

# Induction of Sexual Arousal in Women Under Conditions of Institutional and Ambulatory Laboratory Circumstances: A Comparative Study

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## ABSTRACT

**Introduction.** Measuring under naturally occurring circumstances increases ecological validity. We developed an ambulatory psychophysiological laboratory that allows experiments to be performed at home.

**Aims.** To compare institutional laboratory task measures with ambulatory laboratory task measures.

**Main Outcome Measures.** Vaginal pulse amplitude (VPA), clitoral blood volume (CBV), subjective report of sexual arousal, preconscious attentional bias for erotic stimuli, subjective reports about feeling at ease, tense, anxious or inhibited.

**Methods.** VPA and CBV were measured in eight women with hypoactive sexual desire disorder (HSDD) and eight healthy controls while exposed to neutral and erotic film clips both in the institute's laboratory and at home. Before and after film clip presentations, subjects performed an emotional Stroop task and completed two questionnaires.

**Results.** In healthy controls, genital measures of sexual arousal were significantly increased at home compared with the institutional laboratory, whereas no differences were observed between the institutional laboratory and the at home measurements in women with HSDD. The responses at home were significantly higher in healthy controls compared with women with HSDD. Subjective experience of genital responding increased at home for both groups of women. Concordance between subjective experience and genital sexual arousal was more pronounced in the institutional laboratory setting. Preconscious attentional bias was stronger in the institutional laboratory for both groups of women. Healthy controls felt more at ease and less inhibited at home while subjects with HSDD did not.

**Conclusions.** The use of an ambulatory laboratory is a valuable tool allowing psychophysiological (sex) research under more natural circumstances (e.g., a participant's home). In this study, the increase in ecological validity resulted in a qualitative differentiation between the healthy controls and the women with HSDD in the home setting, which is not apparent in the artificial setting of the institutional laboratory. **Bloemers J, Gerritsen J, Bults R, Koppeschaar H, Everaerd W, Olivier B, and Tuiten A. Induction of sexual arousal in women under conditions of institutional and ambulatory laboratory circumstances: A comparative study. J Sex Med \*\*;\*\*.\*\*\*\_\*\*.**

**Key Words.** Ambulatory Laboratory; Ecological Validity; Hypoactive Sexual Desire Disorder; Clitoral Blood Volume; Inhibition; Genital Measures of Sexual Arousal

## Introduction

In sex research, it might be desirable to measure physiological and subjective sexual responses in the domestic environment of the participants. We introduce an ambulatory psychophysiological

laboratory by which experiments can be performed under more naturally occurring circumstances (e.g., at home without the presence of an experimenter). This ambulatory laboratory can be fully controlled by a participant. Furthermore, new technological developments in remote data

collection made it possible to securely send parallel data streams to a central database in real time. Conclusions of an empirical investigation using this methodology can be generalized with more confidence to the naturally occurring situations in which the phenomenon under investigation occurs (ecological validity) [1] because the measurement takes place in the natural environment [2].

Induction of sexual arousal and execution of sexual behavior results from a delicate balance between excitatory and inhibitory mechanisms [3,4]. Sexual cues, including erotic thoughts or erotic movies may activate sexual excitatory mechanisms. Other factors, like stress, sexual performance related concerns or sexual satiety might evoke inhibitory mechanisms. Contextual factors like environmental setting, physical health, and mood state also influence the induction of sexual inhibition or excitation in women [5]. Individual differences in the sensitivity for activation in such excitatory and inhibitory mechanisms induced by particular stimuli or cues are also likely to exist.

Various procedures have been used to influence sexual excitation and/or inhibition in the laboratory. A relatively straightforward and common method to induce sexual excitation in the laboratory is by exposing subjects to erotic film clips. Attenuation of the physiological and subjective sexual response is less straightforward, but has been induced in the laboratory through different subtle experimental manipulations. For example, during viewing of erotic film clips, the installment of undemanding cognitive distraction [6,7], seeing one's reflection in the mirror [8], inducing the feeling of being watched [9], and monitoring one's sexual arousal (at least in men) [10] can attenuate or inhibit genital and subjective sexual arousal. These findings illustrate that relatively noninvasive psychological manipulations can shift the delicate balance between excitatory and inhibitory factors influencing the sexual response. This implies that systematic factors present in the institutional sex laboratory setting—such as presence of an experimenter in the other room, or the unfamiliar artificial situation—might influence the sexual response in an unknown manner, and thus bias the results.

Vaginal photoplethysmography has been widely used to measure the genital response to erotic stimuli (e.g., exposure to erotic film excerpts). This measurement method has been validated as specific to erotic stimuli [11]. Recently, we introduced the clitoral photoplethysmograph for the measurement of clitoral blood volume (CBV) [12]. This

measure appeared more sensitive to inhibitory influences on the sexual response. Moreover, it may also be a more valid measure of sexual arousal because it measures engorgement of the clitoral and surrounding tissues (see Gerritsen et al. [12] for a discussion on this matter).

Questionnaires are often used in the laboratory to assess subjective arousal. Experiments in men mostly show high concordance between their physiological and subjective arousal, and as a result these subjective measures are more valid in men [13,14]. In women this relationship is less clear, frequently showing discordance between measures of genital and subjective arousal [14–17]. This may be (partly) attributable to the measurement method. Studies using, e.g., thermography as a measure of genital arousal and a lever to indicate subjective arousal, report significant correlations between the two [18,19]. Significant correlations are also reported between laser Doppler imaging and post-stimulus subjective report [20]. It may, however, also be (partly) attributable to measurement setting.

To measure aspects of cognitive–affective information processing of sexual cues, the emotional Stroop task [21,22] may be used. In this task, subjects are instructed to name the color in which emotional and neutral stimuli are printed as quickly as possible while ignoring the meaning of the word. The motivational state of the subject and the emotional content of the stimuli determine the performance on this task in terms of slowing down or speeding up in color naming [23]. Attentional bias for emotional cues is demonstrated when color-naming latencies for emotional stimuli are greater or smaller than color-naming latencies for neutral stimuli. A masked version of this task turned out to be a more reliable measurement of (preconscious) attentional bias for emotional cues [21,22]. It has been suggested that automatic cognitive processes can lead to activation of a genital response when a sexual meaning is present, and that can lead to low levels of sexual arousal and/or the presence of negative affect when other sexually neutral or negative meanings are present [24]. Preconscious attentional bias for erotic cues may reflect such an automatic process and thus possibly influence (the relationship between) physiology and subjective experiences.

General sexual functioning can be measured by structured interviews and validated trait questionnaires such as the Female Sexual Functioning Questionnaire (SFQ) [25]. The SFQ assesses sexual functioning in the domestic setting and can

be used to diagnose different types of female sexual dysfunction (FSD). Studies comparing women with different FSD diagnoses and healthy controls did not find consistent differences in genital or subjective arousal in the laboratory [17,26,27] (although Brotto et al. [26] did find differences between subgroups of patients suffering from female sexual arousal disorder). This lack in group differences in the laboratory is in stark contrast to the reported differences in the real-life experience of these women. This may be a result of a variety of factors, one of which can be that laboratory specific circumstances are different from domestic circumstances. The aforementioned systematic factors inherent to the laboratory may influence the balance between excitatory and inhibitory mechanisms and may conceal group differences. To our knowledge, these discrepancies in observations in the institutional laboratory settings compared with the real-life experience of these groups have not been investigated before.

