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ARTICLE

The associations of sexual desire, daily stress, and intimacy in gay men in long-term relationships

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We investigated the associations between daily stress, sexual desire and intimacy in gay men in long-term relationships. A daily diary method of data collection was used. Twenty-two adult participants completed brief questionnaires ten times per day during seven consecutive days. Multilevel regression analyses revealed significant negative associations of daily stress with sexual desire ($p = 0.003$); higher stress came with lower levels of sexual desire, and vice versa. The hypothesized moderation effect of the associations of stress with sexual desire by intimacy was found significant ($p = 0.003$). However, the effect was not as predicted: at higher levels of intimacy the negative effect of stress on sexual desire was shown to be stronger than at lower levels. Most temporal associations of stress and intimacy with sexual desire were not significant. Nevertheless, the present findings implicate that daily stress and intimacy are important factors in sexual functioning of gay men in long-term relationships.

INTRODUCTION

Satisfaction with one's sexual functioning is an important determinant of individual wellbeing [1, 2], both in same-sex and mixed-sex relationships [3, 4]. Sexual desire in partnered individuals was found to predict sexual satisfaction in mixed-sex couples [5] as well as in male same-sex couples [6]. In the current study, we examined daily stress and intimacy as potentially relevant factors in the regulation of sexual desire in gay men in long-term relationships. Most previous findings on these topics were based on cross-sectional research among men and women in mixed-sex relationships, and are thus silent with regard to causality [7], and not necessarily representative for gay men [8]. The present study aimed to fill this gap by disentangling the interrelations in gay men between daily stress, sexual desire, and intimacy during the day and across multiple days, using high-frequent ecological momentary assessment methodology.

Several definitions of sexual desire have been proposed across recent decades, including expert definitions and those of participants in scientific research [9]. Influential definitions are those of Bancroft ('a state motivated towards the experience of sexual pleasure and possibly orgasm') [10] and of Janssen ('an emotional/motivational state that can be triggered by internal and external stimuli and that can be inferred from central (including verbal), peripheral (including genital), and behavioral (including action tendencies and motor preparation) responses') [11]. The stress construct comprises the event that causes stress, also called stressor, the body's response to such events, called stress response [12], and feelings of stress. Stress responses are any reaction to a stressor, both bodily and mental. When stress is experienced as an adverse event, it is called negative stress [13]. In the context of romantic relationships, external and internal stress are discerned [14]. External stress, also termed 'daily stress', is caused by factors outside the relationship. It can be the result of

high work pressure, arguing with colleagues or friends, stress in one's living environment, etc. Internal stress is caused by factors within the relationship, and can result from busyness at home, tensions or conflicts with the partner, negative communication patterns, illness of the partner, etc. Experiencing daily stress for a long time can cause relational stress, tensions and conflicts in the relationship [14–16]. Moreover, one partner's experience of stress influences the other partner's feelings [17, 18]. This interdependent process is the core tenet of the Systemic Transactional Stress Model [19]. This theoretic model emphasizes that stress always affects both partners, because mutual influence is inevitable [20].

Whereas acute stressors are transient, and their effects are often limited to a single situation, such as a sudden loud noise or dangerous weather conditions [21], chronic stressors are long-lasting in nature, and often involve minor everyday problems or concerns [14]. However, a chronic stressor can also involve major life events, such as illness of an important person, physical violence, death of a loved one, or divorce [22].

Whereas the effects of chronic and major life event stress on other important life aspects have been studied more extensively in gay men e.g., [23–25], strikingly little research has been conducted into the influence of daily stress on the sexual functioning of gay men in long-term relationships. Most prior research on the associations of daily stress and sexual functioning has been conducted in men and women in long-term mixed-sex relationships [15, 26–28]. In these populations, daily stress is robustly associated with sexual problems [26], specifically with an undesirably low level of sexual interest and low frequency of sexual activity [29]. This is consistent with Bancroft [30], who proposed the hypothesis that stress inhibits the sexual response in women. Bancroft and colleagues [31, 32] also investigated the associations of stress and sexual interest in heterosexual and gay men using in-depth interviews. The majority of the male

participants in their study experienced sex with their partner and masturbation as serving to reduce tension. Cross-sectional research has yielded conflicting findings. Among heterosexual women, Abedi and colleagues [33] found a similar negative association between daily stress and sexual desire, whereas a positive association was found between daily stress and sexual desire in a study among men and women [34]. Sexual functioning in women was found to be more responsive to daily stressors, compared to men [28]. There is increasing evidence suggesting that being in a same-sex relationship does make a difference in this respect [23, 35]. Several studies have shown that same-sex relationships are characterized by greater egalitarianism [36], and this may have implications for the way gay men cope with daily stress [35].

