than in the post-sample of the control condition ($t_{75.79}$ = 7.41, p < .001, d_{rm} = .87). Additionally, the cortisol change was not different between women taking hormonal contraceptives and women who did not ($F_{1,36.57}$ = .21, p = .649, η_p^2 = .01). See table 2 and Figure 2 for the cortisol means.

-- figure 2 here --

Table 2. Mean and standard deviations of testosterone and cortisol levels (pg/mg) separated per condition, pre or post saliva sample, and sex.

	Romantic speed-dating				**Control condition**			
	Pre		Post		Pre		Post	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Men								
Testosterone	76.51	27.95	74.03	36.35	81.97	57.41	74.49	29.61
Cortisol	5.66	3.67	4.46	3.39	4.37	5.28	2.04	1.80
Women								
Testosterone	6.79	8.24	8.37	7.62	5.98	2.58	4.92	1.79
Cortisol	4.85	4.17	4.43	5.96	4.15	2.39	1.69	1.01

3.3 Anticipatory hormonal response and attraction

Testosterone The social relation model showed that for both men and women their own anticipatory testosterone response was unrelated to how often they said “yes” to their interaction partner, i.e. selectivity (sel. men: $F_{1,902}$ = 3.16, p = .076, η_p^2 < .01, sel. women: $F_{1,902}$ = .06, p = .806, η_p^2 < .01). Furthermore, how often they said “yes” was also unrelated to the anticipatory testosterone response of their interaction partner, i.e. popularity (pop. women: $F_{1,902}$ = .68, p = .411, η_p^2 < .01;

pop. men: $F_{1,902}$ = .06, p = .806, η_p^2 < .01).

Cortisol The social relation model showed that there were no sex differences in the relationship between participants saying “yes” to their interaction partner and their own anticipatory cortisol response, i.e. selectivity ($F_{1,956}$ = 0.15, p = .701, η_p^2 < .01). Also, when excluding the interactions with Sex, the model showed that how often participants said “yes” was unrelated to their own anticipatory cortisol response ($F_{1,958}$ = .01, p = .947, η_p^2 < .01).

However, the social relation model showed that there were sex differences in the relationship between participants saying “yes” to a date and the anticipatory cortisol response of their interaction partner, i.e. popularity ($F_{1,956}$ = 4.90, p = .027, η_p^2 = .01), see Figure 3. Results showed that women more often said “yes” when their interaction partner experienced a higher anticipatory cortisol response, i.e. male popularity ($F_{1,956}$ = 8.54, p =.004, η_p^2 = .01, odds ratio = 1.91). Women said “yes” to 34% of their dates when their interaction partner experienced an anticipatory cortisol response that was 1SD below the mean, whereas they said “yes” to 65% of their dates when their interaction partner experienced an anticipatory cortisol response that was 1SD above the mean. However, in men, saying “yes” to a date was unrelated to the anticipatory cortisol response of their interaction partner, i.e. female popularity ($F_{1,956}$ = .15, p = .698, η_p^2 < .01).

-- figure 3 here --

Testosterone × Cortisol (T×C) The social relation model showed that for men their own anticipatory T×C response was unrelated to how often they said “yes” to their interaction partner, i.e. male selectivity ($F_{1,894}$ = .01, p = .919, η_p^2 < .01), but for women their own anticipatory T×C response was related to how often they said “yes”, i.e. female selectivity ($F_{1,894}$ = 5.76, p = .017, η_p^2 = .01), see figure 4. Results showed that when women’s anticipatory cortisol response was high, saying “yes” to their interaction partner was not related to their own anticipatory testosterone response ($F_{1,894}$ = .23, p = .629, η_p^2 < .01, -1SD testosterone = 47% yeses, +1SD testosterone = 52% yeses). However, when women’s anticipatory cortisol response was low, a higher anticipatory testosterone response was related to less often saying “yes” ($F_{1,894}$ = 4.98, η_p^2 = .01, p = .026, -1SD testosterone = 62% yeses, +1SD testosterone = 21% yeses).

Furthermore, how often men and women said “yes” was unrelated to the anticipatory T×C response of their interaction partner, i.e., popularity (pop. women: $F_{1,894}$ = .19, η_p^2 < .01, p = .665; pop. men: $F_{1,894}$ = .11, p = .739, η_p^2 < .01).

-- figure 4 here --

3.4 Hormonal change and attraction

Cortisol The moderator regression analyses showed that sex did not moderate the relationship between cortisol change and selectivity ($F_{1,65}$ = .76, p = .386, $r^2\Delta$ = .01) and popularity ($F_{1,65}$ = .57, p = .452, $r^2\Delta$ = .01). Follow-up analyses with partial correlations (controlling for sex) showed that the more selective participants were the larger their cortisol change during romantic speed-dating (r_{66} = .24, p = .047), see Figure 5. Popularity was unrelated to cortisol change (r_{66} = -.06, p = .656).

Testosterone The partial correlations analyses showed that for both men and women selectivity/popularity was unrelated to a change in testosterone levels (sel. men r_{31} = -.034, p = .855; sel. women: r_{36} = .229, p = .180; pop. men: r_{31} = -.211, p = .255, pop. women: r_{36} = -.041, p = .814).

Testosterone × Cortisol (T×C) moderator cortisol change In men, the moderator regression analyses showed that the cortisol change did not moderate the relationship between the testosterone change and selectivity ($F_{1,27}$ = 1.46, p = .238, $r^2\Delta$ = .05) and popularity ($F_{1,27}$ = 1.74, p = .198, $r^2\Delta$ = .06). In women, the moderator regression analyses showed that the cortisol change did not moderate the relationship between the testosterone change and selectivity ($F_{1,32}$ = 1.12, p = .298, $r^2\Delta$ = .03) and popularity ($F_{1,32}$ = .44, p = .511, $r^2\Delta$ = .01).