In the present study, we investigated the influence of the measurement setting (the institutional laboratory vs. the domestic measurement setting) on indices of physiological and subjective sexual responding. We investigated sexual responses in women suffering from hypoactive sexual desire disorder (HSDD) and in a control group of sexually functional women (healthy controls). We believe that the domestic setting might have fewer cues that initiate or sustain inhibitory mechanisms, although we are uncertain about the effects of the sexual history of the women with HSDD at home. We therefore hypothesized that both groups of women would (i) show more attention for subliminally presented erotic stimuli (as measured by a masked version of the Emotional Stroop Task), (ii) show more genital sexual arousal (as measured by vaginal pulse amplitude [VPA] and CBV), and (iii) experience stronger sexual arousal (as measured by the Sexual Arousal Response Self Assessment Questionnaire [SARSAQ]) at home. In addition, we hypothesized that all these effects would be more pronounced in healthy controls, because women with HSDD might have a less sensitive and/or less responsive system for sexual excitation or be more susceptible to activation of inhibitory mechanisms [3,4].

## Method

### Participants

Twenty premenopausal heterosexual women were recruited in order to include a total of eight

women with HSDD and eight healthy controls for participation in this study. They were selected from our database of women who had participated in previous studies. All participants underwent a new intake procedure. Participants were diagnosed for HSDD according to Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, Text Revision (DSM-IV-TR) criteria. All participants signed a written informed consent and received €120 reimbursement for their participation. This study was approved by the local ethics committee (Stichting Therapeutische Evaluatie Geneesmiddelen Medisch Ethische Toetsingscommissie, Almere, The Netherlands), carried out in agreement with the International Conference Harmonization-Good Clinical Practice and monitored by a contract research organization (PSR Group, Hoofddorp, The Netherlands).

### Apparatus and Stimuli

#### VPA and CBV

VPA was measured using a vaginal photoplethysmograph, a tampon-shaped device containing an infrared light-emitting diode (LED) and a photosensitive light detector (photodiode). The cabling is protected with silicon tubing. An additional clitoral photoplethysmograph is attached to the silicon tube (see no. 2 in Figure 1—section “Ambulatory laboratory”) to measure CBV. The shape of the clitoral probe follows the anatomical curves of the area surrounding the urethral opening up to the clitoris, between the labia minora and just above the introitus. The distance between the clitoral probe and the vaginal photodiode is 5 cm and the vaginal probe is rotated 30° clockwise, as seen from behind the clitoral probe. The LED and photodiode for the clitoral probe are located inside the clitoral probe. In order to target the left clitoral bulb, the LED and photodiode are set at an angle of 45°, pointing to the right, as seen from behind the clitoral probe. The clitoral photoplethysmograph used in this study is an improved version of the one described in Gerritsen et al. [12]. The main difference between both clitoral photoplethysmographs is that the present one emits and receives the light through a LED and photodiode that are located inside the clitoral probe instead of in an external connection box with optical cables, which transport light to and from the probe. This improvement makes the probe easier to handle and more sturdy.

#### Stimuli

For this study, neutral, erotic foreplay, and hard-core film clips were used. Neutral clips were

6-minute and 2-minute clips from Dutch action films. The 6-minute neutral film clips were used to establish a baseline VPA. Erotic foreplay clips were 2-minute clips (two versions) showing kissing, caressing, and cunnilingus, but no fellatio. Erotic hardcore clips were 2-minute clips (two versions) showing cunnilingus and coitus, including visible penetration. The erotic film footage was selected and edited by female researchers. The hardcore footage was edited in order to meet the following criteria: the first 20–30 seconds consist of foreplay scenes with kissing, caressing, and cunnilingus but not fellatio; only heterosexual couples were shown, and visible vaginal intercourse was shown within 30 seconds following onset of the clip. Stroking of the penis and fellatio were not included, as these behaviors have been shown to be rated as less arousing by women [28]. Edited clips were judged by the other female investigators and female research assistants. All digitally sampled film clips were presented using Presentation software (Neurobehavioral Systems, Albany, CA, USA).

#### Emotional Stroop Task

To measure preconscious attentional bias for sexual cues, a masked version of the emotional Stroop task was used [21–23]. In this task, words were presented for 26.6 ms in four different colors (red, green, blue, and yellow) on a 75 Hz computer screen (Liteon Technology Corp., Taipei, Taiwan), or on a Dell Latitude D531 laptop (Dell Inc, Round Rock, TX, USA) for the domestic measurement setting, set at a 75 Hz refresh rate. Words were backwardly masked by randomly cut and reassembled letters in the same color. Backward masking prevents conscious processing of the words. Participants were instructed to name the color of the masks as quickly as possible. A microphone connected to a voice-level detector was placed in front of the participant. Initiation of vocal response was registered by the computer's clock and terminated the target (mask) presentation (with a no-response maximum of 3,000 ms). Accuracy of color naming was not scored. Thirty-two unambiguous neutral words from one category (furniture; examples are “chair” and “table”) and 32 unambiguous erotic words (examples are “penis,” “coitus,” and “vagina”) were presented in a blocked manner (eight words per block). The same words were used for each test; however, the sequence of words and their colors differed all eight times this task was used. These different versions were randomized over the participants. An extra set of stimuli consisting of meaningless letter

strings was used for practice trials directly before each Stroop task.

#### SARSAQ

The SARSAQ is a 10-item self-report questionnaire using a 7-point Likert scale (ranging from “not at all” to “extremely”), adapted from Morokoff and Heiman [17] and Heiman and Hatch [29]. It measures current subjective feelings of sexual arousal and sexual desire. Five items concern subjective feelings of genital responding, and five items concern subjective feelings of sexual desire. In the institutional laboratory, participants completed the questionnaire using a touch screen monitor. In the ambulatory laboratory however, number keys were used to complete the questionnaire.

#### SFQ

The SFQ is a validated self-report questionnaire containing 34 items and assessing eight domains of sexual function: desire, arousal–sensation, arousal–lubrication, subjective arousal, enjoyment, orgasm, pain, and partner relationship [25]. The SFQ was administered once during the screening visit. A pen and paper version was used.

#### Subjective Experience Questionnaire (SEQ)

The SEQ is a questionnaire with four items which was construed to evaluate the participants' experienced comfort during the two experimental sessions. Participants were asked directly after each experimental session to rate on a 5-point Likert scale (i) how much at ease they were during the measurement; (ii) how anxious they were during the measurement; (iii) how inhibited they felt during the measurement; and (iv) how tense they were during the measurement. Higher scores meant that participants were more anxious, inhibited and tense, and felt less at ease. A pen and paper version was used in both sessions.

#### Institutional Laboratory

The experimental session in the institutional laboratory took place in a closed, dimly lit, and sound attenuated experimental room containing the signal amplifier and a computer screen on which the film clips were presented. Participants were seated in a comfortable chair and provided with a blanket to cover their lap, in order to prevent external light from interfering with the measurement. An intercom was present to allow for two-way communication (on demand) in case of possible problems or additional instructions.

**Figure 1** Schematic overview of the ambulatory measurement setting. (1) Generic laptop, (2) genital probe, (3) wireless sensor system, (4) handheld computer, and (5) secure central database. See text “Ambulatory laboratory” for detailed description.



### Ambulatory Laboratory

The ambulatory laboratory is based on the MobiHealth Mobile remote monitoring system (MobiHealth B.V., Enschede, The Netherlands) [30]. Study specific functionality of this system enables VPA and CBV measurements, stimulus presentation, and execution of emotional Stroop tasks to be performed at an arbitrary time and location (e.g., house of a participant). This laboratory is operated autonomously by the participant. The ambulatory laboratory transmits all measured data to a secure central database server, at which the researcher can obtain the data for further analysis.