Whereas daily stress has been found to have both negative and positive effects on sexual functioning, intimacy primarily facilitates and improves sexual and relational functioning [37]. A longitudinal study of Rubin and Campbell [38] among men and women found that higher levels of intimacy were associated with more passion and higher odds of partnered sexual activity. Conversely, sexual contact provided more pleasure and stronger intimacy between the partners in this study. In addition, masturbation (solo or with the partner) was found to be associated with stronger feelings of intimacy [39]. In a study among community women, Birnbaum, Cohen and Wertheimer [40] found that sexual desire was positively associated with intimacy and sexual arousal. Baumeister and Bratslavsky [41] argued that not intimacy as such, but the increase in intimacy evokes sexual desire, and that this effect is stronger in men than in women. Multiple studies among men and women in same-sex and mixed-sex relationships have shown that feelings of intimacy buffer the negative impact of stress on relational satisfaction [42–44]. However, these studies were cross-sectional and therefore silent with regard to causality.

In summary, research into the association of daily stress, sexual desire, and intimacy in same-sex relationships has been scarce, and empirical findings are not fully consistent. Moreover, the temporal and causal connections between daily stress and sexual desire of gay men in long-term relationships are yet unknown. Longitudinal studies can provide strong suggestions for causal relationships.

The purpose of this study was to examine the associations among daily stress, sexual desire and intimacy in the daily lives of gay men in a long-term relationship, using ecological momentary assessment methodology (for a description, see Method, Research Design subparagraph). Because sexual desire often has a higher variability than, for example, sexual partner interaction or orgasm, its relationship with daily stress can be modeled more successfully See e.g., [45]. In long-term mixed-sex couples, sexual desire largely explained the relationship between intimacy and sexual activity [46]. In the current study we examined whether there is empirical support for temporal connections in both directions of the association of daily stress and sexual desire among men in same-sex relationships. We will investigate both momentary associations, where the predictor and the criterion variable are measured at the same point in time, and 'lagged' associations, where the predictor variable is measured, on average, 90 minutes before the measurement of the criterion variable. Additionally, we examined the role of intimacy. Can intimacy act as a buffer between daily stress and sexual desire? Intimacy is described as the experience of strong feelings of closeness, connectedness, and bonding [47] and can play a major role in emotion regulation within couples.

The central research question in the current study was whether daily stress is related to sexual desire, and whether intimacy moderates the relationship between daily stress and sexual desire. With regard to intimacy, we focused on short-term changes, as suggested by Baumeister and Bratslavsky [41]. We tested hypotheses using both cross-sectional data, measured at the same time, and lagged data, with criterion variables measured at time T and predictor variables measured at time T-1, to investigate temporal associations. The following hypotheses regarding the prediction of sexual desire by daily stress were tested on cross-sectional data: 1. There is a negative association between momentary stress and momentary sexual desire: higher stress comes with lower sexual desire; 2. The negative association of stress and sexual desire is moderated by momentary intimacy: at higher levels of intimacy, the negative association of stress and sexual desire becomes weaker. Hypotheses for the temporal model using lagged data were: 3. Lagged stress is a negative predictor of current sexual desire; 4. The negative prediction of sexual desire by lagged stress is moderated by lagged intimacy: at higher levels of lagged intimacy, the negative predictive effect of lagged stress on current sexual desire becomes smaller. The following hypotheses regarding the prediction of daily stress by sexual desire were tested on cross-sectional data: 5. There is a negative association of daily stress and momentary sexual desire: higher sexual desire comes with lower stress; 6. The negative association of daily stress and sexual desire is moderated by momentary intimacy: at higher levels of intimacy, the negative association of daily stress and sexual desire becomes stronger. The following hypotheses regarding the prediction of daily stress by sexual desire were tested on temporal data: 7. Lagged sexual desire is a negative predictor of current stress; and 8. The negative prediction of momentary stress by lagged sexual desire is moderated by lagged intimacy: at higher levels of lagged intimacy, the negative prediction of current stress by lagged sexual desire becomes stronger.

METHOD
Sample
Respondents were recruited through the first author's social network and the snowball method. To be eligible for participation in the study applicants (a) self-identified as gay, (b) had a romantic partner relationship of at least 6 months, (c) were at least 18 years of age, (d) spoke Dutch, and (e) had completed at least 8 years of education to ensure comprehension of the questionnaires. Anonymity and confidentiality was guaranteed because the respondents' data was provided with a research code, and data were entered into the database by a co-researcher who did not know the respondents.

