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The consequences of having a dominant romantic partner on testosterone responses during a social interaction

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ABSTRACT

Testosterone reactivity has been conceptualized as a marker of social submission at low levels and social dominance at high levels. However, hormonal fluctuations in response to romantic partners remain largely unknown. Towards this end, 88 couples ($N = 176$) discussed an emotional video. Prior to the conversation, one member of the dyad (the "agent") was instructed to regulate affective displays in a specific way (express or suppress). The other dyad member (the "partner") was given no special instruction and was unaware of regulation instructions given to the agent. Agents who regulated affective displays were expected to exhibit decreased testosterone from baseline because they were prevented from tuning their emotional responses to their partners. Furthermore, we expected declines in testosterone would be moderated by *partners'* authoritativeness: People would be particularly submissive to more dominant partners. Predictions were supported for females and partially supported for males. Agents exhibited decreases in testosterone from baseline relative to partners. For females, this main effect was moderated by partners' trait-level authoritativeness: Females interacting with partners higher in authority exhibited larger decreases in testosterone when instructed to restrict their emotion regulation strategies. This research is the first to document testosterone reactivity in existing romantic relationships and underscores the importance of taking into account social and relational contexts when examining hormonal regulation.

1. Introduction

Testosterone has been conceptualized as a biomarker of dominance in the social interaction literature, based on evidence suggesting that increases in testosterone index social dominance (Carré et al., 2013; López et al., 2009; Mehta and Josephs, 2006; Roney et al., 2007) and that decreases index social submission (Maner et al., 2008). Although testosterone appears to be integral to interpersonal submission, limited research has explored testosterone *reactivity* within established romantic relationships (Roney and Gettler, 2015; Wardecker et al., 2015). The lack of relationship-focused research incorporating testosterone reactivity is noticeable given dominance is a well-established predictor of psychological and physical violence in relationships (Coleman and Straus, 1986; Karakurt and Cumbie, 2012). The current research examines testosterone reactivity as a measure of social submission in the context of an interaction between romantic partners. We adopt a dyadic approach to elucidate how individuals' relationship dominance influences their own hormonal regulation, and importantly, how they impact their partners' hormonal regulation.

1.1. Testosterone in interactions and relationships

Testosterone is an anabolic steroid hormone that plays an important role in social interactions: Fluctuations regulate responses to gaining, maintaining, or losing social status. For instance, males and females with higher basal levels of testosterone tend to behave more dominantly toward others (Dabbs et al., 1995; Dabbs and Hargrove, 1997; Slatcher et al., 2011). Testosterone levels are not static, however, but instead can vary across social contexts, making it a useful tool for understanding dominance and status processes in vivo. To illustrate, testosterone tends to fall for socially anxious, submissive individuals in competitive settings (Maner et al., 2008).

Recent research has mapped basal testosterone levels with intra-individual outcomes in romantic relationships (see Roney and

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Gettler, 2015; Wardecker et al., 2015 for reviews). Testosterone may assist with mobilizing resources needed for mating efforts, but comes at a cost, lowering immune functioning and investments in partnering-parenting (see Roney and Gettler, 2015 for a review). Once relationships are established, less effort is needed to pursue mating goals and testosterone tends to decline (Burnham et al., 2003; Edelstein et al., 2014). However, this past research has focused on correlating basal levels of testosterone with relationship status. No studies have used a dyadic approach to test how testosterone changes in response to the dominance of a romantic *partner*. In the current research we examine testosterone reactivity as a marker of social submission in interactions with romantic partners who differ in trait-level authoritativeness.

1.2. Authoritativeness in interactions and relationships

Research on trait-level dominance in couples has focused on its implications for aggression and domestic violence (e.g., Karakurt and Cumbie, 2012). One subtype of dominance, *authoritativeness,* relates closely to power and status (Hamby, 1996). People high in authoritativeness are characterized as being "in charge," tend to tell their partners how to behave, and largely hold decision-making powers (Hamby, 1996). The greater motives for power exhibited by people high in authoritativeness can have a significant impact on their romantic partners. For example, people who hold greater power seek to exert more influence over interpersonal interactions to produce outcomes in their favor (Simpson et al., 2015). Individuals who have control over decision-making are less likely to acquiesce to their partners' point-of-view (Gordon and Chen, 2013), or make personal sacrifices for their partners (Righetti et al., 2015). In contrast, people who hold less power tune their self-reported emotional responses (Anderson et al., 2003) and are motivated to "get along" with their partners (Copeland, 1994; Ng and Bradac, 1993; Snyder and Kiviniemi, 2001).