Figure 1 depicts a schematic overview of the whole ambulatory measurements setting. The ambulatory laboratory consists of four components: (i) a generic laptop for stimulus presentation and Stroop task execution; (ii) a genital probe for VPA and CBV measurement; (iii) a wireless sensor system; and (iv) a handheld computer (MobiHealth Mobile Base Unit; MBU). The handheld computer is a HTC P3600 (HTC, Taoyuan, Taiwan). Both the genital probe and generic laptop are attached to the wireless sensor system (“Mobi system”; TMSi, Enschede, The Netherlands). The sensor system is controlled by the MBU. The MBU runs the software that controls the whole measurement process, including authorized and secure communication to the sensor system and the secure central database (v). After a measurement session is finished, the MBU automatically terminates the connection. During a session, all data is sent instantaneously (i.e., real time) to the central database server to prevent local data storage, and thus the possibility of unwanted and untraceable data manipulation.

### Procedure

Participants were interviewed by a trained psychologist to diagnose for HSDD according to the

DSM-IV-TR criteria. Additionally, participants filled out the SFQ. To exclude major medical and psychiatric illnesses, a general medical and gynecological anamnesis was taken. Weight and height were measured. Blood pressure (supine), heart rate, and body temperature were measured when the anamnesis indicated further examination. A gynecological examination and urine pregnancy test were performed to exclude pregnancy, vaginal infections, major surgery on the vagina and/or vulva, undetected major gynecological illnesses, or unexplained gynecological complaints. Cultures were taken to exclude Chlamydia or Gonococcus infections. Additionally, participants were asked about childhood sexual abuse and other negative sexual experiences. Twenty participants were screened. Two screened participants were excluded: one suffered from dyspareunia and the other did not meet the DSM-IV-TR criteria for HSDD. A third screened participant stopped prior to the measurements because of personal circumstances.

When participants met all inclusion criteria, they were randomized into one of two possible test sequences: first measurement at home, second measurement in institutional laboratory; or first measurement in institutional laboratory, second measurement at home. Participants of both subgroups were evenly distributed over these two sequences. No experimental days were planned when participants were menstruating.

At the beginning of the measurement in the institutional laboratory, participants were screened for drug and alcohol use. Participants were explained how to insert the genital probe and were subsequently left alone in the experimental chamber to insert the probe. The measurement session began when the participants indicated via intercom that they were ready. Participants first

completed a SARSAQ, after which they completed the first emotional Stroop task. Then a 6-minute neutral film clip was shown in order to establish a VPA and CBV baseline. Participants were then instructed (on the computer screen) to fantasize about an erotic encounter. This could be from memory or imaginary. A short music fragment alerted participants when the fantasy condition ended. The volume of the music fragment started inaudible and steadily increased in volume over 2 seconds to an audible but low level. This was done so that participants who had their eyes closed during the fantasy session would know that the session was at an end but would not be startled. Following the fantasy session, participants completed the SARSAQ again. Then, a 2-minute neutral film clip was shown, followed by a 2-minute erotic foreplay film clip. A third SARSAQ was completed. Then, a 2-minute neutral film clip was shown, followed by a 2-minute erotic hardcore film clip, and a fourth SARSAQ was completed. The erotic film clips were presented in a fixed order (fantasy, foreplay, and hardcore) in order to maximize the sexual response. The 2-minute neutral film clips in between were meant to separate the exposure to the three sexual stimuli without the intention to induce return to baseline. During all film clips and the fantasy condition, VPA and CBV were measured. The experimental session ended with a second emotional Stroop task and SEQ. A measurement session took approximately 30 minutes.

For the experimental session at home, participants took the ambulatory laboratory home. Participants were trained in the setup and use of the ambulatory laboratory beforehand. Only when participants had shown that they could connect and run a mobile laboratory by themselves were they considered sufficiently trained. This training process took 20 minutes on average. Duration of the training was mostly dependant on the subjects' previous experience with computers; experienced computer users were faster to learn the procedure. Also, an instruction manual with photographs and an instruction video was included in which the setup and use of the mobile laboratory was explained. Participants were instructed to replicate the institutional laboratory setting at home as much as possible. They were free to choose the room, as long as it was quiet and they would not be disturbed during the measurement. They were explicitly instructed to sit upright at a table or desk. The experimental session at home was the same as in the institutional laboratory. A cleansing

kit for the genital probe (including instructions) was also taken home by the participants. All probes were cleansed a second time when they returned to the institution.

At the end of the study, a psychologist interviewed the participants concerning their experiences during the home measurement. They were asked if all went well and how they experienced the procedure at home in comparison to the institutional laboratory.

#### Data Reduction

The VPA reflects phasic changes in vaginal engorgement corresponding with each heartbeat. VPA was defined as the peak-to-trough amplitude of the pulse wave and was calculated by acquiring the means of all peaks and troughs and subtracting those. Data from the photoplethysmograph were sampled at 256 Hz and filtered offline (high-pass 1 Hz, 48 dB/oct and low-pass 1.5 Hz, 48 dB/oct), in order to isolate the alternating current (AC) component from the direct current (DC) coupled amplifier, reduce respiration artifacts and high-frequency oscillations. Large movement artifacts (more than 100% increase for a small number of isolated periodic cycles) were manually removed following visual inspection of the data. There were 36 movement artifacts observed in the VPA data collected in the institutional laboratory, and 47 in the VPA data collected via the ambulatory laboratory. One participant accounted for eight of the movement artifacts in the ambulatory laboratory while only having one artifact in the institutional lab. The data were divided into 30-second epochs for each 2-minute film clip, thus yielding four discrete values reflecting VPA during different stages of the film clip. Finally, in order to eliminate inter-personal differences and obtain meaningful data, VPA scores during the foreplay and hardcore clips were related to activity during the first 6-minute neutral clip, using the following formula:

$$VPA_{rel} = ((VPA_x - VPA_{neu}) / VPA_{neu})$$

with  $VPA_{rel}$  being the relative change in VPA related to the first neutral clip,  $VPA_x$  being any 30-second epoch value during the erotic clips, and  $VPA_{neu}$  being the average VPA score during the first neutral clip.

CBV was assessed by analyzing the DC component of the signal from the clitoral photoplethysmograph. The AC signal-to-noise ratio proved to be relatively small and the signal less sensitive to

increasing sexual arousal, when compared with the DC signal. (Since we used a DC-coupled amplifier in the experimental setup, both AC and DC components were available for analysis.) The smaller signal to noise ratio is probably caused by differences in vaginal wall and clitoral/labial tissue. The capillaries in the vaginal wall in which the VPA is measured lie more at the surface of the tissue. Moreover, signal-to-noise ratio of the AC component in the clitoral complex may decrease more if the cavernous tissue fills with blood. CBV data were sampled at 256 Hz and filtered offline (low-pass 0.03 Hz, 24 dB/oct). Again, data were divided into 30-second epochs. The data were baseline corrected for each participant by subtracting the minimum value during the session from the actual values for each epoch. The CBV signal proved to be resistant to participant movement, especially when compared with VPA, therefore no additional artifact rejection was needed. The CBV values were then used to produce relative scores in a way similar to the VPA procedure, i.e., based on the first 6-minute neutral clip.

$$CBV_{\text{corr}_x} = (CBV_x - CBV_{\text{min}})$$

$$CBV_{\text{rel}} = ((CBV_{\text{corr}_x} - CBV_{\text{corr}_\text{neu}}) / CBV_{\text{corr}_\text{neu}})$$

with  $CBV_{\text{corr}_x}$  ("corrected CBV") being the baseline corrected score,  $CBV_x$  being any 30-second epoch value during the erotic clips prior to correction, and  $CBV_{\text{min}}$  the minimum value of all the epochs following the return to baseline clip.  $CBV_{\text{rel}}$  is the relative increase in corrected CBV related to the first neutral clip, as expressed by  $CBV_{\text{corr}_\text{neu}}$ , the average corrected CBV score during the first neutral clip.

The Stroop reaction times for color naming were visually inspected for outliers. There were 115 outliers over all participants in the Stroop data in the institutional laboratory, and 72 in the ambulatory laboratory. After these outliers were excluded, participants' mean reaction times for erotic and neutral words on each trial were calculated. Mean reaction times of erotic and neutral words on each trial were used in the analysis.

