Within-person variability in relationship satisfaction moderates partners' pain estimation in vulvodynia couples

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Abstract

Models of pain communication propose that the social environment contributes to partners' pain estimation. This study examined partners' pain estimation in vulvodynia, an idiopathic vulvovaginal pain condition that disrupts the sexuality and relationships of affected couples. Specifically, we investigated (1) the overall bias and tracking accuracy of male partners' perceptions of women's pain during intercourse and (2) the influence of men's within-person variability in relationship satisfaction on bias and accuracy. Sixty-nine women (mean age = 28.1, SD = 6.7) diagnosed with vulvodynia and their cohabiting male partners (mean age = 29.7, SD = 8.1) participated in an 8-week daily diary study. On sexual intercourse days (mean = 6.1, SD = 5.4), men reported their perception of women's pain during intercourse and women self-reported their pain. Men reported their daily relationship satisfaction on all diary days. Men's within-person variability in relationship satisfaction was represented by the SD of relationship satisfaction scores across all daily diaries. Results indicated that men's perceptions were both accurate in that they tracked changes in women's pain and biased in that they generally underestimated this pain. Men's variability in relationship satisfaction moderated tracking accuracy such that men with higher variability manifested lower tracking accuracy for women's pain. Men's higher variability in relationship satisfaction may interfere with their motivation to accurately infer their female partner's pain. Poorer pain estimation may impair men's ability to adjust their emotional and behavioral responses to women's pain, which may have negative consequences for the couples' coping with vulvodynia.

Keywords: Vulvodynia, Relationship satisfaction, Pain estimation, Daily diaries, Mean-level bias, Tracking accuracy

1. Introduction

Vulvodynia is a chronic idiopathic vulvovaginal pain condition. Its most common subtype, provoked vestibulodynia (PVD), affects 8% to 12% of women in the general population and is characterized by pain upon pressure to the vulvar vestibule.[28,29] Provoked vestibulodynia significantly disrupts the sexuality and romantic relationships of women and their male partners.[18,47] Previous cross-sectional studies on chronic pain have documented biases in observer estimates of patient's pain,[16,40] whereas others found no such biases.[13,22,38] Although perfect agreement is improbable given that the patient and observer have access to different information about the pain, and may at times be unnecessary,[30] a partner's ability to estimate a patient's pain may lead to better adjustment among chronic pain couples.[13,16,32,34,36,40] The accuracy of pain estimation can be

characterized in 2 distinct ways[21,50]: (1) the difference between partners' estimates of patient pain and the patients' pain (ie, mean-level bias) and (2) by the strength of the association between partners' estimates of pain and patients' pain across time (ie, agreement or tracking accuracy).

Cross-sectional research shows that partners' estimations of pain covary with patients' self-reported pain,[13,16,32,34,36,40] suggesting that partners, to some extent, could be accurate in estimating women's pain. However, women with PVD may not communicate their pain for fears of disrupting their partner's sexual enjoyment, losing their partner, or a sense of obligation to engage in intercourse.[3,9,19,20] These factors could contribute to partners' underestimation of women's pain.

Models of pain communication propose that the social environment contributes to partners' pain estimation.[27] Furthermore, interpersonal dynamics have been shown to moderate partner interpersonal perceptions in community couples.[21] Couples with PVD report negative relationship consequences,[19,45,47] suggesting that relationship evaluations may impact partners' pain estimation. Research using cross-sectional designs with other chronic pain populations indicates either no relation between overall patient or partner dyadic adjustment and mean-level bias[22] or a positive association between partners' relationship satisfaction and tracking accuracy.[34] Within-person variability in relationship satisfaction may influence pain estimation independently of average level of relationship satisfaction.[1,2,10] According to interdependence theory, variability in relationship satisfaction may reflect instability in the balance of positive vs negative relationship experiences across time. Higher variability may reflect insecurity about the relationship, resulting in

increased relationship-damaging behaviors and disinvestment, which leads to reduced motivation to understand one's partner in community samples.[2,10] In PVD, greater variability in men's relationship satisfaction may undermine their motivation to understand women's pain experience, leading to lower attentiveness to pain-related cues during sexual activity, and ultimately poorer pain estimation. Motivational accounts of attention to pain suggest that deprioritization of pain-related goals is accompanied by reduced processing of pain-related information.[48]

An 8-week daily diary study investigated male partners' pain estimation and the influence of their within-person variability in relationship satisfaction on this process. We hypothesized that men would, on average, demonstrate tracking accuracy for women's pain but would underestimate this pain. We also hypothesized that men's within-person variability in relationship satisfaction would be negatively associated with their pain estimation.

