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The Relationship between Subjective and Physiological Sexual Arousal in Women with and without Arousal Concerns

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ABSTRACT

Whereas laboratory studies frequently report low correlations between women's physiological and subjective sexual arousal (i.e., concordance), research employing advanced statistical techniques reveals striking between-person variability in this relationship. Moreover, previous research has shown that interoception (i.e., the awareness of changes within the body) influences concordance in women, though how this effect varies by sexual function is yet unknown. The present study used multilevel modeling to examine concordance in women with ($n = 27$) and without ($n = 28$) sexual arousal concerns and explored how concordance varies as a function of interoception. Women viewed a sexual film while their arousal responses were measured and then completed a self-report measure of interoception. A significant relationship emerged between physiological and subjective sexual arousal, in addition to tremendous between-person variability across both groups. Several aspects of interoception moderated concordance (p 's between 0.0008 and 0.03), and this pattern varied across groups. Given this variability even in absence of sexual arousal concerns, these findings question the utility of using concordance as a clinical outcome in treatment research. Individual differences in interoception may have implications for treatment matching.

Sexual arousal in women involves both psychological (i.e., subjective) and physiological components. Subjective sexual arousal has been conceptualized as the “emotional” (Chivers, Seto, Lalumière, Laan, & Grimbos, 2010; Parish et al., 2016) or “cognitive” (Janssen, Everaerd, Spiering, & Janssen, 2000; Spiering, Everaerd, & Janssen, 2003) state of sexual arousal, and was recently defined as positive mental engagement in response to a sexual stimulus (Althof et al., 2017). Physiological sexual arousal in women involves both genital (i.e., vasocongestion, vaginal lubrication), and nongenital responses (e.g., increased heart rate, sweating, pupil dilation, hardening and erection of the nipples, and flushing of the skin).

In a laboratory setting, genital arousal is most commonly measured using a vaginal photoplethysmograph (Palti & Bercovici, 1967; Sintchak & Geer, 1975), which is an acrylic, tampon-shaped device that contains either an incandescent light source or an infrared diode and a photosensitive light detector. The light source illuminates the capillary bed of the vaginal wall, and the phototransistor detects light that is reflected back into the device. The amount of back-scattered light relates to the transparency of engorged and unengorged vaginal tissue and therefore is thought to serve as an indirect index of vasocongestion, with more back-scattered light suggesting higher levels of physiological sexual arousal. When one of the signals that can be derived from the photoplethysmograph is coupled with an alternating current, a measure of vaginal pulse amplitude (VPA) is obtained, which is thought to reflect phasic changes in

vaginal engorgement with each heartbeat (Geer, Morokoff, & Greenwood, 1974). Vaginal photoplethysmography is both a sensitive and reliable index of women's physiological sexual arousal (Laan, Everaerd, & Evers, 1995).

Subjective sexual arousal (SSA) is most often assessed in a laboratory setting immediately after the presentation of an erotic film with several Likert-style, self-report questions, though it can also be measured continuously throughout the film (Rellini, McCall, Randall, & Meston, 2005). The Likert-style questions gauge a participant's level of "mental arousal" (or the degree to which she feels "turned on") during the erotic film.

A considerable amount of research on sexual arousal has examined the concordance, or agreement, between VPA and SSA. Concordance is frequently measured as a "change score," which condenses genital arousal data collected continuously throughout the assessment into a single data point. This data point is then correlated with a discrete measure of SSA. Results from a meta-analysis indicate that correlations between physiological and subjective arousal are generally low in women ($r = .26$; Chivers et al., 2010). Notably, this meta-analysis also indicates that sexual function is not a statistically significant moderator of concordance, suggesting that the agreement between VPA and SSA may not vary dramatically between women with and without sexual dysfunction (Chivers et al., 2010).

Much has been made of this low correlation, likely due to its contrast with results from laboratory studies of men for whom correlations are much higher ($r = .66$; Chivers et al., 2010). Several explanations have been offered for these findings, namely that women's attitudes toward sex and sexual stimuli (Laan, Everaerd, van Bellen, & Hanewald, 1994), pressure to inhibit sexuality in response to cultural messages (Huberman, Suschinsky, Lalumière, & Chivers, 2013), and inability to perceive genital responses may play a role in concordance (Heiman, 1977; Laan, Everaerd, van der Velde, & Geer, 1995).