Thirty-one potential participants were invited in a 10-month period in 2017–2018; 22 participants were retained for analysis in the sample. Of two couples, both partners participated; in the rest of the sample, one of a couple's partners participated. One participant did not complete the online demographic questionnaire. The average age of the respondents was 47.6 years ($SD = 12,4$; range 23–66). Most participants lived together with their partner and were not married (67%). Mean relationship duration was 12.8 years ($SD = 11.4$). Of the respondents, 25.6% had completed primary or secondary education and 73.7% had higher education. The study design and method were approved by the Ethics Review Board of the Open University (ECP U201106015). Written informed consent of all participants was obtained prior to participation.

Research design
Short-term changing emotion processes can be investigated with the Experience Sampling Method (ESM) [48]. This ecologically valid method of data collection has demonstrated feasibility, validity, and reliability in both the general healthy population and clinical populations [49, 50]. It consists of several measurements per day for several days in a row while participants go about their everyday lives. The high frequency of measurements in ESM allows for the investigation of fluctuations in stress, sexual desire and intimacy, as these are expected to change rapidly during the day. ESM furthermore reduces the risk for memory bias, creating an advantage over one-off retrospective self-reports [51]. The way different levels of stress and feelings of intimacy interact with sexual desire is optimally investigated with ESM as it provides a representative picture of these processes within the context of everyday life [49, 52].

Procedure
The participants completed a one-off demographic questionnaire online. During study participation they wore a digital watch that sounded an

audible signal ('beep') at ten quasi-random times per day ('beep moments'). Between 7.30 am and 10.30 pm ten time windows of 90 minutes were construed. Randomly within each time window one beep sounded, prompting respondents to complete a short paper-and-pencil questionnaire immediately after the 'beep'. They also recorded the exact time of completion. All questionnaires for the entire participation period were included in a small-size diary with the items of each registration moment divided over two adjacent pages. Only the questionnaires of participants who validly completed more than 24 questionnaires of the maximum of 70 possible reports were included in the analyses [53]. A questionnaire was considered valid if it was completed within 15 minutes after the beep. To check this, the respondent was asked about the time of filling in. When completed later, the answers are less reliable [53]. Based on these criteria data of all participation were retained for analysis.

Instruments

Daily stress. External daily stress was measured at the beep level on 7-point Likert scales (1 = not, 7 = very). In line with previous studies, the Daily Stress variable was calculated as the average of scores on five items that measured stress, namely activity-related stress (2 items), social stress (2 items) and event-related stress (1 item) [54, 55]. Three questions addressed activity-related stress. The first was intended to make the respondent think about the most relevant activity since the previous beep: 'What am I doing now?' The scores for the next two items were included in the daily stress variable: 'I'd rather do something different' and 'it takes a lot of effort'. Three questions addressed social stress. The first was again an orienting question 'Who am I with?' Answer options were: 'with partner/ alone/with friends/with colleagues/with strangers/other'. The scores for the next two items were included in the daily stress variable: 'I'd rather be alone', and 'I like this company'. Two questions addressed event-related stress. The first was intended to make the respondent think about the most important event since the previous beep. The score for the next item was included in the Daily Stress variable: 'This event was 1 = very unpleasant to 7 = very pleasant'. Positive responses were recoded as 1 and negative responses as 7, so that high scores reflected more unpleasant and potentially stressful events. The scores of the five items were averaged to calculate a total Daily Stress score (scoring range 1–7). The intercorrelations of the five items were moderate to high, ranging between .44 and .82. At the person level, the estimated reliability, McDonald's ω [56] was 0.85. At the beep level, McDonald's ω was 0.64. A multilevel confirmatory factor analysis (MCFA) was performed on the 13 items of the three beep level variables that were used in this study (reported below). The MCFA confirmed Daily stress as a separate factor.

Sexual desire. Sexual desire was measured at the beep level on 7-point Likert scales (1 = not, 7 = very). The three items were: Right now,… 'I feel like having sex', 'I feel sexually excited' and 'I am open to sexual initiative'. These items reflect the consensus of sex research [46] and are based on previous empirical work [57, 58]. The scores of the items were averaged to calculate a total Sexual Desire score (scoring range 1-7). The intercorrelations of the items were high, ranging between 0.82 and 0.95 ($p < 0.001$). At the person level, McDonald's ω [56] was 0.95. At the beep level, McDonald's ω was 0.92. The MCFA confirmed Sexual desire as a separate factor (see report of the MCFA below).

Intimacy. Intimacy was measured at the beep level using 7-point Likert scales (1 = not, 7 = very). Item wordings were based on Sternberg's [47] description of state intimacy: With regard to my partner, I now feel … 'Intimacy', 'Connectedness', 'Love', 'Tenderness', 'Warmth'. For all items a higher score indicated a higher level of intimacy. The scores of the five items were averaged to calculate a total Intimacy score (scoring range 1-7). The intercorrelations of the five items were high, ranging between 0.82 and 0.97. At the person level, McDonald's ω [56] was 0.96. At the beep level, McDonald's ω was 0.91. The MCFA confirmed Intimacy as a separate factor (see report MCFA below).