2. Method

2.1. Participants

Women were recruited in a North American city through[1] clinical appointments with collaborating physicians (21%),[2] advertisements (70%), and by word of mouth (9%). There were no differences between recruitment groups on any demographic variables. A structured interview was conducted by telephone to assess women's eligibility, and they were asked to confirm their partners' participation. Women were then scheduled for a gynecological examination if they had not already attended one with a collaborating physician. Inclusion criteria for women were (1) pain during intercourse that was subjectively distressing, occurs(ed) on 75% of intercourse attempts in the past 6 months, and lasting for at least 6 months; (2) pain limited to activities involving pressure to the vestibule; (3) pain during the diagnostic gynecological examination, which included the validated standardized "cotton swab test"—the recommended gynecological procedure to diagnose PVD[5]; and (4) cohabitating with a male partner for at least 6 months. The examination included a randomized palpation using a dry cotton swab of 3 locations around the vestibule surrounding the hymeneal ring (ie, 3-, 6-, 9-o'clock), to which participants rated their pain at each site on a scale of 0 (no pain) to 10 (worst pain ever). Exclusion criteria were active infection previously diagnosed by a physician or self-reported infection, vaginismus (involuntary tightness of the pelvic floor muscles during attempted penetration, as defined by *DSM-IV-TR*), pregnancy, and age younger than 18 or older than 45 years. The inclusion criterion for male partners was age older than 18 years. Of 126 interested women, 45 (36%) were ineligible: 19 (42%) were not in a relationship, 9 (20%) partners declined participation, 8 (18%) did not receive a diagnosis of PVD by the gynecologist, and 9 (20%) were ineligible for other reasons (eg, non-English speaking, pregnancy). Of the 81 (64%) women and partners who met eligibility criteria and agreed to participate, 9 (11%) couples reported not engaging in intercourse during the study and 3 couples (4%) dropped out, resulting in a final sample size of 69 couples.

2.2. Procedure

Couples attended a laboratory session where they each provided informed consent before completing online self-report questionnaires that assessed demographic information and other measures unrelated to this study. Participants received instructions to complete the daily diaries for 8 consecutive weeks through links to a secure survey server site that were e-mailed individually to each participant. They were told to begin the diaries that same day, to complete them at the same time each day (reflecting on the previous 24 hours), and to not share their responses with their partner. Several strategies were implemented to promote participation. First, participants created implementation intentions for their daily goal of completing a diary. Implementation intentions are "if-then" statements detailing the when, where, and how of goal attainment and have been found to significantly enhance the uptake of a new behavior.[24] Second, a research assistant called participants 3 times a week as a reminder to complete their diaries, and finally, participants were also given a flyer to post in their home. This protocol resulted in an attrition rate of 4% (3 couples). Daily measures included relationship satisfaction and variables not relevant to this study, as well as an item about whether or not the participant had vaginal intercourse in the preceding 24 hours. If the participant indicated that intercourse had occurred, then women completed a measure of their pain intensity during intercourse and men completed a measure of their perception of women's pain intensity during intercourse. The overall rate of diary completion was 86.12% (6655 diaries of a possible 7728), with a mean number of 6.91 (SD = 5.40; range = 1-30) sexual intercourse events over the course of the study. The online survey software recorded the timing of diary completion, and participants were also asked to enter the date they completed the diaries. Of 921 sexual intercourse diaries, 5 (<1%) indicated a mismatch of more than 24 hours between the participant-reported time of completion and the time stamp and 22 (2%) indicated with the time stamp that participants were completing more than one diary on the same day and time. These instances of diary completion were considered invalid and were removed before analyses.

Some participants reported a lack of Internet access over the 8-week course of the study (eg, due to travel). Of the 894 valid sexual intercourse diaries, 76 (9%) were completed by paper and pen (by 27 participants, 15 couples). To respect confidentiality, participants were asked to enter the data themselves once they had access to the Internet again. Studies have shown that paper and electronic diaries yield data that are comparable in compliance rates, psychometric properties, and the pattern of results.[26] Coupled with the low rate of invalid data (<3%) for the electronic diaries, we therefore included diaries completed electronically and by paper in our analyses, resulting in 894 valid sexual event diaries reported by 138 participants (69 couples). Participants received $20 for completing the laboratory session and $12 per week for the diaries ($116 total each). This study was approved by our institutional ethics review board.

2.3. Measures

2.3.1. Pain

Women reported their pain intensity (in reference to the intercourse pain experienced in the past 24 hours) by indicating their level of pain during intercourse using a horizontal numerical rating scale ranging from 0 (no pain) to 10 (worst pain ever). This measure positively correlates with other pain intensity measures.[17] Male partners reported their perception of their female partner's pain intensity (in reference to the intercourse pain experienced in the past 24 hours) by indicating their female partner's level of pain using a horizontal numerical rating scale ranging from 0 (no pain) to 10 (worst pain ever).

Intraclass correlation for women's pain scores and men's perception of women's pain scores were 0.53 and 0.60 respectively, suggesting that relatively equal amounts of variance in these scores were accounted for by individual differences in

Demographics statistics (*N* = 69 couples, unless otherwise noted).

Characteristic	Mean (range)	SD	%
Age (y)			
Women (*N* = 68)	28.12 (18-44)	6.68	—
Men	29.67 (19-55)	8.10	—
Women's duration of pain in years	5.39 (0-19)	4.40	—
Education level (y)			
Women	15.94 (11-24)	2.72	—
Men	15.94 (12-24)	2.9	—
Marital status			
Married	29	—	42
Relationship length in years	5.54 (0-25)	5.24	—
Frequency of intercourse	6.91 (1-30)	5.40	—
Couple's annual income			
$0-$19,999	6	—	9
$20,000-$39,000	14	—	20
$40,000-$59,000	12	—	17
≥$60,000	37	—	54

women's pain and men's perception of women's pain and by event-specific characteristics (and error).