Testosterone × Cortisol (T×C) moderator anticipatory cortisol response In men, the moderator regression analyses showed that the anticipatory cortisol response did not moderate the relationship between testosterone change and selectivity ($F_{1,27}$ = .17, p = .684, $r^2\Delta$ = .01) and popularity ($F_{1,27}$ = .25, p = .621, $r^2\Delta$ = .01). In women, the moderator regression analyses showed that the anticipatory cortisol response did not moderate the relationship between testosterone change and selectivity ($F_{1,32}$ = 2.40, p = .131, $r^2\Delta$ = .07) and popularity ($F_{1,32}$ = .30, p = .589, $r^2\Delta$ = .01).

-- figure 5 here –

Discussion

Testosterone change

Our findings showed that testosterone levels increased in women during romantic speed-dating and decreased in women during the control condition. Although these changes were small-medium effect sizes, they are in line with theoretical models predicting that high testosterone levels relate to more mate acquisition (Archer, 2006; Roney, 2016; Zilioli and Bird, 2017) and more competitive behavior (van Anders et al., 2011). However, surprisingly, in men, testosterone levels did not change during romantic speed-dating and remained high throughout the event. This is not in line with some previous research, as numerous studies have shown that men experience an increase in testosterone levels when talking to a potential mate in a waiting room situation (Roney et al., 2010, 2007, 2003; van der Meij et al., 2008), although one other study also showed that testosterone levels did not change during romantic speed-dating (Lefevre et al., 2013). A speculative explanation for these divergent findings is that romantic speed-dating is a much more arousing social context than a waiting room situation. Unlike a waiting room situation, a romantic speed-dating is an unambiguous dating context where individuals scan each other as potential mates. While the waiting room situation is unlikely to trigger prior expectations because participants do not know that they will be waiting together, participants of a romantic speed-dating do know that they will be evaluated as a potential romantic partner.

Thus, it could be that, in contrast to women's testosterone levels, men's testosterone levels did not increase further due to negative feedback from already high testosterone levels on the hypothalamus-pituitary-gonadal (HPG) axis. This may also have held true for the control condition, as testosterone levels were similar in this condition. In both conditions, men may have experienced greater amounts of social evaluative stress than women, as they were being evaluated on either suitability as a romantic partner or were checking the competition in the control condition. This finding is in line with other recent studies showing that testosterone levels increase in men during stress tasks with a social evaluative component (Bedgood et al., 2014; Lennartsson et al., 2012; Phan et al., 2017; Turan et al., 2015), although some older studies found no change in testosterone levels after psychosocial stress (Gerra et al., 2000; Heinz et al., 2003; Schoofs and Wolf, 2011) and one other study showed a decrease (Schulz et al., 1996). This increase in testosterone levels may be part of an adaptive response that assists an individual to cope with social challenges (Salvador, 2005; Salvador and Costa, 2009). Indeed, previous research has shown that the more men experienced a testosterone increase the more they affiliated with women (van der Meij et al., 2012).

Testosterone and attraction

An important finding is that testosterone levels were unrelated to popularity and selectivity in both men and women. This null finding for men may be related to the previously discussed elevated hormonal levels. Male testosterone levels may have been too elevated for most participants even before the romantic speed-dating began, which reduced variance in testosterone levels such that we were unable to detect a relationship with their behavior (either in selectivity or popularity). However, it is important to note that we may have lacked the power to detect smaller effect sizes, since men and women have different testosterone levels, and thus we had to analyze their testosterone data separately. In men, we did find an indication that a larger anticipatory testosterone response was related to less selectivity, although this effect was statistically not significant. Future studies with larger sample sizes may untangle if heightened testosterone levels during romantic speed-dating makes the relationship between attraction and testosterone undetectable in men.

For women, there was also no relationship between attraction and testosterone levels. This null finding is more difficult to explain, as testosterone levels in women did increase during romantic speed-dating. Additionally, previous research shows that, in a lab setting, an increase in testosterone levels was related to more sexual arousal in women (Tuiten et al., 2000), which suggests that increased testosterone levels could decrease selectivity. A speculative explanation for this null finding in women is that temporal changes in their testosterone levels had less of an effect on their behavior in an ecologically valid environment such as romantic speed-dating. Perhaps women more rationally deliberated the pros and cons of a potential romantic partner and were not so much affected by their own bodily and psychological state. Also interesting was that female popularity was unaffected by their testosterone levels. A possible explanation here could be that that men's selectivity is not so much influenced by female behavior during these speed dates. Men may largely determine beforehand if they will say yes to a date based on physical appearance. For example, in one particular study, BMI predicted 25% of female popularity alone (Kurzban and Weeden, 2005). Another explanation could be that variance in female popularity was limited and this reduced the power to detect an effect of anticipatory testosterone. Indeed, men said yes to 72% of their dates whereas women said yes to 48% of their dates.