Factor analysis of the beep level variables. Multilevel confirmatory factor analysis (MCFA), using the "lavaan" package [59] within the R-environment [60], confirmed that the a priori expected factor structure fitted the data well. Daily stress, Sexual desire and Intimacy were established as three separate factors. A total of 13 items were included in the MCFA. The fit measures for the factor analysis were: Comparative Fit Index = 0.92, Tucker Lewis Index = 0.90, Root Mean Square Error of Approximation = 0.07, and Standardized Root Mean Square Residual = 0.08 (within) and 0.10 (between).

Statistical analysis

The collected measurements contained a hierarchical data structure. Although only beep level variables were used in hypothesis testing, multilevel models (MLM) were used to account for dependence of observations within the same person. For descriptive purposes, person averages of beep level variables were calculated and correlations between these averages and demographic variables were assessed. For each participant also a sum score of sexual activity in the week of research was calculated. Missing beep scores are generally treated as missing cases in multilevel analyses, and case-wise deletion was applied [61]. In the multilevel analysis the beep-level variables Stress, Sexual Desire and Intimacy were centered around the person mean [62].

Multilevel analysis implies that for every respondent a different intercept was included (random intercept). However, for each respondent also the association between predictors and outcome can differ. It was tested in each MLM if this was the case and a separate regression coefficient for each respondent was included if variance in regression coefficients led to a significant improvement of the model (random slopes). Only non-significant improvement of the models will be reported and, consequently, such models will not contain random slopes. They represent effects of predictors on outcome that do not differ between respondents.

Of the eight models that were used to test hypotheses, the first four models had Sexual desire as the outcome variable. Sexual desire was predicted by Stress and Intimacy (H1) and, in a follow-up model, by the interaction of Stress and Intimacy (H2). Significance of the interaction models was tested by assessing the improvement of the model without interaction by a model with interaction. Next, Sexual desire was predicted by lagged Stress and lagged Intimacy (H3), and by the interaction of lagged Stress and lagged Intimacy (H4). Lagged variables represent the same variable but then measured one measurement moment earlier during the day. The first measurement of each day is excluded from the lagged analyses. Lagged analyses allowed for the assessment of short-term temporal associations between beep level variables. Note that the temporal analyses also included the autoregressive effect of the predictor. In the case of testing H3 and H4 this means that lagged Sexual desire was also included in the model. In previous studies, sexual desire was found to linger for longer periods of time during the day, and the level of sexual desire at a previous measurement moment was found to be a relevant predictor of sexual desire at subsequent measurements that needed to be controlled for. e.g., [45].

Hypotheses 5 till 8 were tested with models that had Stress as outcome variable, predicted by Sexual desire and Intimacy (H5) and the interaction of Sexual desire and intimacy (H6). Next, Stress was predicted by lagged Sexual desire and lagged Intimacy (H7) and the interaction of lagged Sexual desire and lagged Intimacy (H8). In the lagged analyses lagged Stress was also included.

We performed power analyses for the main effects hypotheses (H1, H3, H5 and H7), based on estimates for these effects for similar data that is openly available (https://osf.io/3yfbx/). These openly available data were also collected using ESM and almost the same set of questionnaires was used. However, that sample consisted mainly of heterosexual respondents in long-term relationships, and it is not clear beforehand if differences between the current sample from an MSM population and the previously sampled population might be expected for the investigated associations. We therefore used estimates for residual and intercept variance twice as large as found in the previous sample. For the power analyses we used the app PowerAnalysisIL which was specifically developed for power analysis for data collected using experience sampling methodology [63]. We used model 4, which consists of one beep level predictor, with random intercepts modelled at the person level. Using a fixed slope of 0.14, SD of level-1 residuals of 1.5, SD of random intercepts of 1.5 and SD of the predictor of 1. The power analyses showed that for the four main effect hypotheses, a sample of at least $N = 17$ would suffice to attain a power of 0.8 or higher.

RESULTS
Preliminary results
Average sexual desire level in the current sample was 2.4 and average sexual activity was 6.5 times per week. Intimacy scores were on average 4.7 in the current sample, on a scale from 1 to 7, suggesting that, on average, respondents feel that they are intimately involved with their partner. Stress levels were on average 2.1, which can be considered low. A rather high number

of previous sexual partners was reported. This high number is partly due to six respondents reporting 200 or more previous sexual partners. If these respondents are excluded, the average number of sexual partners in life is 11.9 ($SD = 6.6$). Correlations between beep level and demographic variables showed that if respondents experienced higher person average levels of stress that they reported less sexual activity ($r = -0.56$, $p = 0.01$). Furthermore, correlation analyses revealed that sexual desire and sexual activity did not strongly correlate ($r = 0.12$, $p = 0.60$), suggesting that higher sexual desire (averaged over the week) does not translate into more sexual activity in that week in this sample. Descriptive statistics of the variables of interest are shown in Table 1.