It is possible that methodological issues play a role in the low correlation between physiological and subjective sexual arousal. Indeed, in one study that asked participants to report on their subjective arousal continuously *during* the erotic stimulus, as opposed to retrospectively *after* the erotic stimulus, there was no significant difference in the agreement between genital and subjective arousal in women compared to men (Suschinsky & Lalumière, 2011). Statistical choices may also impact the overall magnitude of observed concordance. Rellini and colleagues (2005) examined the relationship between physiological and subjective measures of arousal in sexually functional women using hierarchical linear modeling (HLM) - a statistical procedure designed to accommodate continuously collected data by treating such data as time series rather than compressing them into a single mean. Notably, it was found that a large portion of the overall variance in concordance was attributable to *between-person* variability. This suggests that, for some women, the awareness of changes within the body and, specifically, the genitals, may be an important aspect of SSA. For other women, bodily and/or genital changes may not be particularly relevant.

Since the original publication of Rellini et al. (2005), researchers have increasingly taken a multi-level modeling approach (e.g., Brotto, Chivers, Millman, & Albert, 2016; Suschinsky et al., 2019; Velten, Margraf, Chivers, & Brotto, 2018). For instance, using HLM, Meston and colleagues (2010) found that women with sexual arousal concerns displayed weaker concordance compared to sexually functional women and women with an orgasm disorder, suggesting that concordance may vary as a result of sexual function. However, the authors did not investigate the between-person variability in concordance rates among these groups of women. As such, it remains unknown whether women with arousal concerns display the same between-person variability in concordance as healthy controls or, if by virtue of their sexual concerns, they show more homogeneity in the agreement between their physiological and subjective sexual response. This lack of nuance in our understanding of concordance has practical implications, such as using concordance a meaningful indicator of change in clinical research trials for female sexual dysfunction (i.e., Brotto,

Chivers, Millman, & Albert, 2016). If it is the case that women with and without sexual concerns display similar degrees of variability in concordance, it logically follows that concordance itself is not indicative of greater sexual function and should not be used as an outcome in treatment research.

A possible exception may be in the case of women who, through interoception, pay attention to genital changes and integrate this experience into their SSA. Interoception has been defined in the literature as an awareness of internal states (Craig, 2002), and may therefore facilitate agreement between VPA and SSA. Women who are more aware of changes in their body may find it easier to notice genital changes and incorporate this into their subjective experience of arousal. For women who are less aware of bodily changes, their subjective arousal may be less dependent on genital changes, thus weakening concordance. This pattern may not be true for all women, but rather for women who specifically look to their body for cues when determining their arousal state. If this is the case, interventions designed to increase interoception may be beneficial for women who report awareness of genital changes as an important aspect of their sexual arousal response.

The purpose of the present study was twofold. First, we sought to replicate the findings presented in Rellini et al. (2005) that showed substantial between-person variability in concordance rates in sexually healthy women and to extend this to a group of women with sexual arousal concerns. Results will help elucidate the degree to which women incorporate genital cues into their subjective experience of sexual arousal, and whether there are differences in these patterns across women. Second, we examined whether awareness of bodily sensations (i.e., interoception) influences the relationship between genital and subjective arousal in women, and whether this differs based on the presence of sexual arousal concerns. Examining the role of interoception in concordance between these groups will allow us to determine which moderation effects are unique to women with sexual arousal concerns, which has implications for the viability of concordance as a treatment outcome metric. Furthermore, if interoception differentially influences concordance between these groups of women, interoception itself, rather than concordance, may be a relevant treatment target to examine in future research.

The findings from this study have important methodological and clinical implications. Methodologically, the replication of the findings presented in Rellini et al. (2005) would support increased implementation of statistical techniques designed for time series data in concordance research. From a research design perspective, these findings may illuminate the utility of concordance as a treatment outcome in clinical research trials. Finally, there are several clinical implications, as the examination of interoception as a moderator of concordance could further elucidate the types of clinical interventions that may be most effective for different populations of women with sexual arousal concerns.