Cortisol change

Results showed that both men and women arrived at both the romantic speed-dating and control condition with elevated cortisol levels and that during the course of both conditions their cortisol levels decreased. Furthermore, this decrease was a very large effect size in the control condition and less so in the romantic speed-dating condition (small-medium effect size). Also, cortisol levels were higher at the end of romantic speed-dating than at the end of the control condition. Together these finding indicates that participants perceived the romantic speed-dating as more challenging and stressful than friendship dating. This implies that being judged as a potential romantic partner is more stressful, and requires more impression management than when being judged as a potential friend. Furthermore, results showed that cortisol levels decreased during the course of romantic speed-dating and control condition. These results contrast with other studies showing that a brief social contact with a potential romantic partner produces an increase in cortisol levels in heterosexual men (Roney et al., 2010, 2007), although another study showed that cortisol levels only increased when in such encounters men perceived their potential partner as attractive (van der Meij et al., 2010).

There are two speculative explanations for these different results. First, our speed-dating study took over an hour to complete, thus cortisol levels may have started decreasing towards more normal values due to negative feedback from high cortisol levels on the hypothalamus-pituitary-adrenal (HPA) axis. Second, unlike these other studies, our participants probably arrived with relatively high cortisol levels in anticipation of the event. Thus, after having experienced several speed dates they may have habituated. Adding to this, social affiliation may have reduced anxiety through the release of oxytocin (for a review see Heinrichs et al., 2009). Indeed, previous research has shown that oxytocin administration reduces cortisol secretion during social evaluative stress (Heinrichs et al., 2003).

Cortisol and attraction

There are two interesting findings concerning cortisol and attraction. First, only in men, cortisol release in anticipation of romantic speed-dating was related to more popularity. This effect was substantial as women said “yes” to 34% of their dates when men experienced a small anticipatory cortisol response, whereas they said “yes” to 65% of their dates when men experienced a high anticipatory cortisol response. A possible explanation is that men who arrived with these high levels were more interested in dating women. Consequently, they may have put more energy into making positive impressions during the speed-dates. Additionally, they may have had more energy at their disposal since cortisol secretion increases local cerebral glucose utilization and cardiovascular tone (Sapolsky et al., 2000). However, it is important to note that a causal effect of cortisol on mate attraction could not be established in the current study. Other third variables, such as a high speed-dating motivation, may have produced more mate attraction behaviors as well as a rise in cortisol levels in anticipation of the event. Why women with elevated cortisol levels were not more popular may have to do with the small variance in female popularity. Similar to the function of testosterone, the function of these elevated cortisol levels in men may help them cope with social challenges (Salvador, 2005; Salvador and Costa, 2009). Furthermore, it could also reflect an effort to affiliate, as it has been shown that, in men, increased cortisol secretions during social evaluative stress predicted their feelings of closeness to a stranger in a subsequent interaction (Berger et al., 2016). Thus, our finding lends support for a “tend and befriend response” in men during stressful times (Geary and Flinn, 2002). Finally, this finding is in line with the Physiology of Romantic Pair Bond Initiation and Maintenance Model, as this model posits that HPA-axis activation in mating contexts is necessary to improve evaluations by potential mates (Mercado and Hibel, 2017).

Second, contrary to our hypothesis, in both men and women, a larger cortisol change during romantic speed-dating was related to more selectivity (controlling for baseline and cortisol change in the control condition), although this effect was small to medium. A speculative explanation is that romantic speed-dating was not a positive experience for all participants. Those men and women that experienced an increase in cortisol levels may have been worried that they would end up with no or very few matches. This would be in line with the stress literature as cortisol release is more prominent in social situations that are uncontrollable and pose a social-evaluative threat (for a review see Dickerson and Kemeny, 2004). Romantic speed-dating has both these elements: participants can only guess whether their interaction partner likes them (low control) and they are being evaluated as a potential partner at each date (high social-evaluative threat). In such a scenario, two different effects can be argued. The most rational strategy would be to say “yes” to many dates (low selectivity), to increase the chances of a match. However, our data shows the opposite: a larger cortisol change was related to more selectivity. This shows that a different process may have been going on. Perhaps those participants who experienced a larger increase in cortisol levels during speed-dating were more preoccupied with impression management and found it, therefore, more difficult to connect with their dates. As a result, they could have subjectively experienced fewer matches and said “yes” to fewer dates.

Testosterone × Cortisol

Our results showed overall weak support for the dual-hormone hypothesis (Mehta and Josephs, 2010) in a mating context. The most direct prediction from this hypothesis would be that popularity in romantic speed-dating was related to the interaction between testosterone and cortisol levels, yet we did not find evidence for this. These null findings could mean that the dual-hormone hypothesis is limited to social contexts in which social status can be gained more openly, for example in competition with others (Zilioli and Watson, 2012) or in leadership positions (Sherman et al., 2016). A potential alternative explanation for these null findings is that saying yes or no to other dates may depend on unique conversation dynamics for which we could not control. Perhaps this reduced our power to detect the interaction between both hormones. Indeed, many of the studies showing support for the dual-hormone hypothesis use laboratory tasks (Mehta et al., 2015) in which it is far easier to control for confounding variables.

Nonetheless, we did find support for one of our mutually exclusive predictions based on the dual-hormone hypothesis. Only in women, a higher anticipatory testosterone response was related to more selectivity when their anticipatory cortisol response was low. Women with this hormone profile may not have been motivated to gain social status by going for more matches (thus by being less selective). Instead, these women may have been motivated to gain social status by appearing exclusive. This finding would also be in line with the sexual double standard (Sagebin Bordini and Sperb, 2013). Women feel they are being valued more highly as a partner when they are restrictive in their sexual contacts, whereas for men this is less of a concern.