Person level averages of beep level variables are reported in Table 1. At the beep level these variables showed sufficient variance to warrant inclusion in the multilevel analyses. The beep level variance of stress (not shown in Table 1) was 0.93, of sexual desire it was 2.66, and the beep level variance of intimacy was 2.29. The beep level correlation is the correlation between scores of the three key variables at the same measurement moment. The beep level correlation between stress and sexual desire (not shown in Table 1) was -0.09 ($p = 0.01$), between stress and intimacy it was -0.37 ($p < 0.001$), and between sexual desire and intimacy it was -0.02 ($p = 0.48$).

Predicting sexual desire from daily stress and intimacy

The results of the multilevel regression analyses of contemporaneous data and temporal models predicting sexual desire are summarized in Table 2. Contemporaneous MLRA revealed that higher level of daily stress was associated with lower sexual desire (estimate = -0.26; SE = 0.08; $p = 0.003$). Hypothesis 1 was supported. Intimacy was not a significant predictor of daily stress (estimate = 0.22; SE = 0.17; $p = 0.22$). However, when the interaction of daily stress and intimacy was added to the model with only main effects, intimacy was found to moderate the negative association of daily stress with sexual desire (estimate = -0.19; SE = 0.06; $p = 0.003$): at higher levels of intimacy the negative effect of daily stress on sexual desire was stronger than at lower levels. This is not in accordance with Hypothesis 2, which was therefore rejected. However, when looking at the moderation in more detail, when daily stress levels were very low, higher levels of intimacy were associated with higher sexual desire (Fig. 1). Only when stress levels were above average, higher levels of intimacy were associated with lower sexual desire.

Predicting sexual desire from lagged data on daily stress and lagged intimacy

Temporal MLRA showed that lagged stress did not predict current sexual desire in a model containing only main effects (estimate = -0.03; SE = 0.06; $p = 0.67$). Hypothesis 3 was rejected. Lagged sexual desire was a significant predictor of current sexual desire in this model, however (estimate = 0.54; SE = 0.06; $p < 0.001$), but lagged intimacy was not (estimate = 0.004; SE = 0.06; $p = 0.93$). The effect of lagged stress and lagged intimacy did not vary significantly between respondents. Therefore, no random slopes for these effects were added to the model. When the interaction of lagged stress and lagged intimacy was added to the model with only main effects, this did not lead to a significant improvement of the model containing only main effects (estimate = -0.05; SE = 0.06; $p = 0.37$). Hypothesis 4 was rejected.

Predicting daily stress from sexual desire and intimacy

Current sexual desire was a negative predictor of current daily stress in a model containing only main effects (estimate = -0.09; SE = 0.02; $p < 0.001$); higher sexual desire was associated with lower levels of stress. Hypothesis 5 was supported. Intimacy was also a significant negative predictor of sexual desire (estimate = -0.26; SE = 0.06; $p < 0.001$); higher levels of intimacy came with

Table 1. Descriptives of key variables at the person level and demographic variables.

Descriptives (min–max)	Mean (SD)	Range	Sexual Desire	Intimacy	Relationship duration	Age	Lifetime Partners	Sexual activity
Daily Stress (1–7)[a]	2.1 (0.6)	1.2–3.7	0.20/p = 0.38	−0.27/p = 0.22				−0.56/p = 0.01
Sexual Desire (1–7)[a]	2.4 (0.9)	1.1–3.9		−0.20/p = 0.38				
Intimacy (1–7)[a]	4.7 (1.4)	1.7–6.8				0.47/p = 0.03		
Relationship duration	12.8 (11.4)	1–47					0.53/p = 0.02	
Age	47.7 (12.4)	23–66						
Number of lifetime partners	96 (149)	1–500						0.46/p = 0.04
Sexual activity (per week)	6.5 (5.1)	1–24						

SD Standard deviation.
[a]The mean of the person level averages of each beep level variable is reported. Only significant correlations are reported.

Table 2. Overview of results for the models used to test the hypotheses.