The SARSAQ was administered four times during one measurement session. For each administration the five-item scores for subjective feelings of genital responding (SARSAQ-GR) were added together and the five-item scores concern subjective feelings of sexual desire (SARSAQ-SD) were added together. This yielded two SARSAQ scoring domains, both having a range of 5–35. For each SARSAQ scoring domain, the relative

increase was calculated of which the first SARSAQ was the baseline:

$$SARSAQ_{\text{rel}} = ((SARSAQ_x - SARSAQ_{\text{base}}) / SARSAQ_{\text{base}})$$

with  $SARSAQ_{\text{rel}}$  being the relative change in SARSAQ score related to the first SARSAQ score,  $SARSAQ_x$  being the second (which is completed directly after the erotic fantasy), third (after foreplay) or fourth (after hardcore) SARSAQ score, and  $SARSAQ_{\text{base}}$  being the first SARSAQ.

Genital and subjective measures are, thus, analyzed with transformed variables, which denote the relative change from baseline of each specific measure giving three levels: baseline vs. erotic fantasy, baseline vs. foreplay film clip, and baseline vs. hardcore film clip. In the three levels of the subjective and genital measures, the means of the second level (nearly) always lie between the means of the first and last level (see Table 2), because stimuli of increasing potency (fantasy, foreplay, and hardcore) were presented in a fixed order. All analyses of genital and subjective arousal as described below therefore only describe the first and last of these three levels. For the VPA and CBV, the first and fourth (last) 30-second epochs were compared in order to investigate the maximum effect of the erotic fantasy condition and hardcore film clips on sexual arousal.

### Statistical Analysis

All dependent variables were checked for normality. Outliers were discarded from analysis if they were significant ( $z > 3.1$ ) [31].

Group homogeneity with respect to demographic variables was tested with independent samples *t*-tests with diagnosis as grouping variable (HSDD vs. healthy controls) on all continuous demographic variables and on the domains of the SFQ separately (see Table 1).

VPA and CBV data were analyzed separately, but in the same manner: dependent variables were analyzed in a 2 measurement setting (ambulatory lab vs. institutional lab)  $\times$  2 stimulus type (erotic fantasy vs. hardcore film clips)  $\times$  2 time (epoch 1 vs. epoch 4)  $\times$  2 group (HSDD vs. healthy controls) repeated measures ANOVA, with measurement setting, stimulus type, and time as within subject factors, and group as between subject factor.

The eight dependent variables of the Stroop were analyzed in a 2 measurement setting (ambu-

latory lab vs. institutional lab)  $\times$  2 stimulus type (erotic vs. neutral words)  $\times$  2 time (session 1 vs. session 2)  $\times$  2 group (HSDD vs. healthy controls) repeated measures ANOVA, with measurement setting, stimulus type, and time as within subject factors, and group as between subject factor.

The dependent variables for SARSAQ-GR and SARSAQ-SD were analyzed separately in a 2 measurement setting (ambulatory lab vs. institutional lab)  $\times$  2 stimulus type (erotic fantasy vs. hardcore film clips)  $\times$  2 group (HSDD vs. healthy controls) repeated measures ANOVA, with measurement setting and stimulus type as within subject factors, and group as between subject factor.

Interaction effects between measurement setting and group in the VPA, CBV, Stroop, SARSAQ-GR, or SARSAQ-SD were further examined by repeating the analysis for each group separately.

The SEQ dependent variables deviated from normality so these were tested with the Wilcoxon signed ranks test for nonparametric data. To test the hypothesis that measurement setting influences subjective experience, the four item scores in the two measurement settings (ambulatory lab vs. institutional lab) were compared with the Wilcoxon signed ranks test for nonparametric data twice; once for the HSDD group and once for the healthy controls. Exact probabilities were calculated because the number of possible signed ranks was smaller than 10 [32].

Pearson's correlation coefficient was calculated to investigate the relation between genital (VPA and CBV) and subjective measures (SARSAQ-GR and SARSAQ-SD) of sexual arousal. In these calculations, CBV and VPA data of the fourth 30-second epoch were used because these are likely to correspond most with the subjective measures that were reported following most closely to these epochs. A significance level of  $\alpha = 0.050$  was used for all tests.

## Results

### Sample Description

Sixteen women completed this study (one participant was excluded on the first visit because she tested positive for cannabis and benzodiazepines), eight of which (mean age 34.6, sexual desire [SD] 7.2) were diagnosed with HSDD. Of these subjects with HSDD, one subject was also diagnosed with female sexual arousal disorder, one with female orgasmic disorder and one with both female sexual arousal disorder and female orgasmic disorder. The eight other women (mean age 36.3, SD 8.7) served as control group. There were no major medical psychiatric illnesses. The group means of demographic variables, age, number of parity, and body mass index of both groups did not differ (see Table 1). SFQ domain scores of three participants (two healthy controls and one HSDD) could not be computed. If someone has not had sexual activ-

**Table 1** Comparison of demographic variables and indices of sexual functioning between subgroups

Demographic variables	All participants (N = 16)	Participants with HSDD (N = 8)	Healthy controls (N = 8)	P values
Age (years)	35.4 (8.0)	36.3 (8.7)	34.6 (7.2)	ns
Number of parity	0.9 (1.1)	1.3 (1.2)	0.6 (0.9)	ns
Body mass index (kg/m <sup>2</sup> )	26.2 (4.4)	24.1 (3.5)	28.2 (4.3)	ns
Contraceptives				
OAC	4	2	2	na
IUD (hormonal)	2	0	2	na
Injectable contraceptive	1	0	1	na
Vaginal ring	1	0	1	na
Condom	2	2	0	na
None	6	4	2	na
Ethnic origin				
Caucasian	14	8	6	na
Black	2	0	2	na
Amount of smokers	5	2	3	na
SFQ				
Desire	16.3 (4.8)	13.0 (1.8)	20.2 (4.1)	$P < 0.010$
Arousal (sensation)	11.1 (4.5)	9.0 (3.9)	13.5 (4.2)	ns
Arousal (lubrication)	7.0 (2.1)	6.6 (2.2)	7.5 (2.1)	ns
Total	105.8 (21.0)	92.7 (16.0)	121.2 (15.0)	$P < 0.010$

Note: Cell values represent group means and group standard deviations (in parentheses), except cell values for "Contraceptives," "Ethnic origin," and "Amount of smokers," which represent subject counts. The last column shows the P values of an independent sample t-test comparing the means of the two subgroups (women with HSDD and healthy controls) of the demographic variable of that row. The subgroup means of weight, "SFQ Desire" and "SFQ Total" differ significantly. HSDD = hypoactive sexual desire disorder; OAC = oral anti contraceptive; IUD = intra uterine device; SFQ = Female Sexual Functioning Questionnaire; ns = not significant; na = not applicable.

ity in the last 4 weeks, most items are scored as missing, and therefore, domain scores cannot be computed. The SFQ domains desire, arousal (sensation), arousal (lubrication), orgasm, pain, enjoyment, partner, and the SFQ total score were compared. On average, women with HSDD scored lower on the domain “desire” ( $M = 13.0$ ,  $SD = 1.8$ ) than the healthy controls ( $M = 20.2$ ,  $SD = 4.1$ ). This difference was significant  $t(11) = 4.17$ ,  $P < 0.010$ ,  $d = -2.32$ . Women with HSDD also scored lower on the domain “partner” ( $M = 7.1$ ,  $SD = 1.2$ ) than the women without FSD ( $M = 10.0$ ,  $SD = 0.0$ ). This difference was significant  $t(11) = 5.72$ ,  $P < 0.001$ ,  $d = -0.57$ . Finally, women with HSDD scored lower on the SFQ total score ( $M = 92.7$ ,  $SD = 16.0$ ) than the women without FSD ( $M = 121.2$ ,  $SD = 15.0$ ). This difference was also significant  $t(11) = 3.29$ ,  $P < 0.010$ ,  $d = -0.96$ . The participants did not differ significantly on any of the other SFQ domain scores.