Future directions

An interesting avenue for future research would be to assess how hormones relate to specific behaviors during individual dates, as opposed to the accumulation of many speed-dates. Unfortunately, this was not possible in our current design as the hormonal changes captured the total experience of all the speed dates that had occurred between the pre and post measurement. Assess how hormones relate to specific behaviors is interesting because multiple studies have shown that specific behaviors do lead to more dating success. For example, it has been shown that when participants occupied more physical space, they were more popular, and this effect was stronger for men than for women (Vacharkulksemsuk et al., 2016). Also, video analyses show that being flirtatious leads to higher popularity, but that being flirted with does not lead to being chosen more (Back et al., 2011). Finally, research has also shown that dates that match each other's language style have an increased chance of mutual romantic interest (Ireland et al., 2011), and speed-dates were more likely to result in a match when men show alignment to women (McFarland et al., 2013). To test if these behaviors also relate to hormonal changes, future studies could use a single dating paradigm such that hormonal measurements reflect the experience of one particular date.

In addition, a serious limitation of using a speed-dating paradigm to investigate romantic attraction is that attraction frequently develops over time in response to repeated exposure (the familiarity effect). It would thus be very interesting to investigate whether changes in testosterone and cortisol levels relate to successful bonding in the beginning stages of romantic relationship forming.

General conclusion

Our study highlights the importance of controlling for anticipatory effects when studying the role of hormones in naturalistic stressors, such as participation in a romantic speed-dating event. Only with the inclusion of a control condition were we able to distinguish hormonal changes produced by meeting new people from hormonal changes associated with the attraction of romantic partners. Finally, our findings showed that compared to cortisol, testosterone was less strongly associated with attraction in romantic speed-dating. This suggests that cortisol may be more influential than testosterone in real-world situations in which people find romantic partners.

Acknowledgments

This work was supported by the equipment fund of the Vrije Universiteit Amsterdam.

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Supplementary material

S1 Male and female actor and partner variances

Men Results also showed that some men more frequently said yes to their dates than other men (i.e., male actor variance, variance in male selectivity: $Z = 3.28$, $p = .001$, estimate = 1.80, $se = .55$). Also, some men in general received a yes more frequently from their dates than other men (i.e., male partner variance, variance in male popularity: $Z = 3.24$, $p = .001$, estimate = 1.46, $se = .45$). Furthermore, men who frequently said yes to women in general did not receive a yes more frequently from all their dates (i.e., male generalized reciprocity: $Z = -.41$, $p = .680$, $r = -.081$, estimate = -.13, $se = .32$).

Women Results also showed that some women more frequently said yes to their dates than other women (i.e., female actor variance, variance in female selectivity: $Z = 3.23$, $p = .001$, estimate = 1.13, $se = .35$). Also, some women in general received a yes more frequently from their dates than other women (i.e., female partner variance, variance in female popularity: $Z = 3.40$, $p = .001$, estimate = 1.68, $se = .49$). Furthermore, women who frequently said yes to men in general did not receive a yes more frequently from all their dates (i.e., female generalized reciprocity: $Z = -.72$, $p = .471$, $r = -.14$, estimate = -.20, $se = .27$.

Table S1: The relative percentage of how much a given yes was due to general features of two individuals involved (selectivity of actor and popularity of partner) versus something unique to their relationship (exclusivity) separated by sex.

	Selectivity of actor	Popularity of Partner	Exclusivity (relationship effect plus error)	Total variance (log odds)
Man-to-woman ratings	42.54**	39.76**	17.70	4.220
Woman-to-man ratings	33.23**	43.17**	23.61	3.389

Note. **$p = 0.001$

S2 GENLINMIXED: Anticipatory hormonal response and attraction

To investigate the relationships between selectivity and popularity in speed-dating and how they relate to hormonal levels, we performed a social relation model by adapting the procedure in SPSS described by Ackerman et al. (2015) to GENLINMIXED (with logit-link), as we had a dichotomous outcome variable (yes or no). As a consequence, we chose an unstructured covariance matrix type for the random and repeated measures effects, since a heterogeneous compound symmetry matrix is unavailable for this analysis. We chose not to code for Group (there were three groups with each > 20 dates) since we assumed no substantial group differences due to random allocation.

The data matrix was coded in such a way that each date in the dataset was included as an individual row entry twice: one entry for a date in which a 1st individual within a date is the actor (and the 2nd individual the partner) and one entry for the same date in which the 2nd individual is the actor (and the 1st individual the partner). See Table S2 for the variables we included in the analyses.

Table S2: The included variables in the GENLINMIXED.

Variable	Description
Outcome variable (YesNo)	If they wanted to see the other person again (yes = 1, no = 0).
Repeated measures effect	To investigate relationship effects for each sex we included the interaction term between male rating female target (mf, man = 1, woman =0) and female rating male target (fm, man =0, woman =1). To code for each date we added the interaction term between male and female ID as subject variable.
Random effects	To investigate actor and partner effects for men we included as random effects mf (men's actor variance) and fm (men's partner variance) with male ID as a subject variable. To investigate actor and partner effects for women we included as random effects fm (women's actor variance) and MF (women's partner variance) with female ID as a subject variable.
Fixed effects	Sex (1 = man, -1 = woman), actor and partner anticipatory hormonal response (testosterone or cortisol), and the interactions between the latter variables.