2.3.2. Relationship satisfaction

Men reported their relationship satisfaction using the Kansas Marital Satisfaction Scale (KMSS[44]). The KMSS consists of 3 items that were modified slightly for the daily context and for cohabiting (but not necessarily married) couples. The items were (1) "how satisfied are you with your relationship with your partner today?", (2) "how satisfied are you with your partner today?", and (3) "how satisfied are you with your overall marriage/common-law relationship today?" Ratings were made on a scale of 1 (very unsatisfied) to 7 (very satisfied), and summed responses yielded a daily total score whereby higher scores indicated greater satisfaction. The internal consistency, test–retest reliability, and concurrent and discriminant validity of the KMSS have been established in previous studies.[44] McDonald's omega reliability coefficient, which is an index of the proportion of the item variance that is accounted for by the common factor relative to total variance in scores,[23] was high, 0.92, for the within-person relationship satisfaction scores. The SD of relationship satisfaction scores across all daily diaries was computed as a measure of men's within-person variability in relationship satisfaction.

2.4. Data analysis

The truth and bias model of interpersonal perceptions (T&B[50]) was used as a conceptual and statistical framework for the

data analysis. The model postulates that the perceiver's estimate (men's perception of women's pain during intercourse) may contain systematic bias as indicated by the tendency to overestimate or underestimate the target's characteristic (women's pain) represented by a benchmark (women's self-reported pain). This feature of estimation is termed mean-level (directional) bias. At the same time, the perceiver's estimation (men's perception of women's pain) of the target's characteristic (women's pain) is related to the benchmark (ie, women's self-reported pain); this relation is characterized by the degree of the association between the partner's pain estimate and a woman's self-reported pain across time. In the T&B model, this characteristic of perception is coined as tracking accuracy (ie, how a partner's fluctuations of pain estimates tracks variations in a woman's self-reported pain across time).

To examine men's mean-level bias and tracking accuracy of women's pain, we used only data from jointly reported daily diaries in which vaginal intercourse was indicated. To examine the moderating role of men's variability in relationship satisfaction, we used all reported diaries of relationship satisfaction by men across the 2-month period to obtain an accurate measure of the distribution of daily relationship satisfaction scores within a person. As these data have a hierarchical nested structure (ie, daily diaries nested within partners and partners nested within couples), a multilevel modeling approach was used. The lower (ie, within-person) level is composed of both partners' diary-level data (ie, men's perception of women's pain and women's self-reported pain), whereas the upper (between-person) level consists of men's person-level data (ie, within-person variability in relationship satisfaction). Following West and Kenny,[50] women's self-reported pain on a given instance of vaginal intercourse (ie, the within-person predictor) was centered on each woman's mean self-report of her pain (ie, within-person centering). Thus, the within-person predictor score represents the deviation of women's pain score on a given day of vaginal intercourse from women's mean pain score over all days of vaginal intercourse. Men's perception of women's pain during intercourse (ie, the outcome at the within-person level) was centered on each woman's mean self-reports of pain. This centering strategy permits the estimation of mean-level bias of men's perception of women's pain (ie, the extent to which men's mean perception of women's pain is higher or lower than women's mean self-reports of pain). Men's within-person variability in relationship satisfaction (ie, the between-person predictor of mean-level bias and tracking accuracy) was centered on men's mean perception of women's pain during intercourse for the whole sample (ie, between-person centering).

We first examined the extent to which women's self-reported pain predicted men's perception of women's pain during each

Descriptive statistics and correlations among the study variables.[a]

Variable	1	2	3	4
1. Men's estimate of women's pain				
2. Women's self-report of own pain	0.67***			0.39***
3. Men's mean relationship satisfaction	−0.01	0.02		
4. Men's variability in relationship satisfaction	−0.13	−0.14	−0.33**	
Mean	4.16	4.86	18.29	1.78
SD	1.98	1.87	2.2	1.35
Range	1.00-9.00	1.36-10.00	7.70-21.00	0-5.36

N = 69 couples, 447 jointly reported diaries where vaginal intercourse was reported.
[a] Daily-level correlations are presented above the main diagonal; between-person correlations are presented below the main diagonal.
**P < .01; ***P < .001.

vaginal intercourse event (within-person model). Averaged across all daily diaries and all participants, the intercept represents mean-level bias: the expected difference between the average of men's perception of women's pain and the average of women's self-reported pain, when the predictor variable equals its mean. An intercept that is significantly different from zero indicates that men's perceptions differed (ie, were biased) from women's self-reported pain across all instances of vaginal intercourse. The sign of the intercept points to the direction of the bias; when negative, men underestimated their female partner's pain and when positive, men overestimated this pain. The regression coefficient represents the strength of the association between men's perception of women's pain and women's self-reported pain. A positive and significant slope indicates that men accurately tracked changes in women's pain across vaginal intercourse events (tracking accuracy), whereas a nonsignificant slope indicates poorer tracking accuracy. The intercept and slope for bias and tracking accuracy, respectively, were treated as random effects, ie, they were allowed to vary across participants.

