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Article in Biological Psychology · January 2002
DOI: 10.1016/S0301-0511(01)00113-2 · Source: PubMed

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Social anxiety and response to touch: incongruence between self-evaluative and physiological reactions

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Received 12 February 2001; received in revised form 20 May 2001; accepted 23 May 2001

Abstract

Touch is an important form of social interaction, and one that can have powerful emotional consequences. Appropriate touch can be calming, while inappropriate touch can be anxiety provoking. To examine the impact of social touching, this study compared socially high-anxious (N = 48) and low-anxious (N = 47) women’s attitudes concerning social touch, as well as their affective and physiological responses to a wrist touch by a male experimenter. Compared to low-anxious participants, high-anxious participants reported greater anxiety to a variety of social situations involving touch. Consistent with these reports, socially anxious participants reacted to the experimenter’s touch with markedly greater increases in self-reported anxiety, self-consciousness, and embarrassment. Physiologically, low-anxious and high-anxious participants showed a distinct pattern of sympathetic-parasympathetic coactivation, as reflected by decreased heart rate and tidal volume, and increased respiratory sinus arrhythmia, skin conductance, systolic/diastolic blood pressure, stroke volume, and respiratory rate. Interestingly, physiological responses were comparable in low and high-anxious groups. These findings indicate that social anxiety is accompanied by heightened aversion towards social situations that involve touch, but this enhanced aversion and negative-emotion report is not reflected in differential physiological responding. © 2001 Elsevier Science B.V. All rights reserved.

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Keywords: Social phobia; Anxiety disorders; Physical contact; Respiration; Autonomic nervous system; Stroke volume

1. Introduction

Physical contact plays a major role in social relationships from our earliest days onwards. More than half a century ago, Spitz (1945) noted that human infants who were only infrequently touched exhibited developmental arrest and depression. These findings were extended by Harlow (1958), who used deprivation experiments with rhesus monkeys to show that social contact was necessary for both immediate and later forms of adaptive social and emotional behavior. Since these early studies, researchers have demonstrated convincingly that physical contact, movement, and handling are important to normal neurological and socio-emotional development in human (e.g. Ainsworth, 1979; White and Castle, 1964) and nonhuman infants (e.g. Becker and Lobato, 1997; Bramblett, 1984; Kuhn and Schanberg, 1998). Furthermore, it has been shown that preterm human infants who receive gentle forms of touch (e.g. caressing, massage) gain more weight (Field et al., 1986), require less oxygen support (Daga et al., 1998), and have fewer episodes of apnea, a risk factor for sudden infant death syndrome (Jay, 1982).

The emotional impact of touch in adulthood appears to be somewhat more complicated. On the one hand, touch can have positive social connotations and affective consequences. Brief and light arm touch during a therapy session breaks down discomfort barriers and enhances rapport and patient self-disclosure (Pattison, 1973). Experimentally manipulated touch has been shown to enhance prosocial behavior (Kleinke, 1977), compliance (Willis and Hamm, 1980), responsiveness to marketing requests (Smith et al., 1982), amount of restaurant tips (Crusco and Wetzel, 1984), and willingness to help an overworked college peer (Patterson et al., 1986). Studies that have examined immediate physiological reactions to social touch (Drescher et al., 1980, 1985; Hosey et al., 1994; Lynch et al., 1974a; Vrana and Rollock, 1998) show that social touch, but not self-touching, evokes reliable heart rate decelerations. These results accord with studies of touch in non-humans. Social touch (grooming) has been shown to reduce heart rate in rhesus monkeys (Aureli et al., 1999), and in domesticated animals human touch (petting) reduces heart rate (Lynch et al., 1974b) and attenuates heart rate increase in anticipation of electrical shock (Anderson and Gantt, 1966). On the other hand, touch other than for greeting, attention, or assistance is a rare act between adults in public social life. In most cases uninvited touch from a stranger is experienced as offensive, intrusive, or threatening (Sussman and Rosenfeld, 1978), particularly in Western culture (Remland et al., 1995) and
‘touch avoidance’ (Andersen and Leibowitz, 1978) may lead to an avoidance of social situations in general. Interestingly, the emotional impact of social touch may vary dramatically across individuals. According to DSM-IV (American Psychiatric Association, 1994), social anxiety disorder is characterized by marked and persistent fear of social or performance situations in which embarrassment may occur. Touching or being touched is clearly such a social situation, and several factors may contribute to increased fearfulness about touch in socially anxious individuals. Social touch is controlled within each culture by a set of rules regarding who is supposed to touch whom how and where in which situation (Jourard, 1966). Given the conventions and ambiguities surrounding social touch, socially anxious individuals may be particularly insecure about actively pursuing touch behaviors. Any deviation from etiquette is likely to be registered by the touch interaction partner or by other observers and may cause embarrassment. The generally increased self-consciousness in socially anxious individuals in social situations (Saboonchi et al., 1999) may make touching awkward and strained.

1.1. The present study

In the present study, emotions and attitudes about a variety of social behaviors involving touch were evaluated by questionnaire in individuals selected for high (within a clinical range) and low social anxiety. In addition, physiological and self-report data were gathered for a touch interaction with an unfamiliar person. Our study had three principal aims.