Method

Participants

Participants were recruited through online and printed advertisements at local coffee shops, laundromats, hair salons, and malls. A total of 136 women contacted the laboratory and completed a phone screen for eligibility. Of these women, six were uninterested in participating after learning more about the study and 47 did not meet inclusion criteria; 83 eligible women were scheduled to come into the laboratory to participate in the study. Women were eligible to participate if they were at least 18 years old, premenopausal, fluent in English, sexually active within the past four weeks, heterosexual or bisexual (due to the content of the erotic stimuli) and reported no history of sexual abuse. Of the 47 women who did not meet inclusion criteria, 32 were excluded primarily for a history of sexual abuse, eight for sexual inactivity, six based on menopausal status, and

Table 1. Participant characteristics

Variables	No arousal concerns (<i>n</i> = 28) <i>M</i> (<i>SD</i>) <i>n</i> (%)	Arousal concerns (<i>n</i> = 27) <i>M</i> (<i>SD</i>) <i>n</i> (%)
Age (<i>range</i> : 18–48)	24.25 (6.16)	24.96 (8.39)
Race/Ethnicity		
African American	2 (7)	0 (0)
Asian	5 (18)	3 (11)
Caucasian	14 (50)	19 (70)
Hispanic	7 (25)	3 (11)
Other	0 (0)	2 (8)
Highest Level of Education		
High school diploma/GED	4 (14)	1 (4)
Some college	11 (39)	17 (63)
College degree	10 (36)	7 (26)
Advanced degree	3 (11)	2 (7)
Relationship Status		
Single, not dating	1 (3)	3 (11)
Single, dating	8 (29)	9 (33)
In a committed relationship	16 (57)	12 (45)
Married	3 (11)	3 (11)

Note: *M* = mean; *SD* = standard deviation; GED = General Equivalency Development

one based on sexual orientation. Of the 83 eligible women, 16 women missed or canceled their appointments, resulting in an initial sample of 67 women.

In Rellini et al. (2005) women were excluded from analysis if they did not show an increase in VPA over time. The authors argued that, because the primary question of interest was related to the impact of increases in VPA on SSA, lack of increases in vaginal pulse amplitude would not provide meaningful information related to subjective experiences of sexual arousal. As the primary aim of this study was intended to be replicative of Rellini et al. (2005), individual linear regressions were performed for each participant to determine whether VPA increases as a function of time. Twelve participants, including six participants with and six without arousal concerns, exhibited a significant *decrease* in VPA over time and were therefore excluded from analysis, per the methodology presented in Rellini et al. (2005). This left a final analytic sample of 55 participants.

The present sample consisted of women with (*n* = 27) and without (*n* = 28) sexual arousal concerns. This relative balance reflects purposeful recruitment for even groups and does not accurately represent the prevalence of sexual arousal concerns in the general population. No significant differences emerged between groups of women on any demographic variable. Please see Table 1 for descriptive statistics.

Measures

Experimental stimulus

The experimental stimulus consisted of a 10-minute film comprising a four-minute neutral segment and a six-minute erotic segment. The neutral segment began with a one-minute showing of the word “Relax,” and then progressed to a three-minute nature clip. The erotic segment featured a heterosexual couple engaging in sexual activity that included (in this order): two minutes of foreplay, two minutes of oral sex, and two minutes of vaginal intercourse. The stimulus was selected based on prior use in similar studies wherein it was shown to increase sexual arousal (e.g., Handy & Meston, 2018).

Vaginal pulse amplitude

A vaginal photoplethysmograph was used to assess women’s genital blood flow in response to the erotic film as an index of physiological sexual arousal. To ensure that the phototransistor was

inserted at the correct depth and orientation, a placement device was attached to the cord of the vaginal photoplethysmograph. Vaginal pulse amplitude was sampled at a rate of 200 samples/second throughout the entire film presentation. Each wave in the VPA signal was recorded in millivolts, band-pass filtered (0.5–30 Hz), and recorded on a computer in the next room using the software program AcqKnowledge III, Version 3.8.1 and a Model MP150 data acquisition unit (BioPac Systems, Inc., Santa Barbara, CA, USA) for analog/digital conversion.

Subjective sexual arousal

Subjective sexual arousal was measured continuously during the film presentation with an arousometer (Rellini et al., 2005). The arousometer is a computer mouse mounted on a trackpad that can be moved between the numbers 0 and 7, with 0 indicating no SSA and 7 indicating maximum SSA. The device was easily accessible to participants throughout the film presentations and was positioned on a small table at the side of the participant's chair. Each participant began with the arousometer positioned at 0 and was instructed to move the device throughout the film to indicate changes in SSA. The *y*-axis position of the arousometer was recorded every 0.50 seconds on a computer in the next room using the scripting program MatLab. The arousometer has been validated for use in capturing continuous changes in SSA during exposure to erotic stimuli (Rellini et al., 2005).