We then examined whether men's within-person variability in relationship satisfaction moderated the between-person variation in the intercept and slope for mean-level bias and tracking accuracy, respectively (between-person model). We contemplated the possibility that men's within-person variability in relationship satisfaction may have nonlinear associations with mean-level bias and tracking accuracy (eg, floor or ceiling effects). Therefore, we examined both the linear and quadratic effects of men's within-person variability in relationship satisfaction on mean-level bias and tracking accuracy. Men's mean relationship satisfaction was entered as a covariate to control for the dependency of within-person variability in relationship satisfaction on mean relationship satisfaction across all reported diaries.[4]

Analyses were conducted using Mplus (version 7[37]) and the full information maximum likelihood estimator with SEs and χ^2 test statistics that are robust to nonnormality and nonindependence of observations (ie, maximum likelihood estimation with robust standard errors). Significant between-person effects were probed by calculating simple intercepts and slopes for variability in relationship satisfaction that were ±1 SD from the sample mean.

3. Results

3.1. Sample demographics and intercorrelations

Women who were included in the analyses did not differ from those who were excluded in terms of relationship status and household income. Included women were younger ($b = -6.33$, $t(76) = -2.77$, $P = .01$), less educated ($b = -2.83$, $t(76) = -3.04$, $P = .01$), and had been experiencing pain for a shorter period ($b = -4.50$, $t(76) = 2.87$, $P = .01$), than those who were excluded. Sample descriptive statistics are presented in **Table 1**, and correlations among study variables are presented in **Table 2**. At the daily diary level, men's perception of women's pain moderately correlated with women's self-report of pain. At the between-person level, men's perception of women's pain strongly correlated with women's self-report of pain. However, men, on average, reported perceiving less pain in women than women's self-reports of pain indicated, with a mean difference of -0.70, $t(68) = -3.39$, $P < .01$. Finally, men's within-person variability in relationship satisfaction was negatively correlated with their own mean relationship satisfaction across all reported daily diaries.

Mean-level bias and tracking accuracy of men's estimation of women's pain during intercourse.

Men's estimation of their female partner's pain during intercourse	Estimate (SE)	z
Fixed effects		
Mean-level bias	−0.79 (0.20)	−4.03***
Tracking accuracy	0.39 (0.07)	5.79***

$N = 69$ couples, 447 jointly reported diaries where vaginal intercourse was reported.
***$P < .001$.

3.2. Tracking accuracy and mean-level bias of men's estimation of women's pain

Table 3 presents results of the within-person model in which mean-level bias and tracking accuracy of men's estimation of women's pain during intercourse were estimated. Men demonstrated accuracy in tracking changes in their female partner's pain across vaginal intercourse events, as evidenced by a significant and positively signed slope. Increases in women's self-reported pain during intercourse were associated with increases in men's estimate of women's pain. However, on average, men also underestimated women's pain as indicated by a significant and negatively signed intercept (mean-level bias).

3.3. Effect of men's within-person variability in relationship satisfaction on mean-level bias and tracking accuracy of men's estimation of women's pain

Next, we examined whether men's within-person variability in relationship satisfaction moderated mean-level bias and slope for tracking accuracy (**Table 4**). Both linear and quadratic effects of men's variability in relationship satisfaction on mean-level bias of men's estimation of women's pain were nonsignificant. There was a significant and negative linear effect of men's variability on men's tracking accuracy of women's pain (**Figure 1**). Compared with men with lower variability in relationship satisfaction, men

Estimates of men's within-person variability in relationship satisfaction on mean-level bias and tracking accuracy of men's estimation of women's pain during intercourse.

Men's estimation of their female partner's pain during intercourse	Estimate (SE)	z
Fixed effects		
Mean-level bias	−0.81 (0.24)	−3.38***
Tracking accuracy	0.26 (0.07)	3.63***
Cross-level interactions		
Mean-level bias ← Men's linear variability in relationship satisfaction	0.03 (0.18)	0.16
Mean-level bias ← Men's quadratic variability in relationship satisfaction	0.02 (0.09)	0.22
Mean-level bias ← Men's mean in relationship satisfaction	−0.00 (0.07)	−0.04
Tracking accuracy ← Men's linear variability in relationship satisfaction	**−0.10 (0.04)**	**−2.16***
Tracking accuracy ← Men's quadratic variability in relationship satisfaction	**0.09 (0.03)**	**2.89****
Tracking accuracy ← Men's mean in relationship satisfaction	0.00 (0.02)	−0.03