#### VPA

There was a main effect for “stimulus type”  $F(1,14) = 8.051$ ,  $P < 0.050$ , partial  $\eta^2 = 0.37$ . All women had a stronger VPA increase to hardcore film clips ( $M = 0.86$ ,  $SE = 0.25$ ) in comparison to erotic fantasy ( $M = 0.24$ ,  $SE = 0.08$ ). Also, there was a main effect of “time,”  $F(1,14) = 13.912$ ,  $P < 0.010$ , partial  $\eta^2 = 0.50$ . Relative increase from neutral baseline was stronger in the fourth epoch ( $M = 0.73$ ,  $SE = 0.18$ ) in comparison with the first epoch ( $M = 0.37$ ,  $SE = 0.12$ ). There was an interaction effect among “stimulus type,” “time,” and “group”  $F(1,14) = 6.808$ ,  $P < 0.050$ , partial  $\eta^2 = 0.33$ . Women with HSDD had a smaller increase in response to the hardcore stimuli than the healthy controls, and their response to the erotic fantasy condition did not differ from healthy controls. Finally, a trend was visible in the interaction between “stimulus type,” “time,” and “measurement setting”  $F(1,14) = 3.169$ ,  $P < 0.100$ , partial  $\eta^2 = 0.19$ . All women showed a stronger VPA response to hardcore stimuli in the home measurement setting as compared with the institutional laboratory setting. Their response to the erotic fantasy condition did not differ between measurement settings (see Figure 2).

#### CBV

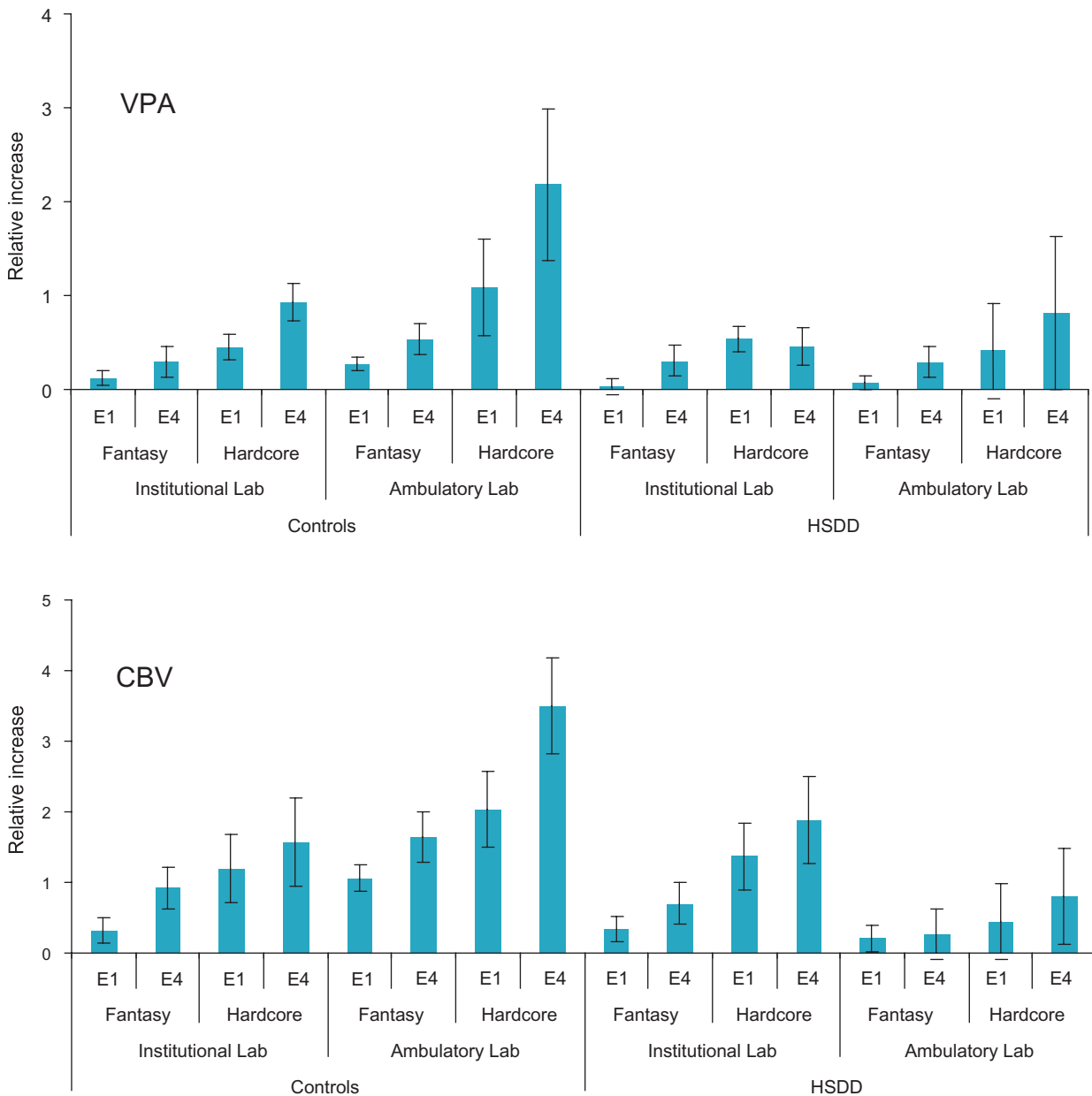
There was a main effect for “stimulus type,”  $F(1,14) = 21.176$ ,  $P < 0.001$ , partial  $\eta^2 = 0.60$ . All women had a stronger CBV increase to hardcore film clips ( $M = 1.60$ ,  $SE = 0.24$ ) in comparison with erotic fantasy ( $M = 0.68$ ,  $SE = 0.13$ ). There

was also a main effect of “time,”  $F(1,14) = 19.198$ ,  $P < 0.001$ , partial  $\eta^2 = 0.58$ . Relative increase from neutral baseline was stronger in the fourth epoch ( $M = 1.41$ ,  $SE = 0.21$ ) in comparison with the first epoch ( $M = 0.87$ ,  $SE = 0.13$ ). There was an interaction effect among “measurement setting,” “time,” and “group,”  $F(1,14) = 6.795$ ,  $P < 0.050$ , partial  $\eta^2 = 0.33$ . Women with HSDD had much smaller increases in CBV in response to the erotic stimuli at home than healthy controls. The responses of both groups to all erotic conditions in the institutional laboratory were largely the same. There was an interaction effect between “stimulus type” and “time,”  $F(1,14) = 4.887$ ,  $P < 0.050$ , partial  $\eta^2 = 0.26$ . CBV increases to hardcore film clips, especially the fourth 30-second epoch were stronger than to erotic fantasy. There was an interaction effect among “measurement setting,” “stimulus type,” and “time,”  $F(1,14) = 9.487$ ,  $P < 0.010$ , partial  $\eta^2 = 0.40$ . Women’s responses increased to erotic fantasy epochs in the home setting, but the response to the fourth 30-second hardcore epoch at home was much stronger. Finally, there was an interaction effect among “measurement setting,” “stimulus type,” “group,” and “time,”  $F(1,14) = 5.621$ ,  $P < 0.050$ , partial  $\eta^2 = 0.29$ . In the institutional laboratory, both groups did not differ. However, in the home setting, healthy controls strongly increased their CBV response to all erotic stimuli, but much more pronounced for the hardcore stimuli, while the women with HSDD had an attenuated CBV response to all erotic stimuli (see Figure 2).