Our first aim was to examine how social anxiety affects general attitudes towards situations involving social touch. We expected that high socially anxious individuals would experience social touch as more aversive than low socially anxious individuals. Our second aim was to evaluate whether high socially anxious individuals differ from low socially anxious individuals in terms of their self-reported emotional responses to an actual episode of social touch. We expected that self-reported anxiety, self-consciousness, and embarrassment, both in anticipation of and during touch, would be increased in individuals who are typically anxious in social situations. Our third aim was to evaluate whether high socially anxious individuals differ from low socially anxious individuals in terms of their physiological responses to social touch. On the basis of prior research, we expected that anxiety would attenuate the heart rate decelerative response to social touch. To better understand the mechanisms of the heart rate deceleration concomitant with social touch and to extend previous findings on general physiological adjustments to a touch provocation (e.g. Vrana and Rollock, 1998), we continuously monitored both parasympathetic and sympathetic nervous system activation and a variety of other measures, including respiratory tidal volume and cardiac stroke volume. These additional physiological measures were necessary because it is now more widely recognized that adaptive patterns of responding can vary across different physiological systems, not just along a unidimensional activation continuum (e.g. Stemmler, 1993).
2. Methods

2.1. Participants

Subjects were selected from a pool of 840 female undergraduates at Stanford University using the Social Phobia and Anxiety Inventory (SPAI) (Turner et al., 1989), a questionnaire validated for identifying social phobic individuals and predicting their distress levels (Beidel et al., 1989a,b). The high socially anxious (HSA) group was selected from the top 25% of the distribution of scores on the social phobia subscale of the SPAI, whereas the low socially anxious (LSA) group was selected from the bottom 25% of the distribution. In addition, subjects had to be above (for the HSA group) or below (for the LSA group) the mean of a customized speech-anxiety subscale comprised of the six SPAI items relating to fear of speaking in front of others (5, 6, and 22 a–d).

Students selected for the study were telephoned and asked to take part in an investigation of the relationship of emotions, emotion regulation, and physiological responses; they received either course credit or money in exchange for participation. One hundred and fifteen subjects came to the laboratory for testing and completed the SPAI a second time so that their social anxiety status could be verified. Test-retest reliability was high: $r(115) = 0.94$, $P < 0.0001$. Two of the subjects were excluded because their scores on the SPAI scale changed markedly from the questionnaire session to the laboratory session (approximately 1-month test-retest interval). Their laboratory scores placed them in the HSA group when their original scores had placed them in the LSA group ($N = 1$), or vice versa ($N = 1$). Five of the subjects were excluded because they had taken psychoactive or cardiovascularly active medication that could interfere with the measurements. In addition, because of technical malfunction that affected at least one channel of the physiological recording, 13 subjects were excluded from the analyses. This left 95 participants for analysis, 48 of them high socially anxious (SPAI score range 76–171), and 47 of them low socially anxious (SPAI score range 2–66).

The ethnic composition of the sample was mixed: 9% African American, 10% Asian American, 57% Caucasian, 7% Latino, 2% Native American and 14% other. HSA and LSA groups were equated for ethnicity. All participants were native English speakers. Written informed consent was obtained after the procedures had been fully explained.

As can be seen in Table 1, mean SPAI scores (completed at the laboratory) for the high anxious group are similar to those reported for female students receiving a clinical diagnosis of social phobia ($M = 106$) (Beidel et al., 1989a). Only women were tested to reduce the number of between-subject variables in the design. Participants filled out several questionnaires at home. Table 1 depicts results from questionnaires most relevant to the current study: fearfulness about negative evaluation (Leary, 1983), trait anxiety (Spielberger et al., 1970), depression (Beck et al., 1961), and anxiety sensitivity (Reiss et al., 1986).
2.2. Procedure

On arrival, the participant was greeted by one of two male experimenters and seated in a well-lit and comfortable 9 × 12-ft. room held between 21 and 23 °C. Time of day was matched between the two groups. Participants had at least 15 min to get used to their surroundings before the procedure began. Physiological sensors were attached to the body and non-dominant hand. The experimenter could communicate with participants by intercom and observe them through a camera that was unobtrusively placed. The participant underwent a social touch interaction with four periods: baseline (3 min), pre-touch (1 min), touch (2 min), and recovery (2 min).

To minimize anxious anticipation before the actual touch interaction and to provide an initial low activation benchmark, during baseline the participant was shown a neutral videotape of seascapes. At the end of the baseline, the participant filled out a questionnaire. The experimenter then entered the room and placed a chair at 90° to the participant’s chair and 1 ft. in front of it, on the side of the participant’s dominant hand.

The experimenter delivered the following instructions just prior to the pre-touch period: “In this next task, I’m just going to sit in this chair for one minute. After a minute, I’ll lightly hold your wrist for two minutes. During this time, I’d like you to rest your right arm here on the table with your palm down and sit still with your eyes open, looking straight ahead.” If the participant was left-handed, ‘left’ would be substituted for ‘right.’ After instructions were delivered, the experimenter sat quietly in his chair, looking straight ahead; no eye contact was made with the participant during either the pre-touch or touch periods. The experimenter then delivered the following instructions just prior to the recovery period: “I’m going to go next door now. Please just sit quietly for the next few minutes until you hear further instructions.” After the recovery period, the participant was asked to fill out a second set of questionnaires. The beginning and end of each period was marked