$N = 69$ couples, 447 jointly reported diaries where vaginal intercourse was reported. Significant effects are in bold.
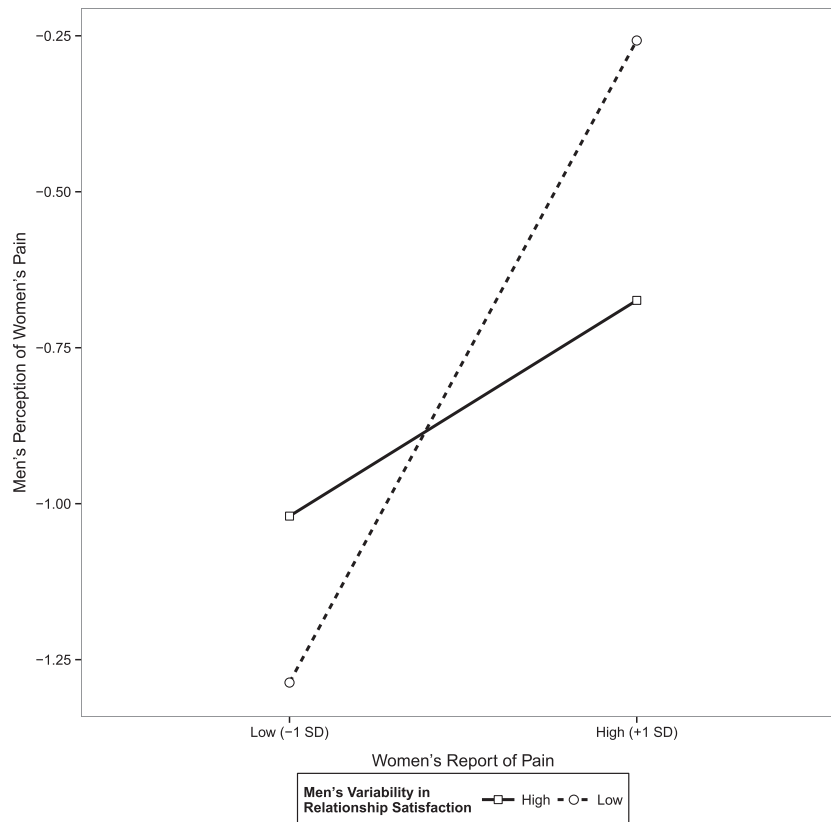*$P < .05$; **$P < .01$; ***$P < .001$.

Figure 1. Linear effect of men's within-person variability in relationship satisfaction on men's tracking accuracy.

with higher variability in their relationship satisfaction were less accurate in tracking changes in their female partner's pain across days of vaginal intercourse (slope for high variability = 0.13, SE = 0.08, z = 1.64, nonsignificant; slope for low variability = 0.38, SE = 0.10, z = 3.70, $P < .001$). This linear effect of variability on tracking accuracy was qualified by a quadratic effect, which suggested that the decrease in tracking accuracy as a function of variability in relationship satisfaction occurred more rapidly for mid to high levels of variability (**Figure 2**). There was indication that for very high levels of variability in relationship satisfaction, the decrease in tracking accuracy plateaued.

Figure 2. Quadratic effect of men's within-person variability in relationship satisfaction on men's tracking accuracy.

4. Discussion

Using a daily diary methodology, this study examined the accuracy of men's pain estimation for women's pain during intercourse and the moderating role of within-person variability in men's relationship satisfaction in couples with vulvodynia. As predicted, men were generally accurate in their ability to track changes in their female partners' pain across instances of sexual intercourse. However, men were also biased in that they, on average, underestimated their female partner's pain. Men's within-person variability in relationship satisfaction moderated tracking accuracy: compared with men lower on this variability, men with greater variability manifested poorer tracking accuracy for women's pain. Findings are consistent with a pain communication model by suggesting that social factors influence observer pain estimation.[27] This study contributes to the literature examining pain estimation and congruence in chronic pain (eg, see Refs. 13, 14, 22, 34, 35) by using an experience sampling method so as to better capture couples' perceptions in their daily lives.

Consistent with our hypothesis, men were able to track changes in their female partners' pain across intercourse events. This result is in line with the findings in other chronic pain populations using single-occasion measurements.[13,16,32,34,36,40] The current finding suggests that across sexual activities, during which cognitive, emotional, relational, and physical factors compete for attention and can vary from one interaction to the next, men are generally sensitive to changes in women's pain. Accurate estimation is often the first step toward adapting one's behavior, which in the case of PVD may translate into men's enhanced ability to contribute to modifying sexual activities to accommodate their partner's pain. In cognitive behavioral

therapy for PVD, women are taught to modify factors affecting the pain.[6] Since partners are able to track changes in women's pain, they could be involved in identifying factors that shape the pain experience, such as their own or their female partners' thoughts, emotions, and behaviors.

Consistent with our hypothesis, men underestimated women's pain across all intercourse events. Previous cross-sectional studies on chronic pain have reported mixed results, with some documenting biases in partners' estimates of patient pain[16,40] and others showing no such biases.[13,22,38] In line with pain communication models,[27] women with PVD may contribute to men's underestimation of their pain by not accurately communicating their pain intensity. Women may conceal their pain to protect their partner, or due to feelings of shame and guilt, concerns over losing their partners, and out of obligation to engage in intercourse.[3,9,19,20,45] Men may be motivated to focus on the positive aspects of the sexual interaction (such as their own pleasure) or its negative aspects (such as feeling frustrated or more inhibited) and may, as a result, be less attentive to cues of pain from their female partner, leading to underestimation of pain. Recent research has shown that inducing a non–pain-related goal (ie, men's focus on their own pleasure or negative feelings) reduced attention to pain in a nonclinical sample.[49] Furthermore, pain estimation may be especially challenging if the context, such as vulvodynia, is viewed as threatening to the relationship.[46] Partners who underestimate women's pain may unwittingly communicate less emotional responsiveness and compassion for their partner[41] and may not recognize the need to adapt sexual activities. Such empathic failures could result in feelings of invalidation, decreased sexual function, and more pain for women.[12,41] Indeed, invalidation has been linked to greater pain and impairment in chronic pain couples[33,39] and in PVD.[8,41]