Variables in the model		Estimate [SE]	*p*-value	Model improvement*
Outcome	Predictors			
Sexual Desire (H1)				
	Daily Stress	−0.26 [0.08]	0.003[a]	–
	Intimacy	0.22 [0.17]	0.22	
Sexual Desire (H2)				$\chi^2(1) = 8.8$
Added To Previous Model	Daily Stress * Intimacy	−0.19 [0.06]	0.003	$p = 0.003$
Sexual Desire (H3)				
	Lagged Daily Stress	−0.03 [0.06]	0.67	–
	Lagged Intimacy	0.004 [0.06]	0.93	
	Lagged Sexual Desire	0.54 [0.06]	<0.001	
Sexual Desire (H4)				$\chi^2(1) = 0.8$
Added To Previous Model	Lagged Daily Stress * Lagged Intimacy	−0.05 [0.06]	0.37	$p = 0.37$
Daily Stress (H5)				
	Sexual Desire	−0.09 [0.02]	<0.001	–
	Intimacy	−0.26 [0.06]	<0.001	
Daily Stress (H6)				$\chi^2(1) = 1.3$
Added To Previous Model	Sexual Desire * Intimacy	−0.03 [0.02]	0.24	$p = 0.25$
Daily Stress (H7)				
	Lagged Sexual Desire	−0.02 [0.03]	0.51	–
	Lagged Intimacy	−0.09 [[0.06]	0.19	
	Lagged Daily Stress	0.32 [0.05]	<0.001	
Daily Stress (H8)				$\chi^2(1) = 3.1$
Added To Previous Model	Lagged Sexual Desire * Lagged Intimacy	−0.05 [0.03]	0.07	$p = 0.08$

*There can be a slight difference in *p*-value between the estimate of the interaction effect and the model improvement, as regression coefficients within the models were assessed with *t*-tests, and for model comparisons Chi-square-tests were used.
[a]Significant *p*-values in bold face.
Note that in models with interactions, main effect estimates only apply when the other main effect in the interaction is equal to zero. In the case of a significant interaction, such estimates would be misleading; in the case of non-significance of the interaction, such estimates would not greatly differ from estimates in a model without interaction. Therefore, and to avoid overload, these estimates have not been included.

lower stress levels. No random slopes were needed for sexual desire, indicating that the effect of sexual desire on stress did not vary significantly between respondents. Adding the interaction between sexual desire and intimacy to the model containing only main effects did not result in a significant improvement of the model, indicating that intimacy did not moderate the effect of sexual desire on daily stress (estimate = −0.03; SE = 0.02; *p* = 0.24). Hypothesis 6 was rejected.

Predicting daily stress from lagged sexual desire and lagged intimacy
Temporal MLRA showed that lagged sexual desire did not predict current stress (estimate = −0.02; SE = 0.03; *p* = 0.51). Hypothesis 7 was rejected. Lagged stress, however, was a significant predictor (estimate = 0.32; SE = 0.05; *p* < 0.001), while lagged intimacy was not a significant predictor of stress (estimate = 0.09; SE = 0.06; *p* = 0.19). No random slope effects were needed for any of the lagged predictors. This signifies that the effect of lagged sexual desire, lagged intimacy and lagged stress on current stress did not vary significantly between respondents. Adding the interaction of lagged sexual desire and lagged intimacy to the model with only main effects did not improve the model, indicating that lagged intimacy did not moderate the effect of lagged sexual desire on current stress (estimate of interaction = −0.05; SE = 0.03; *p* = 0.07). Hypothesis 8 was therefore rejected, although the interaction effect borders on being significant. Visual inspection of

the interaction plot (Fig. 2) seems to indicate that higher levels of lagged intimacy lead to a stronger negative effect of lagged sexual desire on current stress. For these levels of lagged intimacy, an increase in lagged sexual desire seems to forecasts a decrease in current stress. Contrarily, at low levels of intimacy an increase in lagged sexual desire seems to forecast an increase in current stress. As stated, however, this interaction effect was not significant.