To investigate the interaction effects of “measurement setting” and “group” further, the same analysis was run for each group separately. A “measurement setting” and “time” interaction was observed for CBV that was significant for the healthy controls,  $F(1,7) = 5.903$ ,  $P < 0.050$ , partial  $\eta^2 = 0.46$ , but not for the HSDD group. The healthy controls showed a stronger increase over time at home, as compared with the institutional setting. In the healthy control group, there was also a “measurement setting,” “stimulus type,” and “time” interaction for the CBV,  $F(1,7) = 15.997$ ,  $P < 0.010$ , partial  $\eta^2 = 0.70$ , but not for the HSDD group. The healthy controls showed a stronger response over time for the hardcore stimuli at home, as compared with the institutional setting.

#### Stroop

There was a main effect for “time”  $F(1,14) = 6.954$ ,  $P < 0.050$ , partial  $\eta^2 = 0.33$ . Women slowed down 34 ms in color naming at the end of the



**Figure 2** Upper panel: Mean (and standard error) relative increases in VPA to erotic stimuli. Epochs 1 and 4 (E1 and E4; 1st and 4th 30-second epochs) in the fantasy and hardcore conditions are shown for both laboratory settings in both groups of women (healthy controls vs. HSDD). Lower panel: Mean (and standard error) relative increases in CBV to erotic stimuli. Epochs 1 and 4 (E1 and E4; 1st and 4th 30-second epochs) in the fantasy and hardcore conditions are shown for both laboratory settings in both groups of women (healthy controls vs. HSDD). VPA = vaginal pulse amplitude; CVB = clitoral blood volume; HSDD = hypoactive sexual desire disorder.

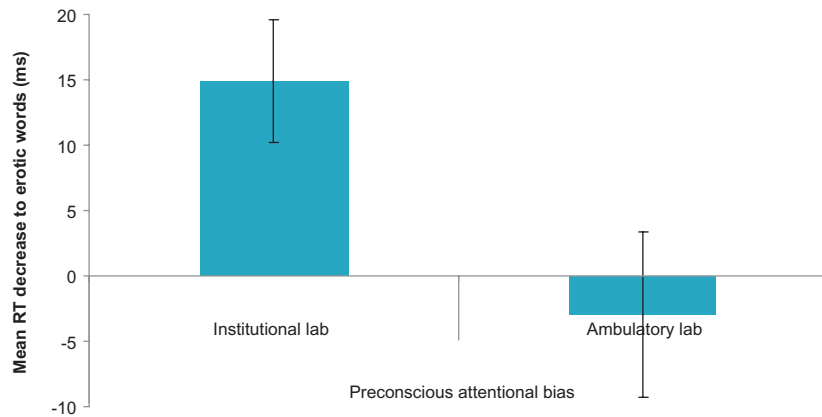
experiment ( $M = 552.9$  ms,  $SE = 20.9$  ms) compared with the start of the experiment ( $M = 528.7$  ms,  $SE = 17.9$  ms). There was an interaction effect between “measurement setting” and “stimulus type”  $F(1,14) = 5.930$ ,  $P < 0.050$ , partial  $\eta^2 = 0.30$ . Women slowed down in color naming of neutral words in the home laboratory setting ( $M = 549.3$ ,  $SE = 20.6$ ) compared with the institu-

tional laboratory ( $M = 526.4$ ,  $SE = 20.4$ ) in contrast to the mean reaction times of erotic words that were largely the same ( $M = 546.4$ ,  $SE = 20.4$  and  $M = 541.3$ ,  $SE = 22.5$ , respectively) (Figure 3).

**SARSAQ**

Investigation of the SARSAQ data showed that one participant had four significant univariate out-

**Figure 3** Whole sample means and standard errors of preconscious attentional bias scores in color naming for erotic words in both laboratory settings. RT = reaction time.



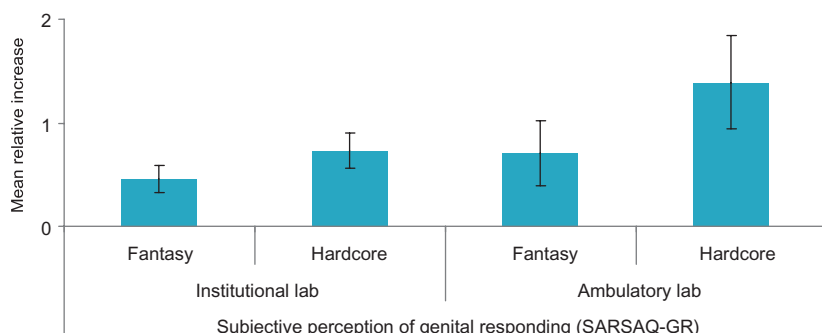
liers ( $P < 0.001$ ). For this reason, this participant was omitted from the analyses of the SARSAQ data. Three SARSAQ dependent variables (two for the SARSAQ-GR and one for the SARSAQ-SD) showed different variances for the two groups. A more stringent  $\alpha$  level ( $\alpha = 0.025$ ) was used to control for Type I error [33]. For SARSAQ-GR there was a main effect for “stimulus type,”  $F(1,13) = 12.073$ ,  $P < 0.010$ , partial  $\eta^2 = 0.48$ . Participants reported more subjective experience of genital responding following the hardcore film clips ( $M = 1.05$ ,  $SE = 0.23$ ) than following the erotic fantasy ( $M = 0.46$ ,  $SE = 0.10$ ). Also, there was an interaction effect between “stimulus type” and “measurement setting,”  $F(1,13) = 7.261$ ,  $P < 0.025$ , partial  $\eta^2 = 0.36$ . The relative increase in subjective experience of genital responding following the erotic fantasy conditions was the same in both measurement settings. Relative increases were stronger following the hardcore film clips and of the two settings, the strongest increase was at home (see Figure 4). For SARSAQ-SD, there was also a main effect for “stimulus type,”  $F(1,13) = 9.424$ ,  $P < 0.010$ , partial  $\eta^2 = 0.42$ . Participants reported more subjective experience of sexual desire following the hardcore film clips

( $M = 1.06$ ,  $SE = 0.45$ ) than following the erotic fantasy ( $M = 0.46$ ,  $SE = 0.13$ ). A trend was observed in the interaction between “stimulus type” and “measurement setting,”  $F(1,13) = 3.050$ ,  $P = 0.100$ , partial  $\eta^2 = 0.19$ . The relative increase in subjective experience of sexual desire following the erotic fantasy conditions was the same in both measurement settings. Relative increases were stronger following the hardcore film clips, and of the two settings was strongest at home.

**SEQ**

The healthy controls reported less inhibition at home ( $Mdn = 1$ ) than in the institutional laboratory ( $Mdn = 2$ ),  $N = 5$ ,  $T = 15.0$ ,  $P < 0.05$  (one-sided),  $r = -0.79$ . The women without FSD also reported being more at ease at home (Median [ $Mdn$ ] = 1) than in the institutional laboratory ( $Mdn = 2$ ),  $N = 6$ ,  $T = 21.0$ ,  $P < 0.05$  (two-sided),  $r = -0.80$ . The item used to measure how “at ease” people were, is asked in an inverse manner when asked in Dutch. Thus, the effect size is negative, and the median in the home setting is lower than the median in the institutional laboratory setting. Women with HSDD showed no differences in the SEQ items between measurement settings.

**Figure 4** Whole sample mean relative increases and standard errors in subjective feelings of genital arousal during the fantasy condition and the hardcore condition in both laboratory settings.