Men's tracking accuracy for women's pain was influenced, in the expected direction, by men's within-person variability in relationship satisfaction and occurred independently of men's average level of relationship satisfaction. Men with higher within-person variability in relationship satisfaction had lower tracking accuracy for women's pain compared with men with lower variability. This negative association was more pronounced for moderate to high levels of variability. Variability in relationship satisfaction may reflect instability in the balance of positive vs negative relationship events for the couple over time.[10] Such variability may enhance feelings of insecurity about the relationship and may lead to men's disinvestment and reduced commitment to the relationship.[42] In turn, reduced commitment may undermine men's motivation to be empathetic toward women's pain experience, resulting in decreased attention to pain-related cues and, ultimately, poorer tracking accuracy. It is also possible that variability in men's relationship satisfaction may be associated with poorer communication between partners, or the reverse may be true. Poor communication may interfere with tracking accuracy for pain, as suggested by a recent study that reported lower couple congruence for patient symptoms of fibromyalgia among those who reported greater communication problems.[35]

Results suggest that it may be beneficial for clinicians to assess the pain perceptions of both women with PVD and their male partners, as well as the stability of men's relationship satisfaction. Clinicians may assist women in more openly communicating their pain experience so that their partners can have the opportunity to be more attuned. A recent study found that couples with fibromyalgia who were similar on levels of communication experienced greater congruence for patient symptoms and functioning, suggesting that communication may be an important target for improving couple congruence and patient well-being.[35]

Theoretically, the current findings support recent efforts to focus on the social context of chronic pain[27] and also support models of pain empathy that highlight intraindividual and interpersonal characteristics as contributing to couples' understanding of the pain.[15,25] The results point to incorporating variability in relationship satisfaction into these theoretical models.

The use of a daily diary method constitutes a notable strength of this study. Previous research has primarily relied on single-occasion measurements to examine pain estimation, which can provide only limited information about dynamic within-person processes[7,43] and partner differences in these processes. By using a within-person design and obtaining daily measures, this study generates findings that possess greater construct validity (ie, by addressing the within-person process characterizing men's pain estimation), internal validity (ie, by minimizing recall and self-report biases), and external validity (ie, by enhancing generalization to real-life situations). A final strength of this study is the application of the Truth and Bias Model (T&B[50]) to pain estimation. Pain researchers may consider using this model to examine pain estimation in other dyadic interactions (eg, patient–health care provider). Other processes influencing pain estimation can be examined in addition to "mean difference" (ie, mean-level bias) and "agreement" (ie, tracking accuracy). For example, it is possible to examine situational factors (eg, partner's sexual satisfaction) that may influence pain estimation distinctly from the truth. These factors are conceptualized as biases in the T&B model. Furthermore, the T&B model proposes the existence of moderators, which may illuminate processes that control accuracy and bias in pain estimation (for a thorough discussion, see West and Kenny[50]). Finally, it is possible to examine how relational context (eg, romantic, therapeutic, etc) may influence pain estimation.

There are also some limitations to this study. Participating couples were heterosexual, and women included in the study were less educated and experienced a shorter pain duration compared with those who were excluded from the study, limiting generalizability to other samples. Although there may be different predictors of acute and chronic pain,[31] the average pain duration of both the excluded and included women was over 5 years, indicating that our sample was not likely biased with regard to pain duration. In addition, it is probable that there is some degree of bidirectionality in the reported associations, such that men's pain estimation is fuelling their variability in relationship satisfaction. The analyses were correlational and causal conclusions cannot be drawn, although the interpretation of the results was guided by theory and previous research. Despite the fact that ratings were closer in time to the sexual event in comparison to cross-sectional studies, the self-reported data in this study were still retrospective (ie, over the course of the day) and could have been influenced by other events that day. Furthermore, this study did not include a measure of general affectivity, and fluctuations in effect could be reflected in the variability observed in relationship satisfaction. Finally, consistent with previous PVD couple research,[41] the relationship satisfaction of participating couples was generally within norms, limiting the generalizability to couples experiencing more relational difficulties.

It should be noted that although most evidence points to the benefits of couple congruence for patient pain,[13,14,16,40] there is also evidence that congruence may be associated with poorer patient outcomes.[22] A perfect match between men's estimation and women's self-reported pain is unlikely given that each have access to different data regarding women's pain experience and may not be necessary for optimal outcomes.[30] It will be important for future research to establish the point at which inaccurate pain

estimation becomes detrimental, the emotional and behavioral correlates of pain estimation, as well as its consequences on the psychological and sexual adjustment of vulvodynia couples.[11] Studies examining the mechanisms underlying partners' estimates of women's pain are also needed to identify the circumstances under which misestimation occurs.[30]

In conclusion, partners of women with PVD demonstrated both accuracy and bias in their perception of women's pain during intercourse. Higher within-person variability in men's relationship satisfaction was associated with lower accuracy in tracking changes in women's pain. Such variability may interfere with men's motivation to accurately infer their female partners' pain and their attention to pain-related cues. In turn, men's pain appraisals may alter their behavior and emotional responses during pain-eliciting sexual activities, which may ultimately influence women's pain and couples' sexuality.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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References

[1] Arriaga XB. The ups and downs of dating: fluctuations in satisfaction in newly formed romantic relationships. J Pers Soc Psychol 2001;80:754–65.