DISCUSSION
The aim of the current study was to investigate the relationship of daily stress to sexual desire and intimacy in gay men in long-term relationships. The results of cross-sectional analyses of the data showed that higher daily stress was associated with lower sexual desire, as hypothesized. These associations are consistent with the findings from the studies of Bodenmann and colleagues [29] and Bancroft [30], and imply that psychological stressors negatively influence the sexual functioning of gay men in long-term relationships. Daily stress can divert attention away from sexual stimuli, as a result of which the sexual response is insufficiently deployed. Previous research also provided support for this explanation. Gay men who reported a decrease in sexual interest in in-depth interviews described how they focused on dealing with stress [32]. In a laboratory study, it was shown that cognitive distraction decreases genital and subjective sexual arousal in
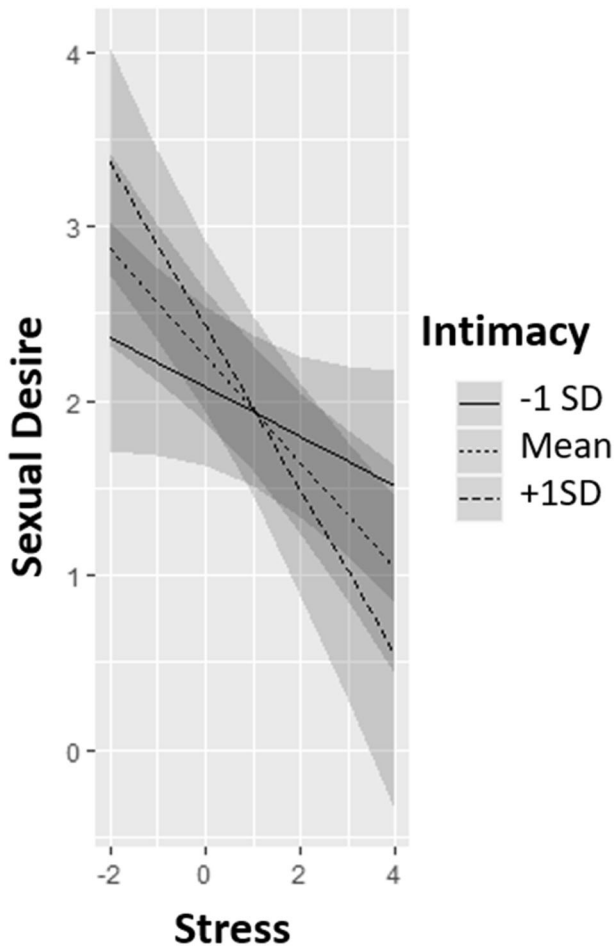
Fig. 1 Moderation of the effect of stress on sexual desire by intimacy. Predictors are centered around person level means.

Fig. 2 Moderation of the effect of lagged sexual desire on stress by lagged intimacy. Predictors are centered around person level means.

heterosexual men [64]. In contrast, the results deviate from the research findings of Ein-Dor and Hirschberger [27] and Boden-mann and colleagues [15]. The results of these last two studies suggest that sexual activity in men in particular increases when stress levels are high. However, these studies investigated mixed-sex relationships. Much less is known about how the stress-sex link may differ for men in same-sex relationships.

In addition to the main effect of stress on sexual desire, intimacy was found to moderate the effect of daily stress on sexual desire, with a stronger negative effect of stress on sexual desire at higher levels of intimacy. However, this contradicted our hypothesis that stress and intimacy would push in opposite directions, allowing intimacy to buffer the negative impact of stress on sexual desire. Instead, intimacy and daily stress seem to reinforce one another at higher levels of stress. Only when stress is almost absent, higher intimacy is associated with higher sexual desire. Speculative explanations could be that increased stress disrupts the expecta-tions to have sex at higher levels of intimacy, or that increased stress at higher intimacy levels takes away the focus from sexual desire but might instead lead to relational coping mechanisms (having a good talk, etc.). Intimacy seems only to promote sexual desire in most relaxed states.

Contrary to expectations, the temporal MLRA showed that lagged daily stress and lagged intimacy did not predict sexual desire, and no interaction effects of sexual desire and intimacy on daily stress were found. Although the sample size in the current study was sufficient for detecting the estimated effects of medium size, the resulting statistical power may have not allowed to
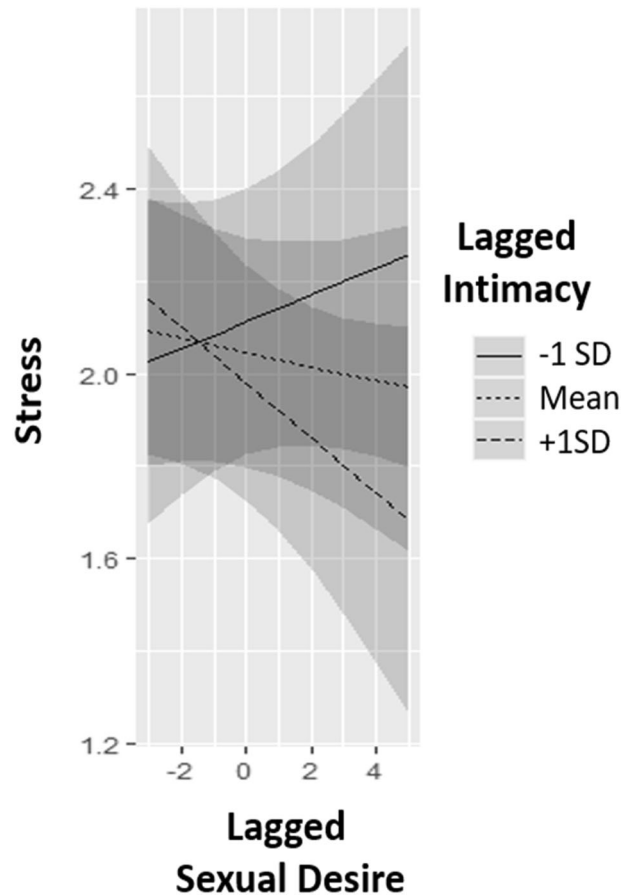
identify smaller-size lagged effects. Previous research in sexuality using experience sampling methodology has demonstrated decreasing effect sizes as the interval between the measurements of the concepts of interest increase [46]. The mean 90-minute interval between measurements in the current study may not have allowed to show any effects of associations with shorter survival time. Future studies using experience sampling metho-dology might use shorter between-measurement intervals.