Table 1
Means (S.D.) of sample characteristics

<table>
<thead>
<tr>
<th></th>
<th>High social anxiety</th>
<th>Low social anxiety</th>
<th>t(94)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number in sample</td>
<td>48</td>
<td>47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>19.3 (1.2)</td>
<td>19.1 (1.1)</td>
<td>1.09</td>
<td>—</td>
</tr>
<tr>
<td>Social Phobia and Anxiety Inventory (0–672)</td>
<td>104.7 (19.1)</td>
<td>34.3 (16.2)</td>
<td>19.39</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fear of negative evaluation (Brief, 12–60)</td>
<td>32.1 (9.0)</td>
<td>18.2 (9.0)</td>
<td>7.52</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>State–Trait Anxiety Inventory-Trait (20–80)</td>
<td>49.5 (8.5)</td>
<td>35.3 (7.6)</td>
<td>8.59</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Beck Depression Inventory (0–63)</td>
<td>11.4 (9.4)</td>
<td>6.3 (4.1)</td>
<td>3.48</td>
<td>&lt;0.0008</td>
</tr>
<tr>
<td>Anxiety Sensitivity Index (0–64)</td>
<td>23.9 (10.4)</td>
<td>16.3 (9.2)</td>
<td>3.75</td>
<td>&lt;0.0003</td>
</tr>
</tbody>
</table>
with a tone. Since video recordings revealed marked physical activity during the solitary recovery period, this period was dropped from all further analyses. The touch interaction was followed by additional tasks not relevant to the present report.

2.3. Self-report measures

Prior to testing, participants filled out a social touch questionnaire (STQ) devised by the authors, comprising the 20 questions listed in Table 2. Participants were asked to “indicate how characteristic or true each of the following statements is of you” on a 0–4 scale (0 = not at all, 1 = slightly, 2 = moderately, 3 = very, 4 = extremely). Items were chosen to provide a broad sample of affects and attitudes towards social touch. Items span such dimensions as giving versus receiving touch, touch involving an acquaintance versus a stranger, touch occurring in a public versus private place, or touch having sexual versus non-sexual connotations. About half of the items have negative polarity. In this sample, internal consistency (Cronbach’s $\alpha$) of the overall questionnaire was 0.89, with an 0.29 average item intercorrelation.

After baseline, pre-touch, touch, and recovery periods, participants rated their anxiety level on an 11-point Likert-type scale, ranging from 0 (none at all) to 10 (extremely). After baseline and touch periods, participants also rated their level of embarrassment and self-consciousness, using the same scale. After the touch period, participants evaluated their experience of being touched using three items: “The touch calmed my nerves”, “The touch felt constricting”, and “The touch was pleasant”. They were asked to indicate their agreement or disagreement with each statement on a 0–10 scale (0 = strongly disagree, 5 = neutral, 10 = strongly agree).

2.4. Physiological measures

During the experimental session, physiological channels were sampled continuously at 400 Hz using laboratory software. Later, customized analysis software written in MATLAB (Wilhelm et al., 1999) was applied to physiological data reduction, artifact control, and computation of average physiological scores for each participant for the baseline, pre-touch, and touch periods. Measures especially relevant to emotional responding were chosen to assess various aspects of activation of the cardiovascular, electrodermal, and respiratory systems. Respiratory sinus arrhythmia, assessed by transfer function analysis, was used to assess parasympathetic activation.

2.4.1. Cardiovascular system

RR intervals were measured from an electrocardiogram and instantaneous heart period and heart rate was calculated. In addition, the continuous arterial blood pressure waveform was taken from the index finger of the non-dominant hand by means of the Finapres™ 2300 (Ohmeda, Madison, WI) system. From this, customized software calculated beat-to-beat systolic/diastolic arterial pressures and
Table 2
Means (S.D.) of social touch questionnaire items (0 = not at all, 1 = slightly, 2 = moderately, 3 = very, 4 = extremely) and total score