S3 Syntax GENLINMIXED

Atar = Actor testosterone anticipatory response
Ptar = Partner testosterone anticipatory response

Investigating if there is an interaction between attraction and sex:

```
GENLINMIXED
  /DATA_STRUCTURE SUBJECTS=Male_ID*Female_ID REPEATED_MEASURES=mf*fm COVARIANCE_TYPE=UNSTRUCTURED
  /FIELDS TARGET=YesNo TRIALS=NONE OFFSET=NONE
  /TARGET_OPTIONS REFERENCE=0 DISTRIBUTION=BINOMIAL LINK=LOGIT
  /FIXED EFFECTS= Sex Atar Ptar Sex*Atar Sex*Ptar USE_INTERCEPT=TRUE
  /RANDOM EFFECTS=mf fm SUBJECTS= Male_ID  COVARIANCE_TYPE=UNSTRUCTURED
  /RANDOM EFFECTS=fm mf SUBJECTS= Female_ID COVARIANCE_TYPE=UNSTRUCTURED
  /BUILD_OPTIONS TARGET_CATEGORY_ORDER=ASCENDING INPUTS_CATEGORY_ORDER=ASCENDING
MAX_ITERATIONS=100
    CONFIDENCE_LEVEL=95 DF_METHOD=RESIDUAL COVB=MODEL PCONVERGE=0.000001(ABSOLUTE) SCORING=0
    SINGULAR=0.000000000001.
```

Investigating male and female actor and partner variances in relation to attraction:

```
GENLINMIXED
  /DATA_STRUCTURE SUBJECTS=Male_ID*Female_ID REPEATED_MEASURES=mf*fm COVARIANCE_TYPE=UNSTRUCTURED
  /FIELDS TARGET=YesNo TRIALS=NONE OFFSET=NONE
  /TARGET_OPTIONS REFERENCE=0 DISTRIBUTION=BINOMIAL LINK=LOGIT
  /FIXED EFFECTS= man woman Atar*man Atar*woman Ptar*man Ptar*woman USE_INTERCEPT=FALSE
  /RANDOM EFFECTS=mf fm SUBJECTS= Male_ID  COVARIANCE_TYPE=UNSTRUCTURED
  /RANDOM EFFECTS=fm mf SUBJECTS= Female_ID COVARIANCE_TYPE=UNSTRUCTURED
  /BUILD_OPTIONS TARGET_CATEGORY_ORDER=ASCENDING INPUTS_CATEGORY_ORDER=ASCENDING
MAX_ITERATIONS=100
    CONFIDENCE_LEVEL=95 DF_METHOD=RESIDUAL COVB=MODEL PCONVERGE=0.000001(ABSOLUTE) SCORING=0
    SINGULAR=0.000000000001.
```

S4 Supplementary analyses

Table S3. The impact on the significant *p*-values reported in section 3.3 and 3.4 of the main manuscript when excluding several participants (outliers and medication use) and when adding several covariates to the analyses (contraceptive use, recreational drug use, condition order).

	Original result	Exclusion of:		Controlling for:		
		Hormonal outliers (SD/IQR)	Medication use	Contraceptives[1]	Recreational drug use[2]	Condition order[3]
Anticipatory response: male popularity & cortisol	.004	.010	.001	.004	.041	.003
Anticipatory response: female selectivity & T×C	.017	.014/.017	.024	.029	.028	.020
Hormonal change: selectivity & cortisol	.047	.058	.063	.052	.066	.047

[1] Use of hormonal contraceptives (yes/no)
[2] The following dummy variables were added: smoking more than 5 cigarettes a day (yes/no), regular hard drug use (once a week or more MDMA/Exctacy/Mushrooms etc.) (yes/no), regular marihuana user (more than 0.5 g a day) (yes/no), heavy alcohol user (3 or more alcoholic units a day for men and 2 or more alcoholic units a day for women) (yes/no).
[3] Speed-dating or control condition first

Table S4. Skewness and kurtosis of the residuals when regression the raw pre-sample on the post-sample separated per condition and for testosterone also per sex.

Residuals (post-pre)	**Skewness**		**Kurtosis**	
	Statistic	*se*	Statistic	*se*
Testosterone men				
Romantic condition	1.99	.39	6.43	.77
Control condition	.73	.41	.49	.81
Testosterone women				
Romantic condition	3.65	.37	16.55	.72
Control condition	.94	.39	.87	.77
Cortisol				
Romantic condition	1.58	.27	6.43	.54
Control condition	3.52	.29	15.85	.57

Table S5. Skewness and kurtosis of the raw variables.

Raw variables		**Skewness**		**Kurtosis**	
		Statistic	*se*	Statistic	*se*
Testosterone men	**Moment**				
Romantic condition	Pre	.54	.39	-.31	.77
	Post	1.76	.39	4.44	.76
Control condition	Pre	1.88	.41	3.14	.80
	Post	.87	.41	1.45	.81
Testosterone women					
Romantic condition	Pre	4.69	.37	25.63	.72
	Post	2.56	.37	7.14	.72
Control condition	Pre	1.05	.39	.37	.77
	Post	.79	.38	.40	.75
Cortisol					
Romantic condition	Pre	1.86	.27	5.54	.54
	Post	4.22	.27	25.58	.54
Control condition	Pre	4.51	.29	28.23	.57
	Post	3.21	.29	13.83	.57