Sexual function

The presence of sexual arousal concerns was determined by scores on the Female Sexual Function Index (FSFI; Rosen et al., 2000) and responses to a sexual arousal assessment.

Female sexual function index. The FSFI is a 19-item self-report questionnaire that includes the following subscales: desire, arousal, lubrication, orgasm, satisfaction, pain, and overall sexual functioning. Items are ranked from 0 (or 1, for the desire subscale) to 5. Items within each domain are summed and multiplied by a factor of 0.6 (desire), 0.3 (arousal and lubrication), or 0.4 (orgasm, satisfaction, and pain). Domain scores are then summed to obtain a total score reflecting overall sexual functioning. Possible scores range from 1.2 to 36, with lower scores indicating poorer levels of sexual function or sexual inactivity. The FSFI is a well-validated tool that has shown excellent internal reliability ($r = 0.89\text{--}0.97$) and test-retest reliability ($\alpha = 0.79\text{--}0.88$), and has been able to consistently discriminate between women with and without sexual complaints (Rosen et al., 2000; Ryding & Blom, 2015; Wiegel, Meston, & Rosen, 2005).

Sexual arousal assessment. The sexual arousal assessment was developed to assess for female sexual arousal disorder based on the criteria from the *International Classification of Diseases – 10* (World Health Organization, 1992). The assessment includes a series of items relating to the participants' current ability to become sexually aroused, and participants were considered to have an arousal problem if they endorsed concerns on each of the following questions: a) whether they had experienced a decrease or absence of various genital sensations (e.g., warmth, wetness, tingling) for the past six months or longer; b) the extent (i.e., no change in genital sensations, decreased sensations, or absent sensations) to which they experienced these sensations in the context of sexual activity; c) whether their experiences of arousal were situational in nature; d) whether they self-identified as having an arousal problem; and e) whether they experienced distress in response to this problem. Total scores are not administered for this measure. For more information, see an outline of this assessment presented in Handy and colleagues (2019).

Participants were included in the sexual arousal concerns group if they reported scores on the Female Sexual Function Index (FSFI; Rosen et al., 2000) that fell below the clinical cutoff of 26.55 (Wiegel, Meston, & Rosen, 2005) and reported having an arousal-specific concern on the sexual arousal assessment. Participants were included in the no arousal concerns group if they scored

above the clinical cutoff score on the FSFI *and* did not report having an arousal-specific concern that caused them distress. Women must have met group-specific criteria on both measures of sexual function to be eligible for this study.

Interoception

To compare results to previous studies of this nature (e.g., Velten & Brotto, 2017), the Multidimensional Assessment of Interoceptive Awareness questionnaire (MAIA) was used to assess interoceptive bodily awareness. The MAIA is a self-report survey that measures interoception across eight dimensions and 32-items (Mehling et al., 2012). The items themselves are presented in a 6-point Likert format that ranges from “never” to “always,” where greater scores indicate greater levels of interoception. Items are distributed across the following dimensions: noticing (awareness of uncomfortable, comfortable and neutral body sensations), not-distracting (tendency to not ignore or distract oneself from sensations of pain or discomfort), not-worrying (tendency to not worry or experience emotional distress about sensations of pain or discomfort), attention regulation (ability to sustain and control attention to body sensations), emotional awareness (awareness of the connection between body sensations and emotional states), self-regulation (ability to regulate distress by paying attention to body sensations), body listening (active listening to the body for insight), and trusting (experiencing one’s body as safe and trustworthy). No total score is calculated for the MAIA, as a single factor model yielded an overall poor model fit in the validation study, but the measure has been shown to have good reliability, with Chronbach’s α s ranging from 0.66 to 0.87 across the eight dimensions (i.e., subscales).

Procedure

Upon arrival to the laboratory, participants were provided with a thorough explanation of all study procedures and measurement instruments. Participants provided informed consent, and subsequently proceeded to complete demographic and survey measures. Participants then viewed the experimental stimuli while their VPA response was measured. During this time, they were also instructed to continuously move the arousometer to indicate their level of SSA. After watching the film presentation, participants were debriefed and compensated with \$20 for their time. These procedures were approved by the University of Texas at Austin.