<table>
<thead>
<tr>
<th>Item</th>
<th>High social anxiety</th>
<th>Low social anxiety</th>
<th>t(94)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>I generally like when people express their affection towards me in a physical way (R)</td>
<td>2.31 (0.97)</td>
<td>3.13 (0.68)</td>
<td>4.73</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>I feel uncomfortable when someone I don’t know very well hugs me</td>
<td>1.73 (1.23)</td>
<td>0.77 (0.96)</td>
<td>4.24</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>I get nervous when an acquaintance keeps holding my hand after a handshake</td>
<td>2.06 (0.95)</td>
<td>1.26 (1.00)</td>
<td>3.98</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>I generally seek physical contact with others (R)</td>
<td>1.94 (0.95)</td>
<td>2.70 (0.93)</td>
<td>3.95</td>
<td>&lt;0.0002</td>
</tr>
<tr>
<td>I feel embarrassed if I have to touch someone in order to get their attention</td>
<td>1.00 (1.05)</td>
<td>0.32 (0.59)</td>
<td>3.87</td>
<td>&lt;0.0002</td>
</tr>
<tr>
<td>I consider myself to be a ‘touchy-feely’ person (R)</td>
<td>1.40 (1.27)</td>
<td>2.32 (1.20)</td>
<td>3.65</td>
<td>&lt;0.0004</td>
</tr>
<tr>
<td>It annoys me when someone touches me unexpectedly</td>
<td>1.21 (1.09)</td>
<td>0.57 (0.83)</td>
<td>3.19</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>I’d feel uncomfortable if a professor touched me on the shoulder in public</td>
<td>1.17 (1.15)</td>
<td>0.51 (0.88)</td>
<td>3.11</td>
<td>&lt;0.003</td>
</tr>
<tr>
<td>I’d be happy to give a neck/shoulder massage to a friend if they are feeling stressed (R)</td>
<td>2.65 (1.26)</td>
<td>3.35 (0.97)</td>
<td>3.01</td>
<td>&lt;0.004</td>
</tr>
<tr>
<td>I feel uncomfortable if I make physical contact with a stranger on the bus or subway</td>
<td>1.69 (1.09)</td>
<td>1.02 (1.09)</td>
<td>2.97</td>
<td>&lt;0.004</td>
</tr>
<tr>
<td>I like being caressed in intimate situations (R)</td>
<td>3.02 (1.16)</td>
<td>3.57 (0.74)</td>
<td>2.77</td>
<td>&lt;0.007</td>
</tr>
<tr>
<td>As a child, I was often cuddled by family members (e.g. parents, siblings) (R)</td>
<td>2.32 (1.18)</td>
<td>2.96 (1.08)</td>
<td>2.73</td>
<td>&lt;0.008</td>
</tr>
<tr>
<td>I would rather avoid shaking hands with strangers</td>
<td>0.60 (1.01)</td>
<td>0.17 (0.44)</td>
<td>2.67</td>
<td>&lt;0.009</td>
</tr>
<tr>
<td>I greet my close friends with a kiss, cheek-to-cheek (R)</td>
<td>0.63 (0.96)</td>
<td>1.23 (1.35)</td>
<td>2.53</td>
<td>&lt;0.02</td>
</tr>
<tr>
<td>I feel comfortable touching people I do not know very well (R)</td>
<td>1.50 (1.15)</td>
<td>2.04 (1.14)</td>
<td>2.31</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>I feel disgusted when I see public displays of intimate affection</td>
<td>1.40 (1.21)</td>
<td>0.91 (1.08)</td>
<td>2.07</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>It would make me feel anxious if someone I had just met touched me on the wrist</td>
<td>1.04 (1.03)</td>
<td>0.66 (0.98)</td>
<td>1.85</td>
<td>(&lt;0.07)</td>
</tr>
<tr>
<td>If I had the means, I would get weekly professional massages (R)</td>
<td>2.75 (1.39)</td>
<td>3.21 (1.40)</td>
<td>1.62</td>
<td>–</td>
</tr>
<tr>
<td>I hate being tickled</td>
<td>1.77 (1.28)</td>
<td>1.38 (1.53)</td>
<td>1.35</td>
<td>–</td>
</tr>
<tr>
<td>I like petting animals (R)</td>
<td>3.06 (1.19)</td>
<td>3.04 (1.18)</td>
<td>0.08</td>
<td>–</td>
</tr>
<tr>
<td>Total score</td>
<td>32.1 (11.8)</td>
<td>20.1 (10.4)</td>
<td>5.28</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

* Note that some of the items are reverse scored (R).
stroke volume using pulse contour analysis. These measurements have been previously validated (Gratz et al., 1992; Imholz et al., 1990; Stok et al., 1993). Values from ectopic or other kinds of abnormal beats were deleted and replaced by linearly interpolated values.

2.4.2. Electrodermal system

A constant-voltage device was used to pass 0.5 V between Beckman electrodes attached to the palmar surface of the middle phalanges of the first and second fingers of the nondominant hand. The skin conductance channel was analyzed as the mean level (skin conductance level) after movement and electrode contact artifacts had been edited out using a special detection procedure (Wilhelm and Roth, 1996). Skin conductance level represents our purest measure of sympathetic nervous system activation.

2.4.3. Respiratory system

Two channels of respiration were measured using an inductive plethysmography device (Respirtrace Corporation, Ardsley, NY) connected to bands containing coils of insulated wires placed around the abdomen and chest. Calibration against 800 ml fixed-volume bags was accomplished by the least-squares method (Chadha et al., 1982) to obtain a lung volume (LV) change signal. Respiratory rate, tidal volume, and minute ventilation were calculated breath-by-breath using customized programs.

2.4.4. Respiratory sinus arrhythmia (RSA)

The beat-by-beat values of HP were carefully edited for outliers due to artifacts or ectopic myocardial activity (any spikes in signals can distort spectral analyses), linearly interpolated, and converted into instantaneous HP time series with a resolution of 4 Hz using cubic spline interpolation. Vagal control of heart rate was estimated as the magnitude of the transfer function relating HP oscillations to LV oscillations (also resampled to 4 Hz) at the peak respiratory frequency (Saul et al., 1991). The computation procedure for this was as follows (for more details, see Wilhelm et al., 2001): HP and LV time series were first linearly detrended, and the power spectral densities (P_{HP} and P_{LV}) were derived for each experimental period using the Welch algorithm (Welch, 1967), which ensemble averages successive periodograms. Averages were derived from spectra estimated for 60-s data segments, overlapping by half. For each 60-s segment, 256 points were analyzed, which includes 240 sampled points with zero padding. The segments were Hanning windowed and subjected to fast Fourier transform. Estimates of power were adjusted to account for attenuation produced by the Hanning window. The products of the segments of P_{LV} and P_{HP} were averaged to form P_{LV,HP}, the cross spectral density of P_{LV} and P_{HP}. The transfer function T_{LV,HP} was computed as the quotient of P_{LV,HP} and P_{LV}. Transfer function RSA is the value of T_{LV,HP} at the respiratory frequency. The respiratory frequency was identified as the greatest local maximum in the 0.13–0.50 Hz lung volume power spectral density function (corresponding to a range of respiratory rates from 7.8 to 30 breaths/min). Spectral coherence between signals at this frequency was required to be at least 0.5 to make
sure that measured HP oscillations were truly due to respiratory sources and not due to non-RSA variation within the respiratory frequency range. RSA measured in this way is adjusted for tidal volume variance across individuals and tasks, and thus can provide a more accurate index of tonic cardiac vagal control than simple HP spectral power (Brown et al., 1993).