Taken together, these findings suggest that individuals with partners higher in power monitor and adjust their own emotions and behaviors to acquiesce to their dominant partners so as to facilitate a more congenial interaction. If testosterone is a marker of submission, individuals should exhibit decreased testosterone levels in response to interactions with their authoritative partners. Moreover, given that people manage interactions with more dominant partners via matching emotional and behavioral displays of affiliation, restricting this tuning should prompt even greater decreases in testosterone as a signal of efforts to regulate submissiveness in the absence of submissive behavior. That is, declines in testosterone should be exacerbated when these individuals are prevented from tuning their emotional responses to those of their partners.

1.3. Current research

The current work examined the dyadic nature of dominance and testosterone regulation in romantic couples during an emotionally laden conversation. We first explored associations between basal testosterone and relationship-specific dominance. Then, we aimed to demonstrate that the regulation of testosterone in romantic relationships can be dyadic: Individuals interacting with authoritative partners were hypothesized to exhibit decreased testosterone reactivity (cf., Maner et al., 2008). Moreover, we expected this pattern to be moderated by partners' trait-level authoritativeness.

To test predictions, we implemented a standardized experimental paradigm from the emotion regulation literature wherein one person (the *agent*) is privately instructed to regulate emotion in a conversation (i.e., express/suppress affective displays), while his/her *partner* remains unconstrained (see Peters and Jamieson, 2016; Peters et al., 2014, for examples). By instructing agents to regulate their emotions in a specific way they were put in a relatively more submissive position in the interaction because individuals holding less power were prevented from tuning their responses to their partners (Anderson et al., 2003). Moreover, agents with partners higher in authority were put in an even more submissive position as both their role in the conversation and their authoritative partners contributed to their submissive position within the social context.

We also examined effects of sex because when faced with authoritative people, it has been posited that females more frequently engage in "tend-and-befriend" behaviors (Taylor et al., 2000), whereas males are more likely to respond aggressively (Ehrensaft and Vivian, 1999; Karakurt and Cumbie, 2012). Thus, females with authoritative partners put in a more submissive position by being instructed to conform to the emotion regulation instructions, rather than freely regulate their emotions in accordance with partners, were expected to exhibit marked decreases in testosterone.

2. Materials and methods

2.1. Participants

One hundred and eighty (180) participants in 90 dyads were recruited via an online study pool and posted flyers. Two dyads were removed after data collection because they reported they had not been in a romantic relationship. Thus, the final sample comprised 176 participants (93 Females; 86 White, 57 Asian, 13 Hispanic, 8 Black, 12 mixed/other; M_{age} = 20.63, *SD* = 2.56, range 18–38) in 88 dyads (83 heterosexual dyads, 5 lesbian dyads; Relationship length: *M* = 14.71 months, *SD* = 13.5, range 3–76). Participants each received $10 or 2-h of extra course credit for participating.

Sample size was determined by an *a priori* power analysis that was targeted to test effects from a broader study of relationship processes. Using an averaged effect size from dyadic emotion regulation studies that included physiological measures (*d* = 0.53; Butler et al., 2003, 2006; Mendes et al., 2003) and a target power level of 0.80, 90 couples were recruited (total *N* = 180 participants in 90 dyads). The sample was originally recruited for a previously published study (Peters and Jamieson, 2016).[1]

2.2. Procedure

Participants were prescreened for pregnancy/breastfeeding and medications with hemodynamic side effects and were instructed not to exercise for 2-h before the study session or consume foods with live cultures (e.g., yogurt) that day. Participants were then escorted to individual testing rooms where they provided consent, completed initial questionnaires, and provided a baseline saliva sample (T0). Then, participants watched a BBC documentary about World War II, "*Hiroshima: BBC History of World War II*" (minutes 46:54–57:54). After viewing the film, participants were told they would discuss their emotional reactions to the video with their romantic partner (Butler et al., 2003, 2006; Peters and Jamieson, 2016; Peters et al., 2014).

One member of the couple (the *agent*) was randomly assigned to receive emotion regulation instructions. *Agents* were not permit-

[1] This dataset was previously used to test for the effects of response-focused emotion regulation strategies (expression vs. suppression of affective displays) on physiological threat responses (as assessed via TPR and cortisol reactivity) in romantic relationships (Peters and Jamieson, 2016). The aims, hypotheses, and measures regarding how having a dominant partner leads to decreases in testosterone reactivity is novel and was not explored in that previous research.

Table 1
Descriptive statistics and correlations among primary study variables.

