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Recommendations for the study of women in hormones and competition research

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“There is no mark on the wall to measure the precise height of women”.
[–Virginia Woolf, *A Room of One's Own*]

Predominant theories in the social endocrinology of competition and status, the *biosocial model of status* (Mazur, 1985; Mazur, *this issue*) and *challenge hypothesis* (Wingfield et al., 1990; Wingfield, *this issue*) have sought to explain the biological underpinnings of dominance-related behaviors by suggesting that these behaviors are driven by fluctuating levels of testosterone during periods of social competition. Although the challenge hypothesis was initially intended to describe increases in testosterone during reproductive or territorial challenges in male birds, it was later applied to human males to explain increases in testosterone in response to face-to-face competitions for social status (Archer, 2006). The biosocial model of status expands upon the notion that testosterone is linked to competitive behavior by proposing that testosterone increases in response to status gained through victory and decreases in response to status lost through defeat (Mazur and Booth, 1998). Although both theories primarily focus on male behavior, Allan Mazur, in his initial description of the biosocial model of status (1985) was open but cautious about the theory's relevance to females:

“This model relies more on research in males than on females. It is proposed as a theory about both sexes, but with a caution that little is known about sex differences in the relation of hormones to dominance behavior (p. 377)”

Despite efforts to apply these models to human females (e.g., Carré et al., 2013; Cashdan, 1995; Casto and Edwards, 2016a; Mazur et al., 1997), women, relative to men, remain an under-studied population in research on hormones and competition (van Anders and Watson, 2006). In this commentary, we make five recommendations for the study of women in hormones and competition research.

1. Include women in study designs

There is approximately two to three times the number of studies on the hormonal response to competition in men compared to women (Carré and Olmstead, 2015; Geniole et al., *this issue*).¹ Studies in this special issue (*Hormones and Human Competition*) also disproportionately represent men in both theoretical discussion and sample population. Similar if not greater disparities exist for the more general use of male compared to female animals in non-human literature (Beery and Zucker, 2011; Hughes, 2007; Prendergast et al., 2014).

Women are excluded from study designs in the hormones and competition literature for several reasons. One reason is that the ‘winner-loser effect’ (i.e., winners have higher testosterone increases to competition than losers) tends to yield stronger effect sizes in men compared to women (e.g., see Wu et al., *this issue*). Indeed, a recent meta-analysis of studies on the testosterone response to competition determined that although the winner-loser effect was not moderated by sex, the effect was only statistically significant in men (men Cohen's $d = 0.23$; women $d = 0.14$, Geniole et al., *this issue*). Given the pressure to publish, it would seem more advantageous to plan studies that are more likely to generate significant effects (i.e., studying testosterone-behavior relationships in men). However, this meta-analytic comparison was made with substantially fewer studies of women than men. Without more equal representation, uncertainty about the true difference in the effect size between men and women remains. Additionally, it is possible that lower effect sizes among the limited sample of women participants are a result of male-centric experimental designs among studies that do

¹ The underrepresentation of women in social endocrinology is unique to studies of *endogenous* testosterone levels. There is a related literature on the behavioral effects of testosterone administration where, for some time, women were sampled almost exclusively due to the lack of an established protocol in men (Bos et al., 2012; Mehta et al., 2015; van Honk et al., 2004; the first validated protocol for T administration was a study of sexual arousal in women, Tuiten et al., 2000). Additionally, women are often over-represented in other areas of psychological research as a matter of convenience (due to the larger number of women majoring in psychology and therefore, available in departmental subject pools).

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include women (this point is elaborated in Recommendation 2). In any case, the potential gender or sex² difference in the testosterone response to competition presents two options for future studies: include women and test for gender effects or, limit conclusions to half the population – the former being more scientifically rigorous than the latter.

Women may also be excluded from study designs to avoid what are thought to be ‘complicating’ factors of menstrual cycle phase and hormonal contraceptive use. It is true that testing menstrual cycle phase effects requires a larger sample size and a more technical and costly methodology for validly determining cycle phase (see Recommendation 3 for further discussion). However, given the relatively small effect sizes of menstrual cycle phase on human behavior (for meta-analysis, see Wood et al., 2014) and relatively small changes in testosterone across the cycle, menstrual cycle phase could be ignored in studies of the testosterone response to competition (van Anders et al., 2014). Although hormonal contraceptive use typically results in lower baseline testosterone among users compared to non-users (Coenen et al., 1996; Liening et al., 2010) and appears to impact social behavior (Montoya and Bos, 2017), information about contraceptive use is easily ascertained from participants and can be included as a factor in statistical designs. Additionally, despite differences between users and non-users in baseline testosterone, testosterone change associated with competition does not appear to be affected by contraceptive use (e.g., Edwards and O’Neal, 2009). Thus, cycle phase and contraceptive use do not inherently create major complications for a study design and do not form the basis of a strong argument for excluding women. Further, the perception that sources of hormonal variation in women are problematic for study designs is especially unfair given that researchers do not exclude male participants on account of the variety of factors that reliably impact testosterone levels in men – body fat, relationship status, and parental status (Burnham et al., 2003; Gray et al., 2002; Pasquali, 2006; van Anders and Goldey, 2010; Vermeulen et al., 1999).