2.5. Statistical analysis

Means on items of the social touch questionnaire were compared between HSA and LSA groups by independent sample t tests. All P-levels reported are two-tailed. For assessment of group differences in physiological activity, period averages were calculated for the last minute of baseline, the pre-touch, and the touch period. Data for each dependent measure and for self-reported anxiety were examined using a 2 (group: LSA, HSA) × 3 (period: baseline, pre-touch, touch) analysis of variance (ANOVA), with repeated measures on the second factor. Data for self-reported embarrassment and self-consciousness were examined using a 2 (group: LSA, HSA) × 2 (period: baseline, touch) ANOVA, whereas the data for self-reported touch evaluation were examined using one-way ANOVAs, with two levels (group: LSA, HSA). The Greenhouse–Geisser ε correction was applied to the degrees of freedom for all effects involving the repeated measures factor, and corrected P values were used throughout. Significant effects were followed using the Tukey honestly significant difference test for unequal N, with comparison-specific error terms for effects involving the period factor. P values smaller or equal 0.05 were taken as indication of significant effects.

3. Results

3.1. Social touch questionnaire

Table 2 compares responses of the high and low socially anxious groups on the social touch questionnaire. Compared to LSA participants, HSA participants rated social touch as more unpleasant and avoided it more across a variety of social situations. However, at the item level, they did not differ on an item not directly referring to social touch (“I like petting animals”).

3.2. Social touch interaction

3.2.1. Self-report measures

Examination of self-reported anxiety indicated a group × period interaction, \( F(2,186) = 25.99, \ P < 0.0001, \ \varepsilon = 0.784 \), and a period main effect, \( F(2,186) = 92.87, \ P < 0.0001, \ \varepsilon = 0.784 \). Pairwise comparisons revealed that the groups were equally anxious during baseline, and anxiety increased significantly for both groups during the pre-touch period, with the HSA group showing a greater increase. The HSA group increased further during the touch period, while the LSA group remained at
pre-touch anxiety levels. Mean anxiety reports are presented for each anxiety group in Fig. 1.

Self-consciousness also showed a significant interaction effect, $F(1,93) = 15.33, P < 0.0002$. Pairwise comparisons revealed that the source for this interaction was a greater increase in self-consciousness for HSA than for LSA. Groups differed significantly at baseline. Embarrassment also showed a significant interaction effect, $F(1,93) = 21.35, P < 0.0001$. Pairwise comparisons revealed that the source for this interaction was a significant increase in embarrassment from baseline to touch for HSA, while it changed only little and non-significantly for LSA. Mean self-consciousness and embarrassment reports are presented for each anxiety group in Fig. 1.

HSA participants experienced the touch of the experimenter as more unpleasant and constricting, and as less calming than the LSA participants (“The touch was pleasant”, HSA: $4.3 \pm 2.2$, LSA: $5.7 \pm 2.3$, $t(93) = 2.90, P < 0.005$; “The touch felt constricting”, HSA: $3.3 \pm 2.7$, LSA: $1.7 \pm 2.3$, $t(93) = 2.99, P < 0.004$; “The touch calmed my nerves”, HSA: $3.1 \pm 2.0$, LSA: $4.7 \pm 2.2$, $t(93) = 3.53, P < 0.0007$). A rating of 5 corresponds to “neutral” on a scale from 0 = “strongly disagree” to 10 = “strongly agree”.

### 3.3. Heart rate and sympathetic/parasympathetic activation measures

Examination of heart rate, skin conductance level, and RSA did not reveal significant group × period interaction effects. Rather, significant period main effects were noted for heart rate, $F(2,186) = 57.45, P < 0.0001$, $\varepsilon = 0.895$, skin conductance level, $F(2,186) = 112.24, P < 0.0001$, $\varepsilon = 0.674$, and RSA, $F(2,186) = 13.98, P < 0.0001$, $\varepsilon = 0.785$. Pairwise comparisons for the period effects revealed that for all three measures, baseline, pre-touch, and touch levels were significantly different from each other. While heart rate decreased and RSA increased from baseline to

![Fig. 1. Means and S.E.s of self-reported anxiety, self-consciousness, and embarrassment for high (HSA, $N = 48$) and low (LSA, $N = 47$) socially anxious groups at baseline (Base), in anticipation of (Pre), and during touch (Touch). Self-consciousness and embarrassment were not evaluated during the pre-touch period.](image-url)
pre-touch, and from pre-touch to touch, skin conductance level increased from baseline to pre-touch, and decreased from pre-touch to touch. The pattern of results for RSA remained the same when it was analyzed using respiratory rate as a changing covariate, indicating that RSA results were not due to respiratory rate changes. Decreasing respiratory rate could induce observed RSA changes without changes in tonic vagal control of heart rate (Wilhelm et al., 1998). Mean heart rate, skin conductance, and RSA responses are presented for each anxiety group in Fig. 2.

3.4. Cardiovascular measures other than heart rate

Examination of systolic/diastolic arterial pressures and stroke volume also did not reveal significant group × period interaction effects. Again, significant period main effects were noted for systolic pressure, \( F(2,186) = 36.87, P < 0.0001, \varepsilon = 0.876 \), diastolic pressure, \( F(2,186) = 21.45, P < 0.0001, \varepsilon = 0.805 \), and stroke volume, \( F(2,186) = 69.33, P < 0.0001, \varepsilon = 0.761 \). Pairwise comparisons for the period effects revealed that for all three measures, pre-touch and touch levels were significantly above baseline, but not different from each other. Mean blood pressure and stroke volume responses are presented for each anxiety group in Fig. 3.