	1	2	3	4	5	6	7	8	9	10	11	*M*	*SD*
1. Females' basal T (T0)												25.79	19.20
2. Females' T task reactivity (T1)	**−0.41****											−2.10	11.31
3. Females' T recovery reactivity (T2)	**−0.69****	**0.73****										−4.17	11.09
4. Females' Authority	0.15	−0.18	−0.15									1.75	0.43
5. Females' Restrictiveness	−0.13	−0.03	0.05	**0.46****								2.38	0.40
6. Females' Disparagement	0.13	0.09	0.05	**0.54****	0.18							1.49	0.40
7. Males' basal T (T0)	0.10	−0.00	−0.06	0.03	−0.09	0.06						84.99	32.38
8. Males' T task reactivity (T1)	−0.10	−0.11	0.06	−0.06	0.18	−0.14	**−0.29****					−1.88	16.61
9. Males' T recovery reactivity (T2)	−0.01	0.07	0.07	−0.14	0.12	−0.07	**−0.22***	**0.50****				−8.33	19.12
10. Males' Authority	**0.27***	**−0.25***	**−0.29****	**0.25***	0.09	**0.22***	0.04	−0.13	0.09			1.96	0.39
11. Males' Restrictiveness	0.04	−0.09	−0.13	0.09	0.19	−0.03	−0.18	−0.01	0.04	**0.25***		1.97	0.40
12. Males' Disparagement	−0.14	0.11	0.061	0.17	0.14	0.14	0.09	−0.06	0.02	**0.55****	0.12	1.68	0.42

Note: T = testosterone.
Boldvalues indicate a significant or marginally significant effect.
* $p < 0.05$.
** $p < 0.01$.

ted to tune their emotion regulation strategies to their partners, and instead were instructed to conform their behaviors to the regulation instructions (express or suppress affect).[2] More specifically, agents instructed to suppress outward displays of affect were given the following instructions:

> *During the conversation, behave in such a way that your partner does not know you are feeling any emotions at all. That is, try not to express your emotions outwardly. Keep stoic even when speaking about your feelings regarding the video. . .talk about your emotions and thoughts related to the content of the video clip, but keep your face and body emotionless. For example, you can talk about your initial feelings upon seeing some of the images or how you feel emotionally about the topic in general, but make every effort you can not to use facial expressions, inflections in your voice, or body gestures to convey those emotions or feelings. For example, try not to even smile back at your partner at any point during the conversation and try to remain still and stoic. The primary task is for you to discuss your most basic thoughts and emotions, but to do so without showing any emotions outwardly.*

Agents in the expression condition were given the following instructions:

> *During the conversation, behave in such a way that the emotions you are feeling are clear to your partner. That is, try to express your emotions outwardly. Use expressive gestures and facial expression to convey your feelings regarding the video. . . talk about your emotions and thoughts related to the content of the video clip, and emphasize these feelings with gestures/expressions. For example, you can talk about your initial feelings upon seeing some of the images or how you feel emotionally about the topic in general. Make every effort you can to use inflections in your voice or body gestures to convey those emotions or feelings. For example, try to use nonverbal signals and facial expressions to convey your specific emotional state to your partner during the conversation and use facial cues likes nods or smiles to let your partner know you understand what they're saying. The primary task is for you to reflect on your most basic thoughts and emotions and to convey these feelings to your partner.*

Thus, whether agents were told to express or suppress emotional displays of affect, the instructions constrained the emotion regulation strategies available to them, putting them in a relatively more submissive position because they were unable to tune their emotional responses to their partners. In contrast, *responders* remained unaware of the manipulation delivered to agents and were simply told to discuss their emotional reactions to the film, free to regulate their emotions as they would naturally.

Following the preparatory period, participants were brought together for the 5-min conversation. After the conversation, participants returned to their private testing rooms where each member provided a saliva sample (T1), timed to be ∼20-min after conversation instructions. A second reactivity sample (T2) was taken 20-min after T1. Participants completed tasks and questionnaires not related to the current study between T1 and T2 (see Peters and Jamieson, 2016; supplemental online material, SOM).

2.3. Testosterone reactivity

Participants provided three, 1 ml saliva samples—at baseline (T0), post-conversation (T1), and a recovery sample (T2)—which were used to assess reactivity. Participants provided samples following "passive drool" procedures whereby they expectorated saliva through a small straw into an IBL SaliCap collection device (Hamburg, Germany). Test tubes were marked with a line indicating 1 ml. Participants were allowed a maximum of 7-min to provide samples.

Immediately after collection, samples were transferred to a −30 °C biomedical freezer where they were stored until study completion. Samples were then packed on dry ice and shipped to Brandeis University (Waltham, MA) where they were analyzed for salivary free testosterone (Testosterone Saliva ELISA, Tecan). Samples were assayed in duplicate and outliers checked by re-assay. Inter- and intra-assay coefficients of variance were <7%. Due to an insufficient sample, 7 samples could not be assayed.

All sessions were conducted between 11:00 am and 7:00 pm. Reactivity was assessed by subtracting testosterone levels measured at baseline from each of the two reactivity periods: (1) Post-conversation (∼20-min after task instructions/stress onset) and (2) 20-min after T1. Note, testosterone levels in the saliva reflect circulating levels ∼15–20 min prior to saliva collection (i.e., when task instructions were given in this context; Dabbs, 1993).