[2] Arriaga ZB, Reed JT, Goodfriend W, Agnew CR. Relationship perceptions and persistence: do fluctuations in perceived partner commitment undermine dating relationships? J Pers Soc Psychol 2006;91:1045–65.

[3] Ayling K, Ussher JM. If sex hurts, am I still a woman? The subjective experience of vulvodynia in hetero-sexual women. Arch Sex Behav 2008;37:294–304.

[4] Baird BM, Le K, Lucas RE. On the nature of intraindividual personality variability: reliability, validity and associations with well-being. J Pers Soc Psychol 2006;90:512–27.

[5] Bergeron S, Binik YM, Khalifé S, Pagidas K, Glazer HI. Vulvar vestibulitis syndrome: reliability of diagnosis and evaluation of current diagnostic criteria. Obstet Gynecol 2001;98:45–51.

[6] Bergeron S, Binik YM, Khalife S, Pagidas K, Glazer HI, Meana M, Amsel R. A randomized comparison of group cognitive-behavioral therapy, surface electromyographic biofeedback, and vestibulectomy in the treatment of dyspareunia resulting from vulvar vestibulitis. PAIN 2001;91:297–306.

[7] Birnbaum GE, Reis HT, Mikulincer M, Gillath O, Orpaz A. When sex is more than just sex: attachment orientations, sexual experience, and relationship quality. J Pers Soc Psychol 2006;91:929–43.

[8] Bois K, Bergeron S, Rosen NO, McDuff P. Sexual and relationship intimacy among women with provoked vestibulodynia and their partners: associations with sexual satisfaction, sexual function and pain self-efficacy. J Sex Med 2013;10:2024–35.

[9] Brauer M, Lakeman M, van Lunsen R, Laan E. Predictors of task-persistent and fear-avoiding behaviors in women with sexual pain disorders. J Sex Med 2014;11:3051–63.

[10] Campbell L, Simpson JA, Boldry JG, Rubin H. Trust, variability in relationship evaluations, and relationship processes. J Pers Soc Psychol 2010;99:14–31.

[11] Cano A. Interpersonal communication research in the context of pain. PAIN 2013;154:2245–6.

[12] Cano A, Barterian JA, Heller JB. Empathic and nonempathic interaction in chronic pain couples. Clin J Pain 2008;24:678–84.

[13] Cano A, Williams AC. Social interaction in pain: reinforcing pain behaviors or building intimacy? PAIN 2010;149:9–11.

[14] Cano A, Johansen AB, Franz A. Multilevel analysis of couple congruence on pain, interference, and disability. PAIN 2005;118:369–79.

[15] Cano A, Johansen AB, Geisser M. Spousal congruence on disability, pain, and spouse responses to pain. PAIN 2004;109:258–65.

[16] Cremeans-Smith JK, Parris Stephens M, Franks MM, Martire LM, Druley JA, Wojno WC. Spouses' and physicians perceptions of pain severity in older women with osteoarthritis: dyadic agreement and patients' well-being. PAIN 2003;106:27–34.

[17] Desrochers G, Bergeron S, Khalifé S, Dupuis M-J, Jodoin M. Fear avoidance and self-efficacy in relation to pain and sexual impairment in women with provoked vestibulodynia. Clin J Pain 2009;25:520–7.

[18] Desrochers G, Bergeron S, Landry T, Jodoin M. Do psychosexual factors play a role in the etiology of provoked vestibulodynia? A critical review. J Sex Marital Ther 2008;34:198–226.

[19] Elmerstig E, Wijma B, Berterö C. Why do young women continue to have sexual intercourse despite pain? J Adolesc Health 2008;43:357–63.

[20] Elmerstig E, Wijma B, Swahnberg K. Prioritizing the partner's enjoyment: a population-based study on young Swedish women with experience of pain during vaginal intercourse. J Psychosom Obstet Gynaecol 2013;34:82–90.

[21] Fletcher GJO, Kerr PSG. Through the eyes of love: reality and illusion in intimate relationships. Psychol Bull 2010;136:627–58.

[22] Gauthier N, Thibault P, Sullivan MJL. Individual and relational correlates of pain-related empathic accuracy in spouses of chronic pain patients. Clin J Pain 2008;24:669–77.

[23] Geldhof GJ, Preacher KJ, Zyphur MJ. Reliability estimation in a multilevel confirmatory factor analysis framework. Psychol Methods 2013;19:72–91.

[24] Gollwitzer PM, Sheeran P. Implementation intentions and goal achievement: a meta-analysis of effects and processes. Adv Exp Soc Psychol 2006;38:69–119.

[25] Goubert L, Craig KD, Vervoort T, Morley S, Sullivan MJL, Williams AC, Cano A, Crombez G. Facing others in pain: the effects of empathy. PAIN 2005;118:285–8.

[26] Green AS, Rafaeli E, Bolger N, Shrout PE, Reis HT. Paper or plastic? Data equivalence in paper and electronic diaries. Psychol Methods 2006;11:87–105.