3.5. Respiratory measures

Like the other physiological measures, respiratory rate, tidal volume, and minute volume also did not reveal significant group × period interaction effects. Significant period main effects were noted for respiratory rate, \( F(2,186) = 4.05, P < 0.02, \varepsilon = 0.867 \), and tidal volume, \( F(2,186) = 6.56, P < 0.002, \varepsilon = 0.785 \). Pairwise comparisons for the period effects revealed that for both measures touch
levels were significantly different from baseline and pre-touch periods. Apparently, an increase in respiratory rate during touch was compensated by a decrease in tidal volume, resulting in unchanged minute volume. Mean respiratory responses are presented for each anxiety group in Fig. 4.

1 Secondary analyses were conducted to explore whether HSA and LSA groups diverged physiologically during any part of the experiment using a 20-s time resolution (except for RSA, which requires longer periods for reliable estimation). Physiological parameters were not significantly different (t-test, two-tailed, $P > 0.05$) between groups for any of the periods for any measures except two respiratory measures; respiratory rate was higher in the HSA versus LSA group in the first 20 s of anticipation ($P < 0.02$) and tidal volume was lower in the HSA versus LSA group in the first 20 s of touch ($P < 0.03$). Of course, after Bonferroni correction for $\alpha$-inflation due to multiple measurement, these isolated differences did not remain significant.
3.6. Mediational analyses

Following the statistical approach outlined by Baron and Kenny (1986), we examined if differences in the experiential response to touch between high and low socially anxious participants were mediated by the participants’ attitudes to touch. We first confirmed that social anxiety (SPAI) was related to anxiety response (touch minus baseline). As expected, this correlation was significant ($r(95) = 0.51, P < 0.0001$). We then asked whether touch attitudes (STQ) were related to social anxiety. This correlation was also significant ($r(95) = 0.59, P < 0.0001$). We finally asked if touch attitudes were related to anxiety response when social anxiety was controlled for. A multiple regression analysis with SPAI and STQ as independent variables and anxiety response as dependent variable indicated that STQ did not significantly affect anxiety response after SPAI was partialled out ($\beta = 0.06, P > 0.6$). Similar results were obtained for self-consciousness ($\beta = 0.09, P > 0.4$) and embarrassment ($\beta = 0.06, P > 0.5$). Taken together, these analyses indicate that touch attitudes did not mediate the pronounced effects of social anxiety on the experiential responses to touch. Since neither social anxiety nor touch attitudes were significantly related to physiological responses to touch (absolute $r’s < 0.2$, $P’s > .1$), touch attitudes also do not appear to have mediated physiological responses to touch.

4. Discussion

Social touch is a ubiquitous feature of social life, and yet the emotional impact of social touch in adulthood is not yet well understood. The present study examined a variety of affects and attitudes concerning social touch, and self-reported and physiological reactions to a touch interaction between an experimenter and individuals selected to be high and low in social anxiety. To obtain a high overall score on the Social Phobia and Anxiety Inventory, participants had to report experiencing anxiety across a variety of social and performance situations (e.g., initiating or maintaining conversations, participating in small groups, dating, speaking to authority figures, attending parties), which is most consistent with the generalized subtype of social phobia (American Psychiatric Association, 1994). In addition, we required fear of public speaking to be elevated for inclusion in the high socially anxious group, which makes it even less likely that participants’ clinical manifestations were confined to a single performance situation. Although clinical diagnoses were not obtained, scores for the high socially anxious participants were comparable to those reported in clinical samples (Beidel et al., 1989a).

4.1. Attitudes toward social touch

Individual responses on the social touch questionnaire indicate that social anxiety is related to a generalized pattern of anxiety and avoidance related to situations involving touch. Socially anxious individuals report that they are less likely to
actively pursue touch behaviors in public, private, and intimate situations, and react more negatively to being touched in these situations. Why might socially anxious individuals avoid touch? Touch implies an extreme form of social presence, which may be even more anxious-making than being gazed at, another situation that is upsetting to socially anxious individuals. Being touched creates an immediate demand for a response, and usually a reciprocal touch is expected. Feelings of inferiority and low self-esteem common in socially anxious individuals may prohibit initiation of touch in public—which signals social status and dominance (Burgoon et al., 1984). Within intimate relationships touch has additional functions such as providing comfort and pleasure that may be difficult for some individuals who are self-conscious and anxious in the presence of others.

4.2. Subjective emotion experience and touch

Self-reported responses in the experimental touch interaction are consistent with results from the social touch questionnaire. High socially anxious individuals reacted to the touch with greater increases in self-reported anxiety than low socially anxious individuals, both when anticipating touch and during touch. They also experienced the touch as more unpleasant, felt more constricted by it, and were made more nervous by it than the low socially anxious individuals. Embarrassment, the hallmark of social anxiety disorder, increased during the touch only for the high socially anxious individuals. Similarly, self-consciousness increased more in high than low socially anxious individuals. Interestingly, these responses to touch were not mediated to a significant degree by attitudes participants had towards social touch as assessed by the social touch questionnaire. Apparently, social anxiety was a dominant factor in explaining differences in social touch attitudes as well as in directly assessed experiential responses to touch.

Self-reported responses to the touch interaction are similar to those observed in studies that have examined responses of socially phobic individuals when giving a speech before an audience or during a verbal interaction (Gerlach et al., 2001; Hofmann et al., 1995). This is somewhat surprising since the touch interaction in our experimental paradigm was designed to minimize any performance fears by asking subjects to remain passive. Thus, anxiety during touch cannot be attributed to performance demands of the situation per se. To our knowledge, no other study has examined reactions of socially anxious individuals in low-performance demand social situations. Pre- and post-performance reactions often have been assessed but are confounded by anticipation and recovery effects. The present findings indicate that performance evaluation is not a necessary factor for inducing substantial increases in experienced anxiety in high socially anxious individuals.