Figure legends

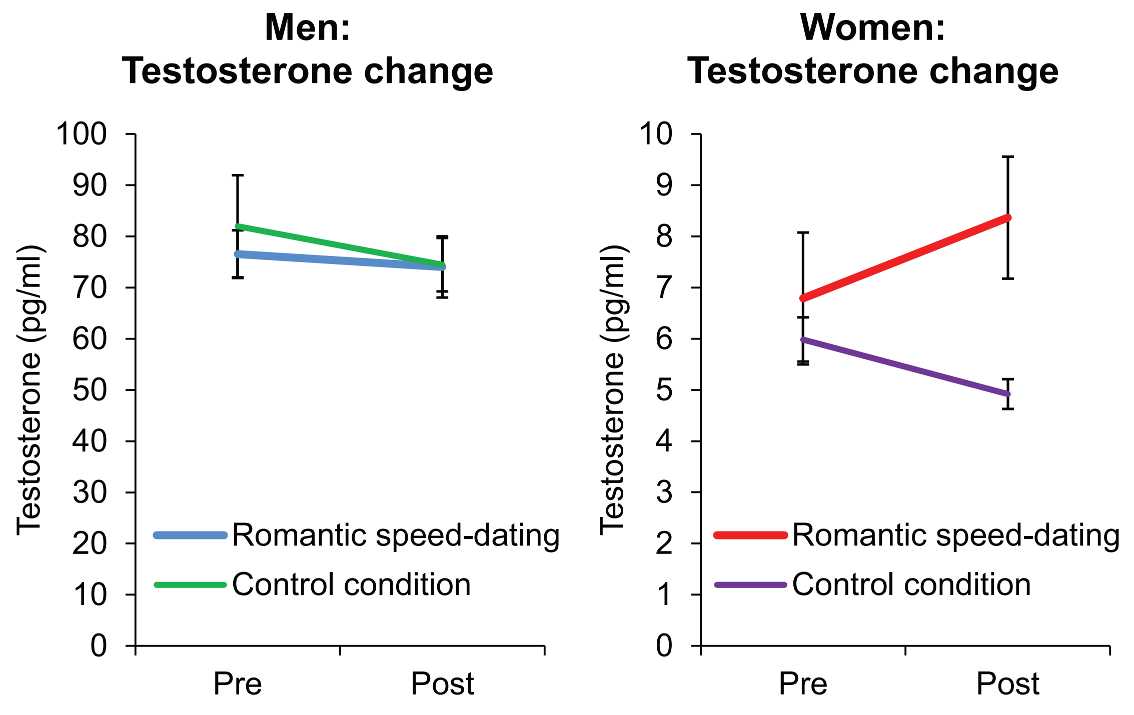
Figure 1. Mean testosterone levels per sample, condition, and sex. Errors bars represent 1 standard error.

Figure 2. Mean cortisol levels per sample, condition, and sex. Errors bars represent 1 standard error.

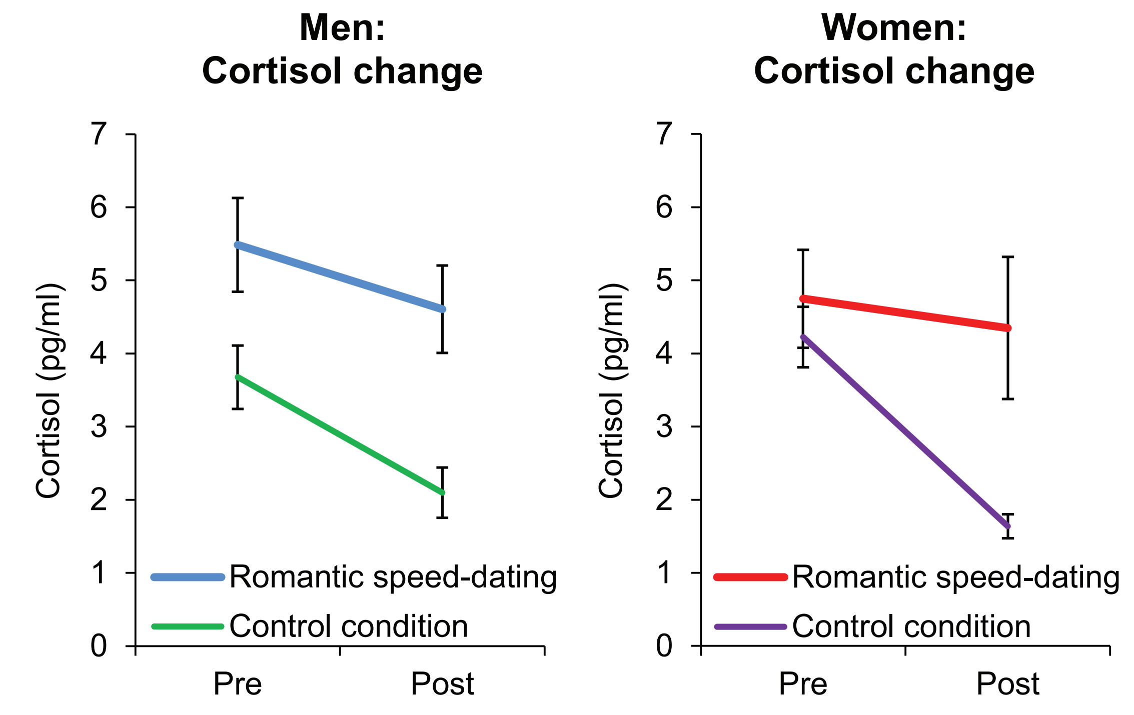
Figure 3. The percentage of men and women saying yes according to the anticipatory cortisol response of their interaction partner.

Figure 4. The percentage of people saying yes to their dates according to the interaction between their own anticipatory cortisol response and their own testosterone response.