[27] Hadjistavropoulos T, Craig KD, Duck S, Cano A, Goubert L, Jackson P, Mogil JS, Rainville P, Sullivan MJL, de C Williams AC, Vervoort T, Fitzgerald TD. A biopsychosocial formulation of pain communication. Psychol Bull 2011;137:910–39.

[28] Harlow BL, Kunitz CG, Nguyen RH, Rydell SA, Turner RM, Maclehose RF. Prevalence of symptoms consistent with a diagnosis of vulvodynia: population based estimates from 2 geographical regions. Am J Obstet Gynecol 2014;210:e1–8.

[29] Harlow BL, Stewart EG. A population-based assessment of chronic unexplained vulvar pain: have we underestimated the prevalence of vulvodynia? J Am Med Womens Assoc 2003;58:82–8.

[30] Kappesser J, Williams AC. Pain estimation: asking the right questions. PAIN 2010;148:184–7.

[31] Katz J, Seltzer Z. Transition from acute to chronic postsurgical pain: risk factors and protective factors. Expert Rev Neurother 2009;9:723–44.

[32] Lehman AJ, Pratt DD, DeLongis A, Collins JB, Shojania K, Koehler B, Offer R, Esdaile JM. Do spouses know how much fatigue, pain, and physical limitation their partners with rheumatoid arthritis experience? Implications for social support. Arthritis Care Res (Hoboken) 2011;63:120–7.

[33] Leonard MT, Cano A, Johansen AB. Chronic pain in a couples context: a review and integration of theoretical models and empirical evidence. J Pain 2006;7:377–90.

[34] Leonard MT, Heller Issner J, Cano A, Williams AM. Correlates of spousal empathic accuracy for pain-related thoughts and feelings. Clin J Pain 2013;29:324–33.

[35] Lyons KS, Jones KD, Bennet RM, Hiatt SO, Sayer AG. Couple perceptions of fibromyalgia symptoms: the role of communication. PAIN 2013;154:2417–26.

[36] Miaskowski C, Zimmer EF, Barrett KM, Dibble SL, Wallhagen M. Differences in patients' and family caregivers' perceptions of the pain experience influence patient and caregiver outcomes. PAIN 1997;72:217–26.

[37] Muthén LK, Muthén BO. Mplus User's Guide. Los Angeles: Muthén & Muthén, 1998-2012.

[38] Pence LB, Cano A, Thorn B, Ward LC. Perceived spouse responses to pain: the level of agreement in couple dyads and the role of catastrophizing, marital satisfaction, and depression. J Behav Med 2006;29:511–22.

[39] Raichle KA, Romano JM, Jensen MP. Partner responses to patient pain and well behaviors and their relationship to patient pain behavior, functioning, and depression. PAIN 2011;1:82–8.

[40] Riesma RP, Taal E, Rasker JJ. Perceptions about perceived functional disabilities and pain of people with rheumatoid arthritis: differences between patients and their spouses and correlates of well-being. Arthritis Care Res 2000;13:255–61.

[41] Rosen NO, Bergeron S, Sadikaj G, Glowacka M, Baxter M, Delisle I. Relationship satisfaction moderates the associations between male partner responses and depression in women with vulvodynia: a dyadic daily experience study. PAIN 2014;155:1374–83.

[42] Rusbalt CE. A longitudinal test of the investment model: the development (and deterioration) of satisfaction and commitment in heterosexual involvements. J Pers Soc Psychol 1983;45:101–17.

[43] Sayer AG, Klute MM. Analyzing couples and families: multilevel methods. In: Bengston VL, Acock AC, Allen KR, Dilworth-Anderson P, Klein DM, editors. Sourcebook on family theory and research. Thousand Oaks: Sage, 2005. pp. 289–313.

[44] Schumm WP, Paff-Bergen LA, Hatch RC, Obiorah FC, Copeland JM, Meens LD, Bugaighis MA. Concurrent and discriminant validity of the Kansas Marital Satisfaction Scale. J Marriage Fam 1986;48:381–7.

[45] Sheppard C, Hallam-Jones R, Wylie K. Why have you both come? Emotional, relationship, sexual and social issues raised by heterosexual couples seeking sexual therapy in women referred to a sexual difficulties clinic with a history of vulval pain. Sex Relation Ther 2008;23:217–26.

[46] Simpson JA, Orina MM, Ickes W. When accuracy hurts, and when it helps: a test of the empathic accuracy model in marital interactions. J Pers Soc Psychol 2003;85:881–93.

[47] Smith KB, Pukall CF. Sexual function, relationship adjustment, and the relational impact of pain in male partners of women with provoked vulvar pain. J Sex Med 2014;11:1283–93.

[48] Van Damme S, Legrain V, Vogt J, Crombez G. Keeping pain in mind: a motivational account of attention to pain. Neurosci Biobehav Rev 2010;34:204–13.

[49] Verhoeven K, Crombez G, Eccleston C, Van Ryckeghem DM, Morley S, Van Damme S. The role of motivation in distracting attention away from pain: an experimental study. PAIN 2010;149:229–34.

[50] West TV, Kenny DA. The truth and bias model of judgement. Psychol Rev 2011;118:357–78.