4.3. Physiological responses and touch

Social touch elicited a distinct and complex pattern of physiological response
that demonstrates the value of sampling across different physiological systems. A unitary construct of activation or arousal fails to adequately capture the richness of participants’ responses, which are better viewed within the framework of modern, empirically derived multi-response system conceptualizations (Fahrenberg and Foerster, 1982; Fowles, 1980).

Consistent with previous studies (Drescher et al., 1980, 1985; Hosey et al., 1994; Lynch et al., 1974a; Vrana and Rollock, 1998), heart rate decreased from baseline to touch periods. Contrary to our expectations, however, high socially anxious subjects did not exhibit attenuated heart rate deceleration compared to low socially anxious subjects, and surprisingly, both groups showed heart rate deceleration during anticipation of touch. This pattern of heart rate findings cannot simply be explained by general physiological deactivation due to time or habituation since blood pressure, skin conductance, and other measures showed a pronounced increase from baseline to anticipation and touch periods.

Rather, the pattern of physiological changes is most consistent with a rarely observed configuration of sympathetic-parasympathetic coactivation (Berntson et al., 1991) of the autonomic nervous system, with a relative predominance of parasympathetic contributions (measured by RSA) to the innervation of the cardiac sinus node. Thus, this study documents for the first time that the heart rate deceleration in anticipation of and during touch is largely caused by increases in vagal nervous outflow to the heart. As previously observed by Vrana and Rollock (1998), skin conductance, a measure of sympathetic activation, showed a significant increase from baseline to touch anticipation and touch. Apparently, the effects of the increase in sympathetic activation on heart rate was compensated for and overridden by the concomitant increase in parasympathetic activation, resulting in a net heart rate decrease. The small reduction of sympathetic activation from touch anticipation to touch apparently did not alter the heart rate deceleration. An increase in parasympathetic activity would explain the reduction in ventricular arrhythmias following pulse palpation in cardiac patients (Lynch et al., 1977).

The observed dissociation between heart rate and blood pressure is a direct consequence of this sympathetic-parasympathetic coactivation. Usually systolic and diastolic arterial pressure changes follow heart rate changes in stress or recovery tasks. Since blood pressure is determined by heart rate, stroke volume, and systemic vascular resistance, a decrease in heart rate usually results in decreased blood pressure. However, our data show that being the recipient of touch causes a pronounced increase in stroke volume that overrides the blood pressure drop that would be caused by observed heart rate deceleration. Increase in contractility of the cardiac muscle is largely due to sympathetic factors.

If heart rate decrease indicated a reduction in metabolism, respiratory rate and minute ventilation would be expected to decrease as well. However, respiratory rate increased slightly during touch, which was compensated by a decrease in tidal volume resulting in unchanged minute volume. In general, effects of touch on respiratory measures were not pronounced, and groups did not react differentially.
4.4. Why did touch produce a complex physiological response profile?

Physiological response to touch was characterized by sympathetic-parasympathetic coactivation, and responses were largely equivalent for high and low socially anxious individuals across all measures. How can this response pattern to touch be explained? The principle of stimulus-response specificity (Engel, 1960) states that specific stimulus situations bring about specific adaptive patterns of responding in different physiological systems, not just an increase or decrease in a unidimensional activation continuum. A special case of stimulus-response specificity was termed “directional fractionation” (Lacey, 1967) and was used to describe a response pattern to environmental stimuli demanding attention. It is characterized by an increase in skin conductance with accompanying decrease in heart rate. In general, heart rate decelerates during environmental intake and accelerates during rejection of the environment such as during performance of a mental task. Heart rate deceleration can be a short-term component of the orienting response, or, more sustained, an adjustment to environmental threat that does not allow fight or escape (Lacey et al., 1963).

Evolutionarily, being touched demands immediate attention, evaluation of the degree of danger potential of the touch, and depending on the outcome of this evaluation, a fight, flight, freeze, or relaxation response. Being touched or held by someone can have many meanings and consequences. Touch can be comforting, accompany mating behavior, signal impending danger, immediately precede physical harm, or restrict motion when captivated. Thus, being touched in a threatening situation or ambiguous context may increase heart rate while it may decrease heart rate in a safe and unambiguous environment. In addition, heart rate may decrease when the situation does not allow escape. The perception of the meaning of the touch may play an important role in determining the physiological response. Subjects in the present experiment were made more anxious by the touch, but the characteristics of the touch interaction where behavioral response in form of movement or eye contact was sanctioned and one arm was held by the experimenter, prevented escape. This would most likely trigger the described “escape inhibition” fear response, and the physiological data in the current study is consistent with this.

4.5. The divergence of subjective experience and physiological responding: implications for social anxiety

Most anxiety researchers would agree that it is important to sample across three systems as proposed by Lang (Lang, 1968, 1979)—motor-behavior, self-report, and physiology. Regrettably, physiology is often omitted in clinical studies or only represented by a single measure such as heart rate, which is not a good window into either the sympathetic or parasympathetic response system. The current data compellingly demonstrate that this can lead to an incomplete picture of the complex psychophysiological adjustments that may take place during a social anxiety provocation. One example is the observed bidirectional relationship of heart rate
and blood pressure, which only makes sense in the context of a more detailed examination of autonomic nervous system responses.