2.4. Relationship dominance

Relationship dominance was measured using the 32-item version of a relationship Dominance Scale (DS; Hamby, 1996). The DS was divided into three subscales: Authority (*12 items*; α = 0.817, e.g., "*I often tell my partner how to do something*"), Restrictiveness (*9* items, α = 0.693, e.g., "*I insist on knowing where my partner is at all*

[2] Post-task attributions from both the person instructed to regulate their emotions and their partners confirmed that agents followed the emotion regulation instructions (see Peters and Jamieson, 2016).

Table 2
Effects of Role (Agents vs. Responders), and Actor's and Partner's Authoritativeness on testosterone reactivity post-task (T1) and during recovery (T2).

	Post-task Reactivity (T1)			Recovery Reactivity (T2)		
	B	SE	t	B	SE	t
Female Effects						
Intercept	0.003	1.18	0.02	**2.73***	**1.24**	**2.20**
Role	**2.21†**	**1.17**	**1.89**	1.26	1.22	1.03
Condition	1.12	1.11	1.01	0.85	1.17	0.72
Partner Authority	**−6.97***	**2.94**	**−2.37**	**−7.64***	**3.08**	**−2.48**
Partner Authority × Role	**8.85****	**2.92**	**3.03**	**5.10†**	**3.06**	**1.67**
Actor Authority	−1.99	2.65	−0.75	−1.57	2.77	−0.57
Actor Authority × Role	2.67	2.60	1.02	2.21	2.74	0.81
Male Effects						
Intercept	0.20	1.95	0.10	−3.30	2.33	−1.42
Role	**4.81***	**1.93**	**2.49**	−0.88	2.30	−0.38
Condition	2.27	1.86	1.22	−0.57	2.22	−0.26
Partner Authority	−3.45	4.35	−0.79	−6.61	5.18	−1.28
Partner Authority × Role	−0.06	4.27	−0.02	4.18	5.09	0.82
Actor Authority	−1.59	4.93	−0.32	4.79	5.86	0.82
Actor Authority × Role	0.69	4.83	0.15	−5.78	5.74	−1.01

Note: Role was contrast coded −1 agent of regulation, 1 responder of regulation. Condition was contrast coded −1 suppression, 1 expression.
Boldvalues indicate a significant or marginally significant effect.
† $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.

times"), and Disparagement (*11* items, α = 0.825, e.g., "*My partner doesn*'*t have enough sense to make important decisions*") on 4-point Likert scales (1 = *Strongly Disagree*, 4 = *Strongly Agree*). Please refer to the SOM for the full scale. Our *a priori* predictions centered on authority, but the DS subscales of restrictiveness and disparagement were included to rule out possible alternative explanations for hypothesized effects (see Sections 3.2. and 3.3.).

3. Results

3.1. Preliminary analyses

First, we tested for outliers. Only two reactivity scores were flagged as outliers (>3 *SD*), but these were included in all analyses because they were biologically plausible values. Removing these outliers had no impact on the results or interpretation of findings. Next, we tested for effects of possible covariates, including oral contraceptive use, relationship length, age, and time since waking on key variables (testosterone reactivity and authority). None of these were significantly correlated with the primary study variables and thus were not included in the models. As expected, raw mean levels of testosterone at the baseline, post-task, and recovery phases were higher in males than for females (*F*s > 235, *p*s < 0.001) which affected our analytic approach and models (see Section 3.2.). Finally, exploratory bivariate correlations (see Table 1) indicated that females with partners higher in authority exhibited *higher* basal testosterone levels, $r = 0.27$, $p < 0.05$, but there was not a positive association between self-reported authority and basal testosterone, $r = 0.15$, *n.s.*

3.2. Dyadic analyses

The core prediction was a *Partner* Authority × Conversation Role interaction such that females randomly assigned to the agent role (which limited "partner tuning" and was a more submissive position) would exhibit lower testosterone reactivity when their partners (i.e., responders) were high in authority. We tested for effects using the MIXED procedure in SPSS 22 following guidelines by Kenny and colleagues (2006). Individuals' testosterone reactivity scores were regressed on: (1) role (−1 agents of regulation, 1 = responders to the regulation); (2) sex (−1 = females, 1 = males); (3) *individuals*' grand-mean centered scores of authority, and associated interactions with role and sex (to assess actor effects); (4) *partners*' grand-mean centered scores of authority, and associated interactions with role and sex, which tested our prediction; and (5) emotion regulation condition to control for the agents' particular instructions (−1 = suppression, 1 = expression).[3] Dyads were distinguished by sex, with members of homosexual couples randomly assigned on the distinguishing variable for analyses.