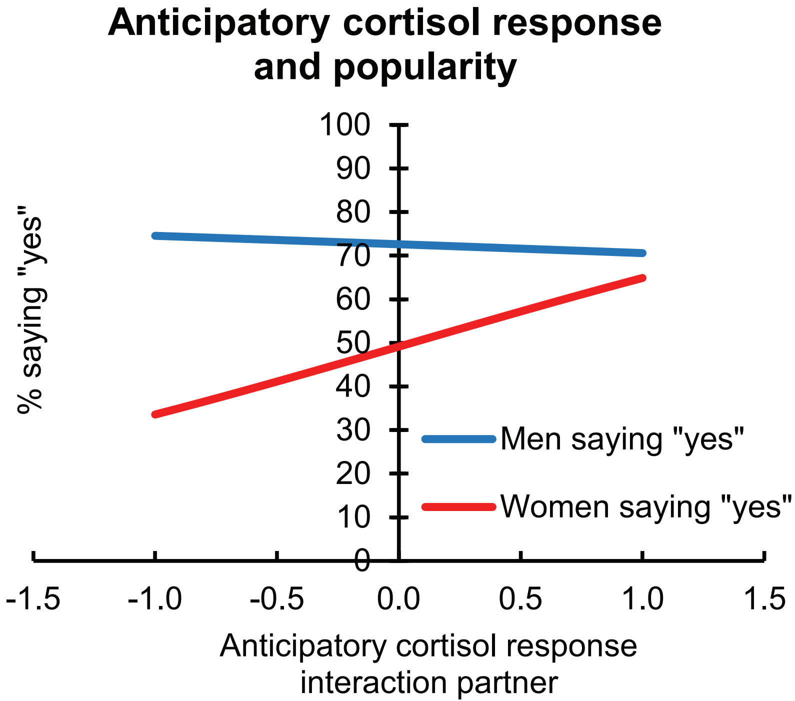
Figure 5: Scatterplot showing the relationship between cortisol change during romantic speed-dating (minus the control condition change) and selectivity. A higher score on selectivity means that participants said less frequently yes to their dates. Selectivity was coded as a percentage: (1-(number of given “yeses” divided by the number of completed dates)) × 100. Plotted are the regression line (solid line) and its corresponding 95% confidence intervals (dashed lines).

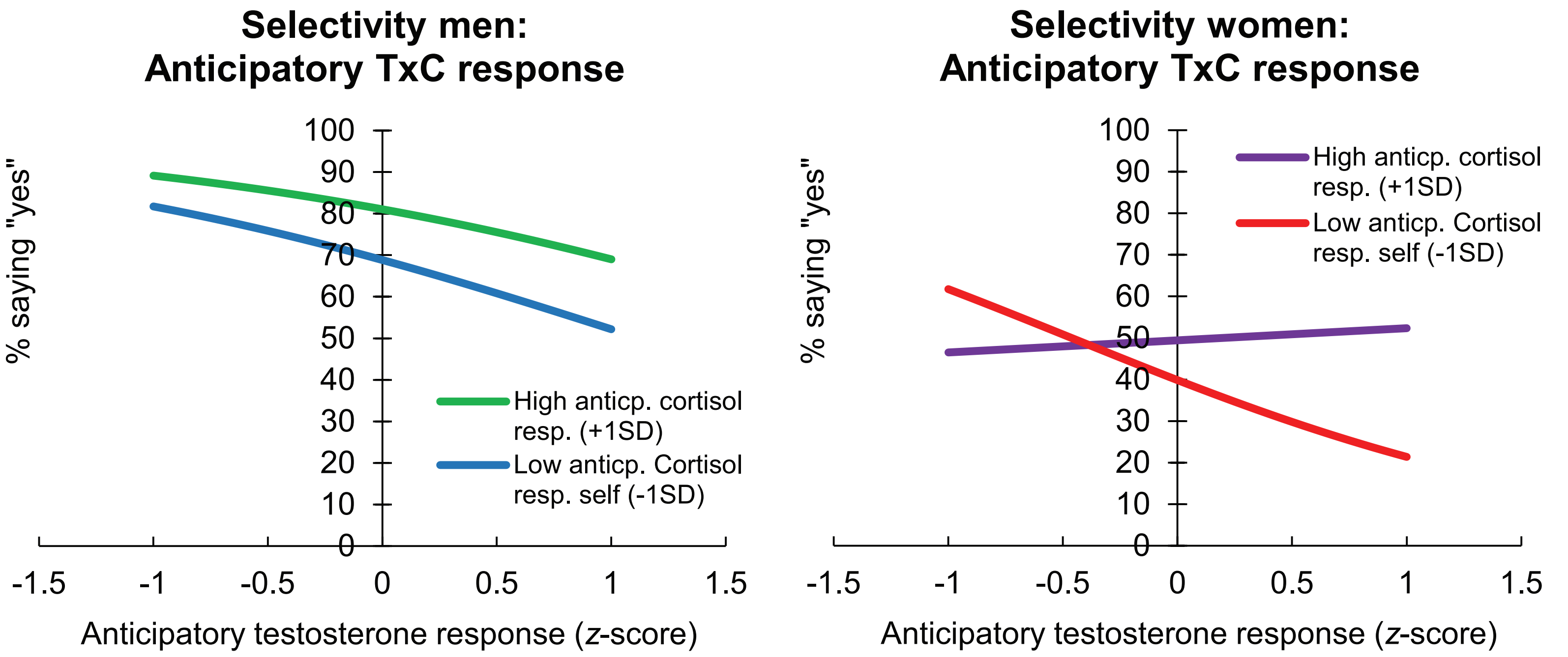


Men:
Testosterone change
100
90
80
70
60
50
40
30
20
10
0
Testosterone (pg/ml)
Romantic speed-dating
Control condition
Pre
Post
Women:
Testosterone change
10
9
8
7
6
5
4
3
2
1
0
Testosterone (pg/ml)
Romantic speed-dating
Control condition
Pre
Post