Data reduction

Vaginal pulse amplitude

Vaginal pulse amplitude data were exported from AcqKnowledge 3.9.3 to Microsoft Excel for processing. Movement artifacts in the data were isolated and removed through an automatic processing procedure that has been previously shown to be effective in removing outliers and providing results comparable to visual inspection (Pulverman, Meston, & Hixon, 2018). This procedure was conducted within the R environment (Team, 2019) using the *mgcv* package for generalized additive modeling (Wood, 2011). For a more comprehensive explanation of this data-reduction procedure, see Pulverman, Hixon, and Meston (2015). The VPA data were then binned in 5-second epochs representing mean peak-to-peak VPA response, yielding a total of 120 data points per participant.

Subjective sexual arousal

The corresponding SSA data (i.e., SSA data from the same film as when VPA was measured) was exported from MatLab to Microsoft Excel for processing. The SSA data were then binned in 5-second epochs, yielding a total of 120 data points per participant.

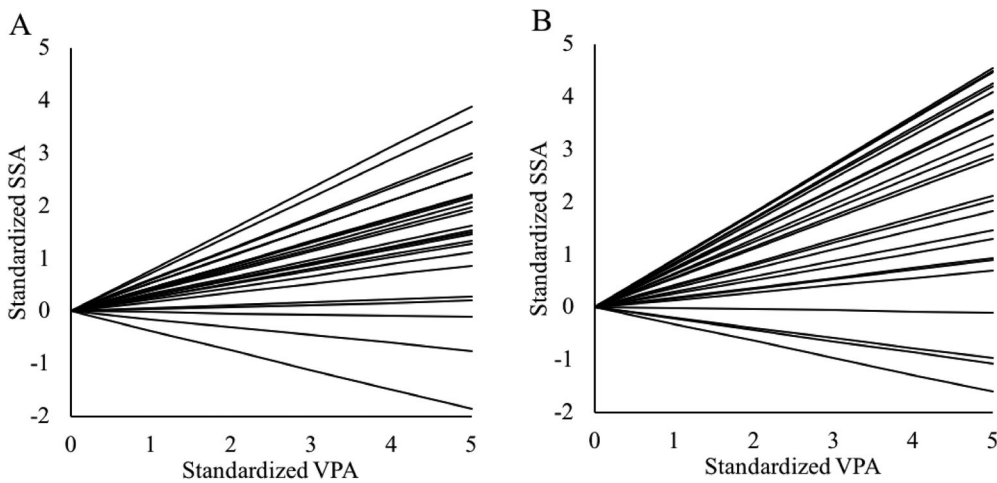


Figure 1. Individual regressions plotted for vaginal pulse amplitude (VPA) predicting subjective sexual arousal (SSA). Here, (A) reflects the slopes for women with sexual arousal concerns, and (B) reflects the slopes for women without sexual arousal concerns.

Data analysis

Primary analyses were conducted in R 3.2.3 (Team, 2015) using the nlme package (Pinheiro, Bates, DebRoy, Sarkar, & Team, 2017) for linear and nonlinear mixed effects. The car package (Fox & Weisberg, 2011) was invoked for an assessment of equality of variances.

The VPA and SSA data were standardized within each participant.¹ To assess concordance between physiological and subjective sexual arousal, a hierarchical linear modeling (HLM) approach was used. This approach can be thought of as a multilevel modeling process wherein the first step is to look at within-subject effects by examining the intercept and slope of individual regression lines for each participant. Here, VPA was used to predict SSA. The slopes and intercepts for these regression lines then become the outcome variables in a separate linear model that examines between-subject effects and, in this case, assesses the relationship between continuous SSA and VPA. An interaction model was then tested to determine whether sexual function status moderated the relationship between VPA and SSA. Finally, as part of an exploratory analysis, each of the eight subscales of the MAIA were entered as potential moderators of the relationship between VPA and SSA for women with and without sexual arousal concerns separately. Alphas were Bonferroni adjusted for multiple comparisons across both groups.

Results

Relationship between physiological and subjective sexual arousal

Pearson's r correlations calculated on the continuous VPA and SSA data for each participant ranged from -0.37 to 0.78 for women with and -0.32 to 0.91 for women without sexual arousal concerns. This similarity suggests that there may not be meaningful group differences in concordance. Refer to Figure 1A,B for a graphical representation of the dispersion of concordance in each group. This figure helps to illuminate the nearly indistinguishable distribution of slopes and questions the strength of the association between concordance and sexual function.

¹Using unstandardized data for similar procedures has also been suggested, as in Page-Gould (2016). As such, results from analyses containing unstandardized data will be summarized in footnotes.

Table 2. MAIA scores by group.