As hypothesized, in cross-sectional analysis both sexual desire and intimacy were found to predict daily stress. However, contrary to the hypothesis, no interaction effects of sexual desire and intimacy were found that added to the prediction of daily stress. Both seem to act as independent factors that mitigate daily stress. Furthermore, lagged sexual desire and lagged intimacy did not predict current stress levels, refuting our hypothesis.

The current study did not provide empirical support for causality in both directions of the association of daily stress and sexual functioning among gay men, based on prediction using lagged data. Several speculative explanations can be suggested for this failure to find the expected associations of stress and sexual desire. It may be that this association only exists at lower stress levels; the stress level of gay men could simply be too high, partly as a result of chronic minority stress, referring to stress that is uniquely associated with the membership of socially stigma-tized groups [65]. Or as the Transactional Stress Model [20] emphasizes, it is partly a result of the interdependence and reciprocity between partners, meaning that stress of one partner always affect the other partner. Moreover, the daily stress as operationalized in the current study may not have as strong an

association with sexual functioning as the types of stress in previous research on this topic [15, 27].

The results of cross-sectional analysis of the data also showed that intimacy was positively associated with sexual desire. Similar associations have been found in previous cross-sectional studies of Bodenmann and colleagues [29] and Stephenson and Meston [2]. These findings are in line with the theory of Basson [66] who postulated that sexual motivation is mainly driven by the desire for intimacy with the partner. Basson's hypothesis was initially aiming to account for variability in women's sexual desire, but was later also found to also explain sexual functioning in men [67]. This means that the need for intimacy ensures that people are willing to open themselves up for sexual stimuli that activate their sexual system. Our results show that intimacy is also important for the sexual functioning of gay men in long-term relationships, as previously found for heterosexual men and women [2, 38, 46].

While previous research has shown that intimacy can serve as a buffer against the negative influence of stress on relationship satisfaction in both same-sex and different-sex relationships [42, 43], the current findings do not support this hypothesis for gay men in long-term relationships.

Limitations, strengths, and implications of the study

A number of limitations should be taken into account when interpreting the current findings. The Experience Sampling Method in this study used self-reporting for data collection. A limitation of self-reporting is that the researcher must rely on the respondent's honesty and motivation [68]. Completing the questionnaires incorrectly or inaccurately could give a distorted picture. However, it has been shown that respondents' compliance with ESM research is good [50]. Another limitation of the study concerns the representativeness of the sample, which was not randomly drawn from the population. The respondents were recruited from the researchers' social network. It is also conceivable that respondents who cooperated differ from non-respondents. This may have led to volunteer bias [69], reducing the generalizability of the results to clinical samples or the gay population at large. A final limitation concerns the measurement of daily stress. The chosen operationalization of daily stress does not take all possible stressors into account that participants might experience, such as stressors that are specific to gay men as a minority group, including stigmatization, prejudice and discrimination based on sexual orientation [70]. We also did not investigate the relationship with internal stress factors that are related to the relationship with one's partner. Another limitation to the external validity of our findings is the strict focus on the psychological perspective, which ignores the contextual and cultural origin of stressors, including stressors that are specific to minority groups such as gay men.

Despite these limitations, this research makes a unique contribution to the study of the associations between daily stress and various aspects of the sexual functioning and intimacy of gay men in a long-term relationship. Firstly, it is one of the few studies that provides insight into the feelings, activities and thoughts related to daily stress and sexual desire in the context of daily life. Second, by applying the Experience Sampling Method, recall bias is avoided as ESM samples experiences at the moment they occur [71], and does not rely on retrospective self-reports [51]. Finally, the results may help to unravel complex processes related to daily stress, sex and intimacy in men in same-sex relationships. This could help researchers and sexual health care providers to understand such processes.

DATA AVAILABILITY

The data and SPSS syntax to analyze it are available at: https://osf.io/3yfbx/.

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AUTHOR CONTRIBUTIONS

COMPETING INTERESTS

ADDITIONAL INFORMATION