A third reason some researchers may exclude women is because of concern about the validity of standard immunoassay techniques for salivary testosterone measurement, particularly for saliva samples provided by women (Granger et al., 2004, 2007; Welker et al., 2016). Indeed, a recent study comparing testosterone levels obtained from enzyme immunoassays (EIA) kits to liquid chromatography tandem mass spectrometry (LC-MS/MS), a more sensitive and accurate method of salivary hormone measurement, showed inflated levels of testosterone from EIAs compared to LC-MS/MS at lower concentrations, levels that are typically observed in women. However, this study also revealed that the correspondence between testosterone levels obtained from EIAs and LC-MS/MS were low to moderate in women and men (Welker et al., 2016). With the potential for validity issues when using EIAs to determine salivary testosterone regardless of participant gender, there seems little reason to selectively exclude women. Additionally, although access to LC-MS/MS is limited, researchers could use this technique to reliably assay saliva samples in studies including women and men.

Given the absence of firm exclusion criteria, women should be included in study designs on the testosterone response to competition.

² Although *sex* and *gender* are different constructs, *sex* having more to do with biology and *gender* having more to do with socially or culturally-based conceptions of sex, the terms are overlapping and often used interchangeably in psychological research (Glasser and Smith, 2008). There is an insightful, yet complicated literature and ongoing debate on how to define and measure sex versus gender and the degree with which this distinction is meaningful (for a comprehensive review, Muehlenhard and Peterson, 2011). In this manuscript, we attempt to follow the APA publication manual recommendation to use *gender* “when referring to men and women as social groups” and *sex* when referring to instances when “the biological distinction is predominant” (p. 71, APA, 2010). However, we acknowledge that these distinctions are particularly difficult to make when discussing relationships between hormones and social behavior (e.g., see van Anders et al., 2015). Further, we acknowledge that most studies of the social neuroendocrinology of competition do not directly measure sex or gender beyond asking participants to indicate if they are “male” or “female” or to enroll in the study only if they are male or female – a practice that conflates sex and gender.

To quote McCarthy et al. (2012) regarding the exclusion of female animals in neuroscience research,

“In our view, what most deters investigators from including females in their studies are misconceptions; misconceptions that it is difficult to do it right, and misconceptions of the value of comparing males and females, with many neuroscientists thinking they are not likely to learn anything useful, much less make novel discoveries (p. 2241).”

2. Employ more inclusive theoretical models of competitive and status-motivated behavior

That the challenge hypothesis and biosocial model for status have been tested primarily with men comes as no surprise given that the ‘male’ sex hormone testosterone is at the center of these theories – women have substantially less circulating testosterone than men. Although testosterone surges at critical periods of development are responsible for phenotypic masculinization in genetic males, there is ample evidence that both men and women show transient elevations in testosterone in response to a variety of social behaviors (for review Eisenegger et al., 2011; Casto and Edwards, 2016b; e.g., Hahn et al., 2016). Despite this, research on testosterone and social behavior remain in many ways tied to a masculine perspective (van Anders, 2013). In an attempt to address this bias, Sari van Anders et al. (2011) introduced a gender inclusive model of hormone-behavior relationships – the Steroid/Peptide Theory of Social Bonds (S/P Theory). The S/P theory encourages a perspective in which predictions are made about how social behaviors, motivated by nurturance and competition, relate to basal and changing hormone levels regardless of gender (for more detailed explanation, see van Anders, 2013; van Anders et al., 2011). Nearly five years after its publication, this inclusory reformulation has received little attention in the hormones and competition literature.

Like testosterone, competitive behavior is also subject to a masculine bias: competitive, instrumental, and agentic behaviors are considered more desirable and thus, are reinforced at greater rates in men compared to women (Prentice and Carranza, 2002; Rudman and Glick, 2001; Rudman and Phelan, 2008; Runge et al., 1981; Schmader and Block, 2015; Spence and Helmreich, 1980). Consequently, women are less likely than men to choose to enter a competition (Apicella et al., 2017; Niederle and Vesterlund, 2007) and less likely to perform well in competitive environments (Gneezy et al., 2003). Perhaps even framing tasks as “competitions” with an explicit win-loss focus creates a situation in which the desire to compete and perform well directly conflicts with the desire to behave in a way that is socially acceptable (women face backlash for agentic behavior, Amanatullah and Morris, 2010; Rudman and Glick, 2001). Indeed, the role of socialization on competitive behavior is clear: gender differences in competitiveness are reversed or attenuated within matrilineal societies where women are encouraged to compete throughout development (Andersen et al., 2013; Gneezy et al., 2009).

Despite the influence of gender socialization on the expression of competitive behavior, studies of the hormone-competition relationship rarely account for individual differences in how men and women conform to gender roles of masculinity and femininity, agency and communality (for one notable exception, see van Anders et al., 2015). Gender identity is a complex and multidimensional construct extending beyond self-categorization into a gender group (male, female, transgender male, transgender female, genderqueer, or intersex; Carver et al., 2003; Joel et al., 2013; Tate et al., 2014). Thus, simply inquiring about participant’s gender category misses important information about that individual relative to competitive behavior. Moreover, certain components of gender identity such as gender-role attributes (agency vs. communality, Spence and Helmreich, 1980) and gender typicality (Egan and Perry, 2001; Tate et al., 2015) explain differences in the expression of

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