Dimension	No arousal concerns (<i>n</i> = 28)	Arousal concerns (<i>n</i> = 27)
	<i>M</i> (<i>SD</i>)	<i>M</i> (<i>SD</i>)
Noticing	2.69 (0.91)	2.50 (0.96)
Not distracting	1.95 (1.08)	2.19 (1.25)
Not worrying	2.65 (0.58)	2.83 (0.78)
Attention regulation	3.05 (0.74)	2.73 (0.72)
Emotional awareness	3.75 (0.91)	3.40 (1.33)
Self-regulation	2.87 (1.04)	2.76 (1.26)
Body listening	2.65 (1.37)	2.46 (1.28)
Trusting	3.25 (1.33)	3.08 (1.22)

Note: MAIA = Multidimensional Assessment of Interoceptive Awareness; *M* = mean; *SD* = standard deviation

Moderation effects of sexual function

Moderation analyses were run to examine the degree to which sexual function status interacts with the relationship between subjective and physiological arousal. These regression analyses indicated that sexual function status (where 0 = no arousal concerns and 1 = arousal concerns) significantly moderated the relationship between VPA and SSA, $\beta = -0.12$, $t = -5.53$, $p < 0.001$, $\eta^2 = .158$.² The negative β coefficient indicates that the relationship between VPA and SSA is weaker for women with arousal concerns than for those without. Post-hoc simple linear regressions confirmed that there was a significant, positive effect of VPA on SSA for both women with ($\beta = 0.32$, $t = 19.66$, $p < 0.001$, $\eta^2 = .107$)³ and without ($\beta = 0.44$, $t = 29.52$, $p < 0.001$, $\eta^2 = .212$).³ This indicates that for every one standardized mV of increase in VPA, SSA increased by 0.32 units and 0.44 units for women with and without sexual arousal concerns, respectively. This suggests that while both groups show a significant relationship between VPA and SSA, this pattern may be slightly stronger for women without sexual arousal concerns.

In addition to VPA predicting SSA, SSA also predicted VPA and this was moderated by sexual function status, $\beta = -0.14$, $t = -6.21$, $p < 0.001$, $\eta^2 = .158$.³ This negative β coefficient indicates that concordance was greater for women without sexual arousal concerns. Similar to the models described above, the predictive ability of SSA on VPA was significantly lower for women with ($\beta = 0.33$, $t = 19.66$, $p < 0.001$, $\eta^2 = .107$)³ than without ($\beta = 0.47$, $t = 29.52$, $p < 0.001$, $\eta^2 = .212$)² sexual arousal concerns. These findings further echo the results presented in Rellini et al. (2005) and suggest that, while physiological and subjective arousal are inversely predictive of one another, this pattern is weaker for women with sexual arousal concerns.

Moderation effects of interoception

No differences emerged between women with and without arousal concerns on dimensions of interoception. For a summary of scores, see Table 2. To look at the potential moderating impacts of interoception on concordance, simple slopes analyses were run separately for women with and without sexual arousal concerns using the eight subscales of the MAIA. For women without sexual arousal concerns, the not distracting subscale negatively influenced concordance ($\beta = -0.14$, $t = -10.56$, $p < 0.001$, $\eta^2 = .238$),³ as did the not worrying subscale ($\beta = -0.33$, $t = -12.36$, $p < 0.001$, $\eta^2 = .248$).³ In addition, high scores on the emotional awareness subscale increased concordance for this group ($\beta = 0.06$, $t = 3.85$, $p < 0.001$, $\eta^2 = .216$),³ as did high scores on the self-regulation subscale ($\beta = 0.07$, $t = 4.78$, $p < 0.001$, $\eta^2 = .218$).³ Each of these results remained significant after a Bonferroni correction for multiple comparisons (corrected for 16 comparisons;

²This effect was significant, though stronger, when using unstandardized data.

³This effect was significant, though weaker, when using unstandardized data.

Table 3. Summary of effects of MAIA subscales on concordance by group.

Dimension	Effect on concordance	
	No arousal concerns	Arousal concerns
Noticing	–	Decrease
Not distracting	Decrease	Increase
Not worrying	Decrease	Increase
Attention regulation	–	–
Emotional awareness	Increase	Decrease
Self-regulation	Increase	–
Body listening	–	–
Trusting	–	–

Note: MAIA = Multidimensional Assessment of Interoceptive Awareness

α of 0.05/16 = 0.003). There were no significant relationships between concordance and the noticing, attention regulation, body listening, and trusting subscales in this group.