**Table 2** Means and SE of the relative increases from baseline of VPA, CBV, SARSAQ-GR, and SARSAQ-SD

Measure	Laboratory setting	Condition	RI epoch	Controls			HSDD		
				N	Mean	SE	N	Mean	SE
VPA	Institutional	Fantasy	1	8	0.12	0.10	8	0.03	0.06
			4	8	0.30	0.15	8	0.31	0.17
		Foreplay	1	8	0.23	0.17	8	0.20	0.09
			4	8	0.78	0.19	8	0.50	0.16
		Hardcore	1	8	0.45	0.15	8	0.54	0.13
			4	8	0.93	0.23	8	0.45	0.18
	Ambulatory	Fantasy	1	8	0.27	0.08	8	0.07	0.07
			4	8	0.53	0.19	8	0.29	0.14
		Foreplay	1	8	0.68	0.44	8	0.23	0.43
			4	8	1.77	0.82	8	0.60	0.55
		Hardcore	1	8	1.08	0.52	8	0.41	0.51
			4	8	2.18	0.95	8	0.81	0.64
CBV	Institutional	Fantasy	1	8	0.33	0.14	8	0.34	0.21
			4	8	0.92	0.34	8	0.70	0.24
		Foreplay	1	8	0.88	0.21	7*	0.44	0.19
			4	8	1.31	0.33	7	1.12	0.36
		Hardcore	1	8	1.20	0.31	8	1.37	0.60
			4	8	1.58	0.46	8	1.88	0.74
	Ambulatory	Fantasy	1	8	1.06	0.22	8	0.21	0.15
			4	8	1.65	0.38	8	0.27	0.33
		Foreplay	1	8	1.27	0.34	8	0.49	0.30
			4	8	2.55	0.63	8	1.05	0.52
		Hardcore	1	8	2.04	0.64	8	0.45	0.41
			4	8	3.50	0.84	8	0.80	0.47
SARSAQ-GR	Institutional	RI Fantasy	8	0.39	0.19	7*	0.53	0.13	
		RI Foreplay	8	0.73	0.21	7	0.92	0.28	
		RI Hardcore	8	0.91	0.26	7	0.73	0.26	
	Ambulatory	RI Fantasy	8	0.76	0.33	7	0.15	0.07	
		RI Foreplay	8	1.07	0.41	7	0.94	0.28	
		RI Hardcore	8	1.40	0.55	7	1.18	0.25	
SARSAQ-SD	Institutional	RI Fantasy	8	0.32	0.20	7	0.60	0.18	
		RI Foreplay	8	0.65	0.15	7	0.93	0.27	
		RI Hardcore	8	0.72	0.22	7	0.74	0.26	
	Ambulatory	RI Fantasy	8	1.04	0.55	7	0.37	0.22	
		RI Foreplay	8	1.50	0.69	7	0.75	0.27	
		RI Hardcore	8	1.80	0.80	7	0.98	0.30	

\*Significant outliers excluded ( $Z > 3.1$ ).

SE = standard error; VPA = vaginal pulse amplitude; CVB = clitoral blood volume; SARSAQ-GR = Sexual Arousal Response Self Assessment Questionnaire-genital responding; SARSAQ-SD = SARSAQ-sexual desire; HSDD = hypoactive sexual desire disorder; RI = relative increase.

### Concordance Genital and Subjective Measures

Correlation analysis of the genital and subjective measures of sexual arousal (see Table 3) revealed a positive relationship between VPA and SARSAQ-SD for the healthy controls in the fantasy condition in the institutional laboratory,  $r(6) = 0.84$ ,  $P < 0.010$ . The HSDD participants showed a positive correlation between VPA and SARSAQ-GR in the hardcore condition in the institutional laboratory,  $r(5) = 0.88$ ,  $P < 0.010$ . Overall, VPA correlated with SARSAQ-GR,  $r(13) = 0.59$ ,  $P < 0.050$ , and SARSAQ-SD,  $r(13) = 0.73$ ,  $P < 0.010$ , in the fantasy condition in the institutional laboratory. Also, VPA correlated with SARSAQ-GR in the hardcore condition in the institutional laboratory,  $r(13) = 0.61$ ,  $P < 0.050$ . At home, no significant correlations were observed.

### Discussion

The results of this study support our hypothesis that in healthy controls, clitoral and subjective laboratory measures of sexual arousal show stronger increases to erotic stimuli in the home environment than in the environment of the institutional laboratory. This effect was apparent in response to hardcore stimuli, but not to erotic fantasy. Contrary to what we expected, VPA did not increase more strongly at home in the healthy controls. In the institutional laboratory, women with HSDD and healthy controls did not differ in their genital and subjective response to erotic stimuli. However, the marked increase herein at home as observed in the healthy controls was absent in the women with HSDD. The institutional laboratory setting seemed to initiate or sustain certain inhibitory mechanisms in both

**Table 3** Pearson's correlations (*r*) between genital (VPA and CBV) and subjective (SARSAQ-GR and SARSAQ-SD) measures of sexual arousal for the control group, the HSDD group, and overall

		Institutional laboratory					
		Control (N = 8)		HSDD (N = 7)		Overall (N = 15)	
		VPA	CBV	VPA	CBV	VPA	CBV
Fantasy	SARSAQ-GR	0.67	0.08	0.57	0.42	0.59*	0.16
	SARSAQ-SD	0.84**	0.49	0.75	0.02	0.73**	0.28
Foreplay	SARSAQ-GR	-0.11	0.32	0.56	0.57 <sup>†</sup>	0.14	0.42 <sup>‡</sup>
	SARSAQ-SD	0.22	0.66	0.25	0.53 <sup>†</sup>	0.11	0.51 <sup>†</sup>
Hardcore	SARSAQ-GR	0.54	0.18	0.88**	0.31	0.61*	0.23
	SARSAQ-SD	0.62	0.41	0.60	-0.28	0.49	-0.02

		Ambulatory laboratory					
		Control		HSDD		Overall	
		VPA	CBV	VPA	CBV	VPA	CBV
Fantasy	SARSAQ-GR	0.36	0.38	0.23	-0.04	0.43	0.46
	SARSAQ-SD	0.32	0.47	0.21	0.17	0.37	0.47
Foreplay	SARSAQ-GR	-0.15	0.40	0.74	0.23	0.12	0.34
	SARSAQ-SD	-0.12	0.26	0.35	0.01	0.05	0.27
Hardcore	SARSAQ-GR	-0.13	-0.07	0.52	-0.09	0.03	-0.01
	SARSAQ-SD	-0.04	-0.07	0.01	0.11	0.04	0.11

\* $P < 0.05$ ; \*\* $P < 0.01$ .

<sup>†</sup>N = 6, due to a significant outlier in the CBV (see also Table 2); <sup>‡</sup>N = 14.

Note: The scores of seven HSDD participants were included in the calculation of the correlations because one participant's SARSAQ scores were mostly significant outliers (see results section).

VPA = vaginal pulse amplitude; CVB = clitoral blood volume; SARSAQ-GR = Sexual Arousal Response Self Assessment Questionnaire-genital responding; SARSAQ-SD = SARSAQ-sexual desire; HSDD = hypoactive sexual desire disorder.

groups of women. In healthy controls, but not in women with HSDD, these inhibition-inducing/enhancing factors were less pronounced at home, resulting in increased subjective and genital arousal. To our knowledge, this is the first study that investigates ecological validity of sexual psychophysiological measures by comparing those assessed in the institutional laboratory to those assessed at home with an ambulatory laboratory.

At home, as compared with the institutional laboratory setting, the healthy controls showed more pronounced increases in both genital arousal and the subjective perception of genital arousal in response to erotic stimuli (especially hardcore erotica) compared with neutral stimuli. As expected, they reported "feeling less inhibited" during the home session, as well as "feeling more at ease," as compared with the institutional laboratory setting. These findings are in agreement with the dual control model of sexual functioning [3,4], which states that decreased inhibition leads to increased sexual arousal. We also observed a decrease in preconscious attentional bias for erotic words at home.