Given large sex differences in testosterone, researchers have used various statistical approaches in analyses of testosterone. Some have standardized testosterone levels within sex (e.g., Jones et al., 2005), whereas others have analyzed raw values (e.g., Booth et al., 2005). In the context of the current research, within-sex standardization is not advised when modeling dyadic data (Edelstein et al., 2014; Kenny et al., 2006). Thus, testosterone reactivity was grand-mean centered across analyses. However, we confirm that the reported effects remained significant when analyzing within-sex standardized scores of testosterone reactivity.

3.2.1. Testosterone reactivity post-task (T1)

We first tested whether the effects of authority differed across males and females by running dyadic models that pooled effects across sex, and modeled the main effects and interaction of sex while accounting for dependence across couple members' data (Model 1). However, given the differences in testosterone reactivity between men and women (in addition to the *a priori* theoretically-based sex difference prediction) and the lack of power in testing three-way interactions, we conducted models that simultaneously estimated parameters separately for males and females while continuing to account for dyadic dependence (two-intercept model, Model 2; see Kenny et al., 2006).

Model 1 revealed a main effect of Role, such that agents exhibited decreases in testosterone relative to responders, $b = 3.51$, $SE = 1.17$, $t = 3.00$, $p = 0.004$, $r = 0.32$. A marginally significant *partner* effect also emerged. Participants with partners high in

[3] The reported pattern of effects was similar whether or not emotion regulation condition and associated interaction terms were included in the models. None of these predictors were significantly related to testosterone reactivity, but we included the main effect of condition and its interaction with gender to ensure that effects were not due to differences in emotion regulation instructions.

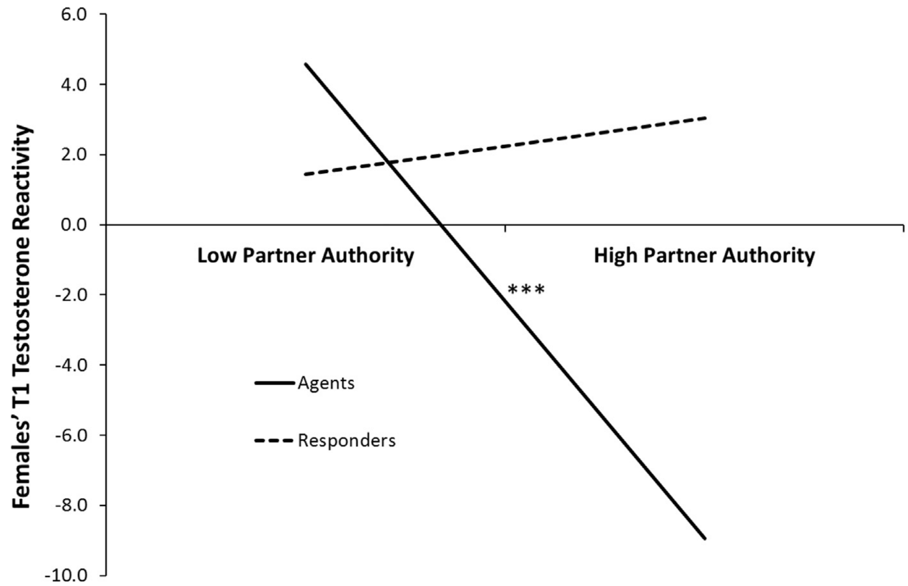

Fig. 1. Testosterone post-task reactivity (T1) by Role and Partner Authority for females. *** denotes $p < 0.001$.

authority exhibited decreased testosterone, $b = -5.21$, $SE = 2.65$, $t = -1.96$, $p = 0.052$, $r = 0.17$. However, these main effects were qualified by a marginal *partner* Authority × Role interaction, $b = 4.39$, $SE = 2.56$, $t = 1.72$, $p = 0.088$, $r = 0.15$, which was further qualified by a marginal *partner* Authority × Role × Sex interaction, $b = -4.46$, $SE = 2.61$, $t = -1.71$, $p = 0.090$, $r = 0.15$.

To more precisely examine males' and females' testosterone reactivity, we then conducted the two-intercept model (Model 2). Effects are shown in Table 2. Similar to Model 1, Model 2 revealed a main effect of role: Agents exhibited decreases in testosterone reactivity compared to their uninstructed partners (i.e., responders) that was marginally significant for females ($b = 2.21$, $SE = 1.17$, $t = 1.89$, $p = 0.062$, $r = 0.20$) and significant for males ($b = 4.81$, $SE = 1.93$, $t = 2.49$, $p = 0.015$, $r = 0.27$). Consistent with predictions, a main effect of *Partner* Authority emerged for females, $b = -6.97$, $SE = 2.94$, $t = -2.37$, $p = 0.020$, $r = 0.26$, but not for males. Females with partners higher (vs. lower) in authority exhibited decreases in testosterone reactivity.