The surprising fact that physiological responses across a wide variety of bodily systems were equivalent between the high and low socially anxious groups calls for further investigation. In other clinical studies that used anxiety provocations, heart rate increase covaried with self-reported anxiety (Wilhelm and Roth, 1998a; Witvliet and Vrana, 1995) and is generally considered a good index of emotional activation when exercise activation is controlled (Wilhelm and Roth, 1998b). On the other hand, in several studies with socially anxious individuals, elevated self-report of anxiety was not reflected in physiological hyperreactivity (Grossman et al., 2001; McNeil et al., 1993).

The three-systems approach views anxiety as a response complex with loosely coupled motor-behavioral, self-report, and physiological components. The looseness of the coupling of autonomic and experiential responses may derive in part from cognitive processes that shape the conscious awareness and language representation of the emotional response. With respect to the current study, cultural norms against touch between adults, which are strong in Western culture (Remland and Jones, 1988; Remland et al., 1995), may have biased self-reports especially in socially anxious individuals, resulting in amplified anxiety self-reports without physiological concomitants. Socially anxious individuals have been shown to be specifically prone to cognitive distortions and dysfunctional beliefs about themselves and social standards, which has been suggested to lie at the root of the disorder (Clark and Wells, 1995). In addition, socially anxious individuals are more likely to focus their attention on monitoring their external appearance (Saboonchi et al., 1999), probably at the cost of accurate interoception of the quality and extent of physiological concomitants of their emotional activation (cf. “competition of cues theory” (Pennebaker, 1982)). Thus, emotion ratings of our study participants may have been based less on physiology and more on cognitive interpretations or expectations brought about by the experimental situation. The fact that physiological and self-report responses were similar between the anticipation of touch and actual touch also suggests that cognitions played an important role in this paradigm. Results from studies in infants and in animals, where touch appears to have a calming and health promoting effect, further indicate that touch provokes anxiety because of learned cultural factors.

The dissociation of autonomic and experiential components of the emotional response to touch can also be viewed from a perspective of neural organization of central fear circuits. LeDoux (2000) argued that the pathway of fear response to external stimuli involves an implicit and largely unconscious memory system, mediated by the amygdala and related subcortical areas, triggering autonomic responses, and an explicit and largely conscious memory system, mediated by the hippocampus and related cortical areas, encoding neutral or ‘cold’ information about an emotional situation. The interoception of autonomic activation typically fuses in consciousness with explicit memories of past emotional situations to give rise to an integrated emotional experience. Under some circumstances only the implicit pathway is activated, resulting in autonomic activation without conscious
representation of memories linked to this emotional activation. One can expect that there are also instances where the opposite is true: conscious representation of emotional memories without autonomic activation. In fact, it appears that in the present study this might have played a role in the exaggerated self-report of fear in high socially anxious individuals. The biological and psychological mechanisms underlying the dissociation of autonomic nervous system activation and subjective experience of anxiety clearly require further scrutiny.

4.6. Limitations and directions for future research

Several important limitations of the present study must be emphasized. Only young women college students were studied, and high social anxiety was assessed by questionnaire, not by structured clinical interview. Replication within a mixed-sex clinical sample of social phobics applying for treatment is desirable. A clinical control group could ensure that effects are specific to social anxiety and not to psychopathology in general. The order of conditions was not randomized in order to preserve a natural sequence of social interaction (approach, touch). This may have caused habituation to the presence of the experimenter, resulting in the observed physiological deactivation from anticipation to touch. However, self-reported anxiety increased from anticipation to touch in the socially anxious group. Future research has to address the ecological validity of the touch paradigm used in the present study. Touch interactions often involve touch behavior of shorter duration that happens spontaneously and reciprocally in social situations. The effects of active touch behavior and of other dyadic combinations of gender and age group have to be examined, given that age and gender influences attitudes towards touch (Jones and Brown, 1996; Remland et al., 1995). Perhaps physiological differences between high and low socially anxious participants can be elicited by a more demanding social touch provocation, e.g. unexpected touch or touch in the presence of several observers.

This study raises a number of directions for future research. For example, how are active and passive touch in socially anxious individuals in naturalistic settings different in terms of frequency, location, and duration? How early in life are these differences evident, and what is their course throughout life? How is behavioral inhibition and shyness in childhood (Kagan et al., 1987) related to touch behavior of mother and child? What is the relationship of cultural patterns of touch avoidance to social anxiety? Does informational and behavioral learning of socially accepted and expected touch behaviors increase effectiveness of cognitive-behavioral treatment for social anxiety? Given the powerful health promoting effects of touch in infancy, is touch avoidance in socially anxious individuals at higher age associated with social isolation and impaired health? Furthermore, is the association between marriage and reduced mortality due not only to social support, but also more specifically to increased availability of touch? Since high RSA at baseline has been shown to protect coronary artery disease patients from exaggerated cardiovascular responses to psychological stress (Grossman et al., 1996), being touched during a stressful task may have similar protective effects since touch
heightens RSA acutely. And finally, what role does touch aversion play in individuals suffering from eating disorders and in victims of sexual abuse? We view the present study as an initial foray into an exciting area at the intersection of clinical psychology, social psychology, and psychophysiology.

Acknowledgements

This research was supported by Grants MH56094 and MH58147 from the National Institute of Mental Health, Grant SBR-9728989 from the National Science Foundation, and by the Department of Veterans Affairs. The authors would like to thank Brian B. Jones for helping with the data collection and Iris Mauss for helping with the data reduction. We also would like to thank other members of the Stanford Psychophysiology Laboratory for their help with this research. Some data from this study were presented at the 40th Annual Meeting of the Society for Psychophysiological Research, San Diego, CA, USA.

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