For women *with* arousal concerns, the noticing subscale significantly decreased concordance ($\beta = -0.05$, $t = -3.35$, $p = 0.0008$, $\eta^2 = .11$),³ as did the emotional awareness subscale ($\beta = -0.03$, $t = -2.09$, $p = 0.036$, $\eta^2 = .108$).² Moreover, high scores on the not distracting subscale significantly increased concordance ($\beta = 0.037$, $t = 2.85$, $p = 0.004$, $\eta^2 = .109$),² as did high scores on the not worrying subscale ($\beta = 0.10$, $t = 4.60$, $p < 0.001$, $\eta^2 = .112$).² Moderation effects of the emotional awareness subscale were no longer significant after applying a Bonferroni correction. There were no significant relationships detected between concordance in this group and the attention regulation, self-regulation, body listening, and trusting subscales. See Table 3 for a summary of the effects of interoception on concordance.

Discussion

The present study examined concordance in women with and without sexual arousal concerns using a statistical technique designed to accommodate nested, time series data, and considered how interoception may influence these relationships. We replicated findings from Rellini et al. (2005) in sexually functional women and extended those findings to a group of women with sexual arousal concerns. More specifically, results indicate that variations in concordance between subjective and physiological sexual arousal can be detected using a multilevel modeling approach, and that concordance rates are relatively similar for women with and without sexual arousal concerns, though observed concordance was slightly weaker for women with arousal concerns. Concordance was also found to vary across groups as a function of interoception. Most notable was the large between-person variability in the range of women's responses that was present in women with *and without* sexual arousal concerns.

These findings have important methodological implications for concordance research. The replication of Rellini et al.'s (2005) findings suggests that correlational research, which is a common statistical approach used to examine concordance, obscures the wide range of diversity in women's sexual response. These findings suggest that while, on average, there is only a modest relationship between subjective and physiological sexual arousal, the relationship between VPA and SSA is strong for some women and weak for others. One conclusion that can be drawn from these data is that, for some women, genital changes play a critical role in the overall experience of SSA. For other women, genital changes may not be an important aspect of the arousal experience, and other types of cues (e.g., environmental, relational) may be more salient. This is a critical nuance in concordance research that is masked by correlational methods. As a result, these findings strengthen support for using statistical procedures designed to accommodate the features of continuously collected variables when examining concordance.

These results also present important implications for clinical practice and research. Interestingly, the between-person variability noted above was similar across groups of women with and without sexual arousal concerns. These findings support recommendations made by Chivers and Brotto (2017) and Meston and Stanton (2018), whose recent papers questioned the assumption that physiological and subjective measures of arousal should perfectly align. If there is such diversity in the range of responses across groups of sexually functional women and groups of women with sexual arousal concerns, it logically follows that the relationship between these two constructs is not diagnostic and should not be used as a clinical outcome in treatment research. Furthermore, these findings suggest that concordance is only a relevant clinical goal if genital changes are identified as an important or desired aspect of subjective arousal for a specific woman. In such cases where genital changes are important to a woman's experience of SSA, interventions based on mindfulness or attention to bodily cues may be indicated. As suggested by Chivers and Brotto (2017) and Handy and Meston (2016, 2018), moderator analyses are an important step forward in understanding the factors that enhance and inhibit concordance, and understanding which populations are likely to benefit from such treatment.

The results of our moderation analyses examining the influence of each MAIA subscale on concordance revealed differences between women with and without sexual arousal concerns. Across each subscale that significantly moderated concordance, a pattern emerged: whenever a facet of interoception strengthened concordance for women without arousal concerns (i.e., emotional awareness, self-regulation), it either had no effect or a *weakening* effect for women with arousal concerns. The reverse also held true, with subscales that strengthened concordance for women with arousal concerns (i.e., not distracting, not worrying) weakening concordance for women without arousal concerns. This pattern suggests there are key differences in the way women with and without arousal concerns interpret bodily, including sexual, sensations.