Main effects for females were qualified by a *Partner* Authority × Role interaction, $b = 8.85$, $SE = 2.92$, $t = 3.03$, $p = 0.003$, $r = 0.32$ (see Fig. 1). Simple effects revealed that female agents with partners higher in authority exhibited a stronger decrease in testosterone levels from baseline compared to female agents with partners lower in authority, $b = -15.82$, $SE = 4.27$, $t = -3.71$, $p < 0.001$, $r = 0.38$ (effect within agent role), and to female *responders* with partners higher in authority, $b = 12.00$, $SE = 2.92$, $t = 4.11$, $p < 0.001$, $r = 0.42$ (effect across role).

3.2.2. Testosterone reactivity during recovery (T2)

We next examined whether the decrease in females' testosterone levels persisted 20-min after T1. Model 2 analyses revealed a main effect of *partner* authority that was significant for females, $b = -7.64$, $SE = 3.07$, $t = -2.48$, $p = 0.015$, $r = 0.27$, but not males, $b = -6.61$, $SE = 5.18$, $t = -1.28$, $p = 0.206$, $r = 0.14$ (see Fig. 2). Females with partners higher (vs. lower) in authority continued to exhibit decreased testosterone. Analyses also revealed a marginally significant *Partner* Authority × Role interaction, $b = 5.10$, $SE = 3.06$, $t = 1.67$, $p = 0.100$, $r = 0.18$, for females. Simple effects tests revealed that female agents with partners high in authority exhibited lower testosterone reactivity than female responders with partners higher in authority, $b = 6.88$, $SE = 3.04$, $t = 2.26$, $p = 0.027$, $r = 0.24$ (effect across role), and female agents with partners lower in authority, $b = -12.74$, $SE = 4.47$, $t = -2.85$, $p = 0.006$, $r = 0.30$ (effect within agent role). The pattern of testosterone reactivity observed at T2 conceptually replicates that observed at T1, and also demonstrates the potential lasting impact of a partners' authoritativeness on hormonal regulation.

3.3. Exploratory analyses

We hypothesized *a priori* that the most relevant dominance subscale in this context would be the authority subscale because it maps onto power/status concerns relevant to the situation studied here (i.e., non-physical dominance). To be as thorough as possible, however, we recomputed analyses including the actor and partner effects of restrictiveness and disparagement as additional predictors. As expected, the hypothesized interaction between partner's authority and role remained significant for females at T1 (but not T2), Model 2; $b = 7.24$, $SE = 2.94$, $t = 2.47$, $p = 0.016$, $r = 0.27$, and non-significant for males (Model 2; $b = -0.45$, $SE = 4.28$, $t = -0.105$, $p = 0.917$, $r = 0.01$). This supports an interpretation that effects represent females' reactions to high-authority partners and not due to their partners being overtly aggressive or antagonistic.

Sessions were scheduled between 11:00 am and 7:00 pm to help control for the diurnal rhythm of testosterone (Mazur et al., 1997), but this range was wider than what some others have used (e.g., Geniole et al., 2011). However, when time since waking was included in the models, the hypothesized interaction between partners' authority and role for females at T1 remained significant, $b = 8.43$, $SE = 2.91$, $t = 2.90$, $p = 0.005$, $r = 0.31$, and non-significant for males, $b = -0.02$, $SE = 4.41$, $t \leq -0.00$, $p = 0.996$, $r < 0.01$.

Lesbian couples were included because our predictions were general to females, not just those in opposite-sex relationships. However, one might argue gender roles could operate differently in same-sex compared to opposite-sex couples. Thus, we re-ran analyses with lesbian couples removed. This had no impact on the results or interpretation of the core findings.

There is a debate about which of simple change scores (post-pre) or residual as a dependent variable (residual change) approaches are more appropriate when analyzing changes in testosterone over time (Allison, 1990; Cronbach and Furby, 1970; Woody and Costanzo, 1990). The concern with the simple change score approach used here is that it confounds change with baseline scores, inviting potential for regression to the mean effects. An