The stronger increase in genital arousal at home in comparison with the institutional setting was especially apparent in the CBV response; the stronger VPA increase pointed in the same direc-

tion but did not reach statistical significance. In a previous study [12] we showed that participants' CBV decreased dramatically following an inhibitory stimulus—a sudden warning over the intercom—contrary to their VPA. The strength of the participants' CBV decline was related to the strength of the sympathetic response to the inhibitory stimulus. This was not true for VPA. It would thus appear that CBV is the more sensitive measure for sexual inhibition than VPA. Stronger influence of inhibitory stimuli on CBV may be caused by a stronger influence of sympathetic activity on smooth muscle contraction in the clitoral tissue complex as compared with the arterial plexus of the vaginal wall (see Gerritsen et al. [12] for a discussion). The decrease in the reported feelings of inhibition and the stronger increase of CBV compared with the slight increase of VPA in the home measurement setting, supports the idea that there are less inhibitory influences at home as compared with the institutional laboratory.

The second major finding of this study was that the genital arousal to erotic stimuli of women with HSDD and of healthy controls only differed from each other in the ambulatory laboratory setting. Many studies have compared participants with different FSD diagnoses to healthy controls in an institutional laboratory, but consistent differences

in genital arousal between these groups have not been found [17,26,27]. In the present study, both women with and without HSDD did not show different responses in the institutional laboratory either, however, a clear difference was found at home. Unlike the healthy controls, women with HSDD did not show more genital responding at home as compared with the institutional laboratory setting. This may be (partially) caused by a less sensitive/responsive sexual excitation system in women with HSDD. The comparable levels in preconscious attentional bias for sexual cues between both groups of women in both settings challenges this, but it has never been established that preconscious attentional bias for erotic cues is directly linked to sensitivity/responsivity of the sexual excitation system. Also, the women with HSDD did not report feeling significantly less inhibited or feeling significantly more at ease at home either. Cues that activate or sustain inhibitory mechanisms still may have been present for these women, at least more so than in controls. It is possible that these women were influenced by other inhibitory stimuli in the home setting, e.g., context dependent cues [34,35] that could induce negative memories of past—e.g., bedroom experiences. Such inhibitory stimuli may have a different influence on subjective experience, seeing that these women reported increased subjective perception of genital arousal while genital arousal itself did not increase. It seems less likely that distraction accounted for these findings because preconscious attentional bias was comparable with controls in both settings. Further research is necessary to elucidate these findings.

Concordance between genital and subjective measures of sexual arousal was observed in some conditions in the institutional laboratory but not in the home setting. We expected that creating a more appropriate context for genital and subjective sexual responding by measuring in the home setting would on one hand increase genital and subjective sexual responding, and on the other hand increase concordance between these measures. However, for most participants in the home setting, a strong increase in the subjective measures was accompanied by relatively smaller increases in physiological measures or vice versa. It is possible that this finding reflects less interdependence between genital and subjective sexual arousal in women, as compared with men (see Suschinsky et al. [36] and Chivers [37] for a discussion on this matter). Inspection of the scatter diagrams showed that the significant correlations in the

institutional laboratory were partly the result of floor effects in the subjective and genital measures of sexual arousal, thus inflating correlations. These floor effects may in part account for the unexpected observed differences in concordance magnitude between the two measurement settings. According to Basson's model of female sexual response [38], sexual stimuli must have an appropriate context for sexual arousal to occur. An appropriate setting (e.g., home) forms a part of this appropriate context, as demonstrated by the present findings of increased genital and subjective arousal. It has been proposed that women's subjective arousal—in contrast to men's—is more dependent on the meaning that a sexual stimulus generates [39]. Increasing the appropriateness of the context by altering the meaning of sexual stimuli traditionally presented in a psychophysiological lab (e.g., erotic film clips) could result in more concordance. The present experimental procedure may be complemented by instructions from a trained psychologist/sexologist, focusing on how to fantasize or how to experience bodily responses during viewing of an erotic film clip. It must be kept in mind that within-subject correlations could not be computed because a continuous measure of subjective arousal (e.g., a potentiometer during film clip viewing) was not used. Between-subject correlation is a less sensitive measure of concordance. Also, the low sample size renders these observations less reliable. Further research in the home setting is necessary to investigate these findings.

Attentional bias in the form of sexual content induced delay [40] seems to be dependent on magnitude of arousal induced by the sexual stimulus and independent of stimulus valence; both positive and negative stimuli can induce a delay, and the length of the delay is dependant upon the strength of the arousal [41]. In the current study, both groups of women showed preconscious attentional bias for erotic stimuli in the institutional laboratory, but not at home. Reaction times to neutral stimuli were larger at home compared with the institutional laboratory, while the reaction times to erotic stimuli did not differ between measurement settings. The surroundings of an experimental chamber in an institutional laboratory are purposely made stimulus-deprived to avoid distraction from the experimental stimuli. The home environment does not match the institutional laboratory environment in this respect. Possibly, the home environment is too distracting to measure subtle differences in Stroop reaction

times. If this prolongation of reaction times to neutral stimuli at home is caused by the more distracting surroundings, a ceiling effect herein would explain why this was not observed for the erotic stimuli. Additional research is needed to test these hypotheses.

This study has several limitations. All of our participants were naive to the home laboratory setting, but not to the institutional laboratory setting. This may have influenced the results, but it cannot explain the differential results of the two subgroups. Other confounding factors are likely to have been present in the home measurement setting; e.g., environmental noise or the presence of children or a spouse in the house. These factors are unlikely to be systematic, reducing their influence on the (direction of our) results. Nevertheless, such unsystematic bias would be less influential with more participants. We did not control for phases of the menstrual cycle other than the menstruation phase, when our participants were not tested. Sexual experience has been shown to vary over the phases of the menstrual cycle (see Bullivant et al. [42] for an overview), which could have influenced the findings presented here. Finally, more direct and objective investigation of inhibitory mechanisms is recommended using biological markers of psychological stress (e.g., saliva cortisol or electrodermal activity) because simply asking people whether they feel “at ease” at home may be susceptible to social desirable answering [43].

This study was also a methodological exercise to look into the feasibility of using an ambulatory laboratory and real time plural data transmission as a tool for the study of variables that are influenced by their ecological surroundings; e.g., translational research. To ensure that the measurement at home is optimal, subjects had to be trained in the institution. The duration of the training was mostly dependent on the computer skills of the subject, but a lack of computer skills did not give rise to serious problems. None of the subjects reported having any problems or difficulties in running the ambulatory lab. Movement or other measurement artifacts were comparable as in the institutional laboratory. There were more movement artifacts in the VPA at home, but this difference was attributable to two subjects. The number of outliers in the Stroop task was smaller at home. Data transmission was without problem. Both the method of data collection, as well as the results of this study warrants further investigation of this methodology. As a next step, we will investigate the influ-

ence of different pharmacological treatments for FSD on the psychological and physiological sexual response at home.

## Conclusion

The ambulatory laboratory is a valuable tool that allows researchers to perform psychophysiological (sex) investigations under naturally occurring conditions (e.g., a participant’s home). In the present study, the increase in ecological validity resulted in a qualitative differentiation between the healthy controls and women with HSDD in the home setting, which is not apparent in the artificial setting of the institutional laboratory.

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*Conflict of Interest:* Jos Bloemers and Jeroen Gerritsen are researchers/psychologists at EB and PhD students. Richard Bults is CTO of MobiHealth B.V. Walter Everaerd is advisor to EB and supervisor of the PhD-thesis of Jos Bloemers. Hans Koppeschaar is researcher/internist, neuroendocrinologist at EB. Adriaan Tuiten is CEO/psychologist of/at EB. Berend Olivier is supervisor of the PhD-thesis of Jos Bloemers. This study was supported by Emotional Brain B.V.

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