Subscales related to recognizing and regulating emotions and internal states were positively related to concordance in women without sexual arousal concerns. It is possible that women without arousal concerns tend to look to their bodily sensations to help guide their emotional experience, and this facilitates concordance. Women with arousal concerns, on the other hand, may attach a negative valence to sexual sensations in response to their experience of sexual difficulties. Increased awareness of bodily sensations may then lead to increased awareness of uncomfortable or distressing sexual sensations, and inhibited concordance. This explanation is supported by Barlow's model of sexual dysfunction (Barlow, 1986), which posits that sexual dysfunction can emerge from the misinterpretation of bodily sensations. According to this model, the interpretation of sexual arousal sensations as anxiety can lead to an increase in anxious autonomic arousal. This negatively impacts one's ability to become sexually aroused in the future, contributing to a negative feedback loop that may manifest as sexual dysfunction.

Conversely, subscales related to not distracting oneself from or worrying about internal sensations weakened concordance in women without arousal concerns and strengthened concordance in women with such concerns, echoing patterns exhibited by women with low sexual desire (Velten & Brotto, 2017). For women with sexual concerns, regardless of whether they stem from difficulties with arousal or desire, the ability to not suppress focus on uncomfortable physical sensations facilitates agreement between subjective and genital sexual arousal. To this end, it is possible that women without sexual concerns are more attuned to sensations they dislike and are thus more able to guide a sexual situation away from sensations that might cause them to feel discomfort or distress. Velten and Brotto posited that concordance may be hindered in women with sexual concerns by a lessened ability to distract one's self from the negative affect that may accompany arousal. Women who struggle to become aroused seem to demonstrate increased concordance as they worry less about feelings of pain or discomfort. It stands to reason that decreases in worrying about genital sensations might increase concordance.

There are a few limitations to the present study worth mentioning. Firstly, the inclusion criteria here are relevant to criteria outlined in the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM; American Psychiatric Association, 2000) and tenth edition of the *International Classification of Diseases* (World Health Organization, 1992). These results may not be applicable to women diagnosed with female sexual interest/arousal disorder as defined in DSM-V (American Psychiatric Association, 2013), which limits the generalizability of these findings. Additionally, the inclusion criteria were such that only women with scores below the clinical cutoff on the FSFI and women who endorsed an arousal specific concern were included in the study. As it is possible that concordance is related to a lack of arousal and not necessarily to corresponding arousal concerns, this feature of the sample may limit our ability to fully explore the nuanced nature of this relationship across a range of arousal contexts. Finally, as childhood sexual abuse has been linked with decreased genital arousal in adulthood (e.g., Rellini, Elinson, Janssen, & Meston, 2012), women with such history were excluded to increase sample homogeneity. However, women who experienced childhood sexual abuse are also more likely to experience difficulties with sexual arousal than women without a history of abuse (Laumann, Paik, & Rosen, 1999), thus limiting the generalizability of these findings to a more representative group of women with sexual arousal concerns. Future research should examine the effect of interoception on concordance in a population of women with a history of childhood sexual abuse, as it is not uncommon for these women to report feeling uncomfortable in or detached from their bodies (e.g., Mills & Daniluk, 2002).

In conclusion, VPA and SSA were found to significantly predict each other in women with and without sexual arousal concerns, and there was large between-person variability in concordance in both groups. These results have methodological implications: considering the temporal nature of genital and subjective arousal at the person-level is critical, and analyses that condense data across person and time should be avoided. Furthermore, given that some women had relatively strong and some had relatively weak associations between their subjective and genital responses, assessments of individual differences should be conducted.

Our individual differences analyses indicate that women who allocate more attentional resources to their bodily sensations show a greater relationship between genital and subjective sexual arousal. However, variants of this pattern were generally present among women regardless of the presence of a sexual arousal concern. This suggests that, although different facets of interoception may be important markers of concordance, this construct is likely not, on its own, clinically diagnostic of an arousal disorder, but rather an ideal target for intervention for those women who identify genital changes as important to their experience of arousal. Cognitive restructuring around the interpretation of bodily sensations may also be beneficial for these women, as some facets of interoception were also found to decrease concordance. Furthermore, there is little to no evidence that concordance itself is linked to greater levels of sexual function, satisfaction, or well-being in women. As such, concordance may not be a suitable endpoint in treatment outcome research. Instead, clinicians should assess other factors that are associated with SSA, such as contextual factors. Indeed, many women report contextual factors (i.e., relationship and partner characteristics) as primary cues to arousal (Graham, Sanders, Milhausen, & McBride, 2004) as well as important aspects of the arousal experience (Handy et al., 2019). There are a multitude of factors other than genital arousal that contribute to the subjective experience of arousal, and therefore it is suggested that clinicians personalize interventions, including interventions targeting interoceptive awareness, based on the cues that are most salient for women on an individual level.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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