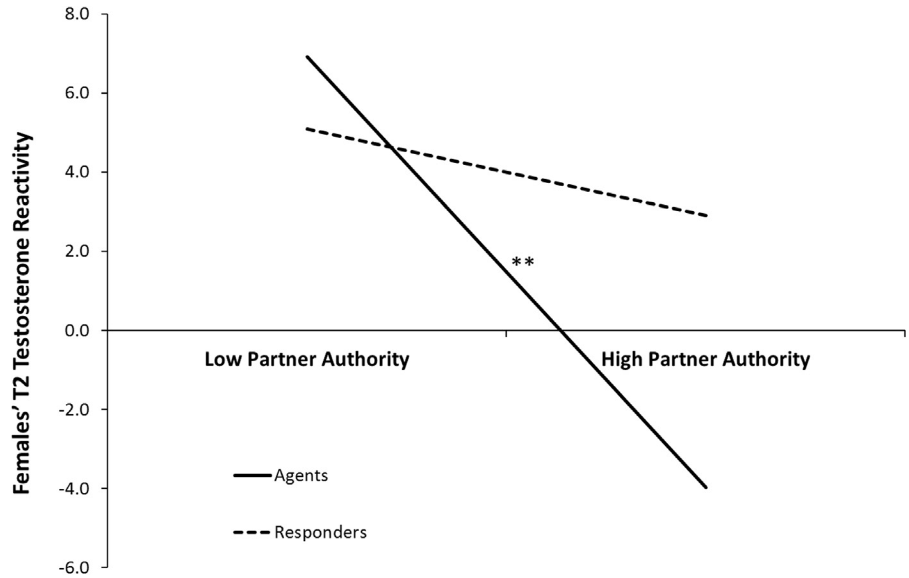

Fig. 2. Testosterone recovery reactivity (T2) by Role and Partner Authority for females. ** denotes $p < 0.01$.

alternative approach that helps to resolve problems with regression to the mean is the residual change approach. Thus, we reran all analyses using two residuals as the dependent variables, which were calculated by regressing T1 and T2 on T0. All significant interactions and simple effects that were observed using the simple change approach remained significant using the residual change approach.

4. Discussion

Research on testosterone and dominance in romantic relationships has focused on correlating basal testosterone levels with relationship outcomes, and previous work suggests the utility of using testosterone reactivity as a biological marker of social submission (e.g., Maner et al., 2008). The research reported here extended work in this area by investigating how dominance influences testosterone regulation in romantic partners who engaged in an emotional discussion in which one person was instructed to regulate his/her affective displays. Because agents (i.e., those instructed to regulate affect) were constrained by the manipulation instructions, they were prevented from tuning their affective displays to those of their partner and were put in relatively more submissive position. Accordingly, agents exhibited decreased testosterone reactivity, which has been shown in previous research to be associated with social submission. Importantly, for females, the main effect of role was moderated by their *partners*' authoritativeness: trait-level differences in the desire to control relationship events and have the "final say" in conversations. Females with partners high in authority exhibited marked decreases in testosterone when they were given instructions for how to regulate their emotions likely because they were unable to tune emotional responses to those of their authoritative partners.

The moderation of partner authoritativeness with role effects on testosterone reactivity demonstrates how social context influences hormonal regulation. When placed in a situation in which emotion regulation strategies are contextually constrained, testosterone decreases, and individuals with authoritative partners are particularly likely to exhibit decreased testosterone. Notably, the current study manipulated the emotion regulatory strategy, not the valence of the emotion itself. That is, agents could match the valence of their partners' emotional responses, but were forced to exclusively suppress or express displays of affect. This replicates prior research by demonstrating that people who hold less power tune their emotional responses to their partners (Anderson et al., 2003), but extends that research by suggesting that the enacted emotion regulatory strategies, rather than felt emotions, may lead to physiological consequences.

Furthermore, testosterone reactivity was further moderated by participant sex. Females with authoritative partners exhibited marked decreases in testosterone when assigned to the agent role. These declines in testosterone may reflect females' greater tendency to engage in "tend-and-befriend," nurturing-type behaviors when faced with the power and status concerns of an authoritative person compared to males (Taylor et al., 2000). Exhibiting decrements in testosterone may function to facilitate pro-social behaviors (Baron-Cohen, 2010; Hare et al., 1990; Harris et al., 1996) to buffer against the authoritativeness of their romantic partners and compensate for being unable to tune their emotion regulation strategies to their partners.

Previous research has also suggested a positive association between self-reported dominance and basal testosterone (e.g., Slatcher et al., 2011). However, we did not observe this association here. Interestingly, however, a *partner* effect emerged, such that females with partners higher in authoritativeness exhibited *higher* levels of basal testosterone. The non-significant association between basal testosterone and relationship authority may indicate that different processes occur with testosterone and dominance in committed (versus less committed) romantic relationships. For example, the dominance and basal testosterone association may be stronger early on in the relationship formation stage because individuals vie for attention and compete for mates. However, as relationships develop and grow, basal testosterone tends to be lower (Burnham et al., 2003; Edelstein et al., 2014), potentially weakening the association between basal testosterone and dominance. The current study suggests the value of considering the social and relational milieu in future studies to better understand the role of hormonal regulation in relationships.

4.1. Limitations, implications, and future directions

We examined responses to an emotionally negative film clip rather than a relationship-specific topic because doing so would have confounded dominance and magnitude/intensity of hormonal reactivity. That is, individuals with partners high in authority may have been unwilling to share negative feelings with their partners. By capitalizing on an existing, validated emotion regulation paradigm (e.g., Butler et al., 2003), the current study maximized experimental control. However, previous research suggests emotion regulation differs as a function of the relational context (Impett et al., 2012, 2014; Lemay et al., 2013). Thus, future studies may seek to replicate and extend the findings from the current research by focusing on other conversation domains.