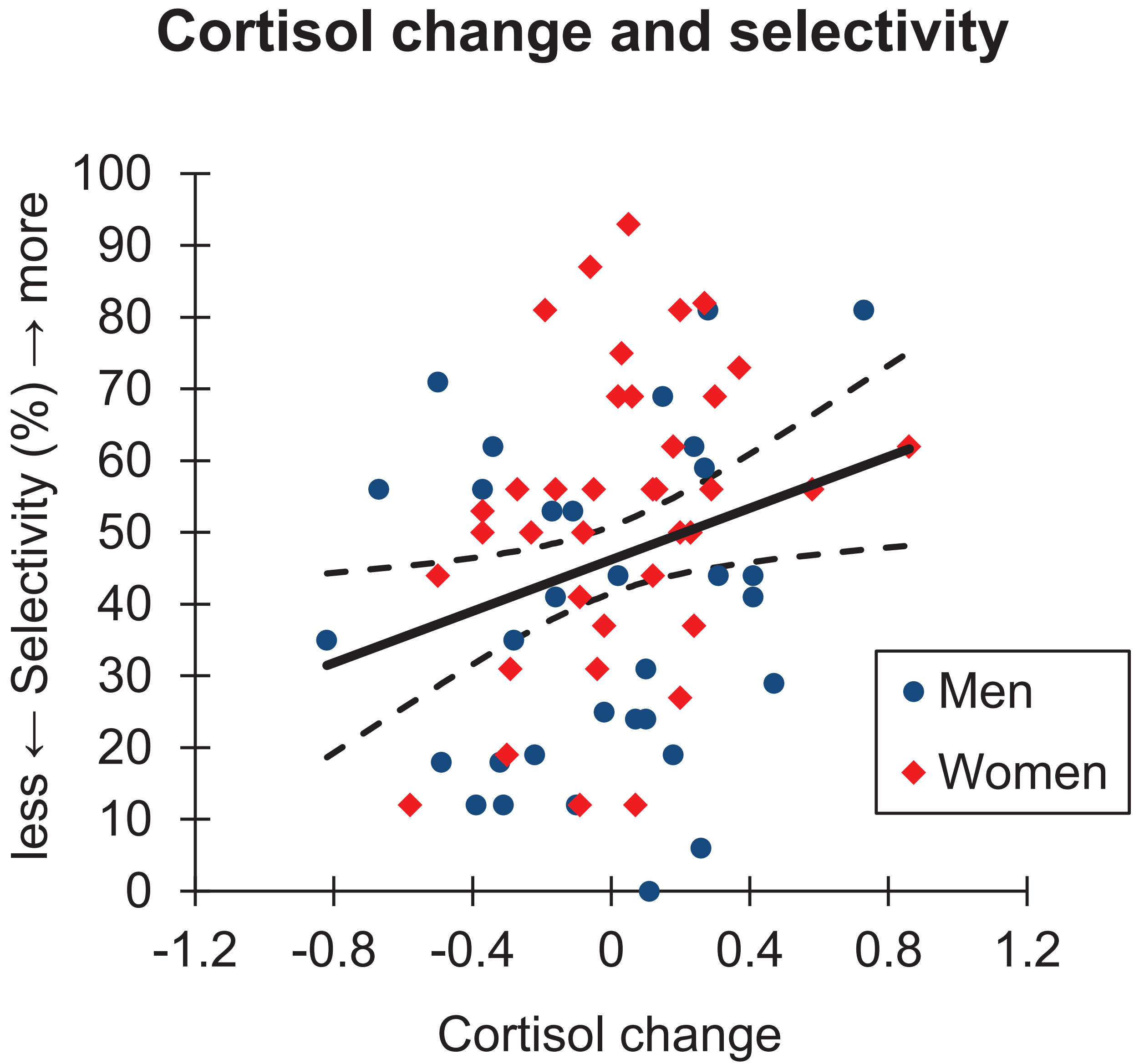


Men:
Cortisol change
Cortisol (pg/ml)
0
1
2
3
4
5
6
7
Pre
Post
Romantic speed-dating
Control condition
Women:
Cortisol change
Cortisol (pg/ml)
0
1
2
3
4
5
6
7
Pre
Post
Romantic speed-dating
Control condition


Anticipatory cortisol response
and popularity
100
90
80
70
60
50
40
30
20
10
0
% saying "yes"
Men saying "yes"
Women saying "yes"
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
Anticipatory cortisol response
interaction partner



Selectivity men:
Anticipatory TxC response
% saying "yes"
100
90
80
70
60
50
40
30
20
10
0
-1.5
-1
-0.5
0
0.5
1
1.5
High anticp. cortisol resp. (+1SD)
Low anticp. Cortisol resp. self (-1SD)
Anticipatory testosterone response (z-score)
Selectivity women:
Anticipatory TxC response
% saying "yes"
100
90
80
70
60
50
40
30
20
10
0
-1.5
-1
-0.5
0
0.5
1
1.5
High anticp. cortisol resp. (+1SD)
Low anticp. Cortisol resp. self (-1SD)
Anticipatory testosterone response (z-score)


Cortisol change and selectivity
less ← Selectivity (%) → more
100
90
80
70
60
50
40
30
20
10
0
-1.2
-0.8
-0.4
0
0.4
0.8
1.2
Cortisol change
Men
Women