This research was the first to examine testosterone reactivity and emotion regulation in the context of ongoing, romantic relationships. We conceptualized testosterone decreases as an index of submissiveness – agents were forced into a submissive role because their capacity to tune their emotions to their partners was restricted. We further posited (and found support) for the idea that testosterone decreases signaled efforts to regulate submissiveness in the absence of overtly submissive behaviors. An interesting avenue for future research might be to test the conditions under which decreases in testosterone *accompany* behavioral signs of submission. Moreover, restraining response-focused emotion regulation strategies is likely only one of many ways to manipulate the social context to elicit decreases in testosterone.

One potential alternative explanation for the findings observed here is that agents may have been put in a *more* (not less) dominant position in the interaction. For individuals with authoritative partners, being prevented from tuning emotional responses may have created a mismatch whereby agents were forced into a more dominant behavioral strategy than they would have normally pursued. Then, the anxiety or distress resulting from the mismatch between submissive intentions and forced situational dominance could have resulted in a decrease in testosterone (see Maner et al., 2008, for a similar argument). Exploratory analyses of post-conversation attributions revealed mixed support for this alternative. Although agents (both males and females) relative to responders reported higher task demands ($b = -0.16$, $SE = 0.08$, $t = -1.94$, $p = 0.056$), female agents reported the task was more difficult ($b = -0.58$, $SE = 0.29$, $t = -2.01$, $p = 0.048$), and individuals with partners high in authority reported less coping resources ($b = -0.46$, $SE = 0.22$, $t = -2.13$, $p = 0.035$), no *Partner* Authority × Role interactions emerged for any post-conversation attributions. The lack of *Partner* Authority × Role interactions suggests attributions of the conversation were not mirroring testosterone reactivity responses (see Figs. 1 and 2). Moreover, neither role nor partner authority had any effect on self-reports of how uncomfortable the conversation was. Finally, if the agent role was the more dominant position, one would expect a main effect of Role on testosterone reactivity such that agents (vs. responders) would exhibit greater increases in testosterone. However, the *opposite* pattern emerged (see Table 2): Agents exhibited decreased testosterone reactivity during the conversation relative to responders. Although we sought to offer a mechanistic account that best represented *a priori* hypotheses and the data observed, future work is needed to elucidate the mechanisms underlying testosterone decreases in dyadic interactions.

The current study focused on one subtype of relationship dominance (authority). An avenue for future inquiry would be to see how other types of dominance (i.e., restrictiveness and disparagement) influence hormonal regulation. For example, individuals high in trait-level restrictiveness are often concerned about where their partners are and what they are doing. Consider a scenario in which individuals are privy to some knowledge that their restrictive partners are not. This situation may be particularly stressful for individuals with restrictive partners because they may anticipate their partners' negative, controlling reactions, which, in turn, may lead to poor health and relationship outcomes downstream. Along similar lines, we measured testosterone after the conversation which was ∼20 min after manipulation instructions were delivered (i.e. stress onset). It is possible that post-conversation reactivity may also index biological responses that are in *anticipation* of the conversation (for similar effects see Jamieson et al., 2012; Peters and Jamieson, 2016; Peters et al., 2014; Yeager et al., 2016). That is, female agents anticipating having to interact with their authoritative partners while regulating their affective displays might have already started to experience reductions in testosterone before the conversation even began. Future work is needed to unpack these underlying cognitive mechanisms in preparation of these conversations.

Exploring testosterone fluctuations in future interpersonal research will also extend understanding of the links between lower basal testosterone and relationship commitment (see Roney and Gettler, 2015; Wardecker et al., 2015, for reviews). For instance, although we focused on decreases in testosterone to be indicative of submission (Maner et al., 2008), another complimentary way to interpret these results is that these decreases in testosterone reactivity may indicate relationship maintenance processes and nurturing behaviors (Edelstein et al., 2014; Roney and Gettler, 2015; Wardecker et al., 2015). Drops in testosterone in this context could suggest individuals are more committed and are submitting to their partner to buffer against and/or avoid potential conflict. Thus, the decline in testosterone observed here may predict *greater* relationship satisfaction in the long-term. In contrast, being too submissive may put a strain on the individual with a dominant partner and the relationship, and in the long term may lead to relationship dissolution.

5. Conclusion

By embracing a dyadic perspective, this research underscores the importance of accounting for the social and relational context when examining hormonal regulation in relationships. Although it is important to understand the extent to which dominance influences an individual's own hormonal regulation, the current study reveals that it is just as important to consider how an individual's hormonal regulation is influenced by characteristics of his/her partner.

Contributors

Peters and Jamieson were involved in conception and design of the study and acquisition of data. All authors contributed to data analysis, interpretation of the data, and drafting and revising the article. All authors have approved the final article.

Conflicts of interest

None.

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n/a.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.psyneuen.2016.09.024.

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