Abstract

This study assessed the influence of trait social anxiety on cardiovascular, emotional and behavioral responses to active performance situations representing social and cognitive demands. Thirty-six male and thirty-six female students categorized as either high or low in trait social anxiety performed a mental arithmetic task and two interpersonal tasks requiring persuasive behavior: Preparation and Performance of a Speech, Role-played Interpersonal Interactions. The cardiovascular effects of social anxiety varied over experimental stressors and appear to reflect differences in effort or task engagement rather than differential affective experiences. During Role-played Interactions high socially anxious subjects displayed lower increases in systolic blood pressure compared to low anxious participants. This effect was partially mediated by behavioral indicators of social competence and suggests a more inhibited coping approach of socially anxious participants. Findings for Mental Arithmetic were in the opposite direction, high socially anxious subjects displayed greater heart rate effects. In the absence of group differences in state anxiety this effect might result from stronger audience effects on effort or task motivation in socially anxious participants. These findings strengthen the view that active performance situations elicit cardiovascular effects that are largely attributable to differences in task engagement. The data also indicate the importance of considering situational factors in social anxiety research.

Key words: Active coping, Mental stress, Social stress, Cardiovascular reactivity, Social anxiety, Social competence, Behavioral Assessment
Introduction

It is well established that cardiovascular response patterns vary with the type of stressful situation. Specifically, the task typology of active vs. passive coping (Obrist, 1981) was found to exert differential effects on the cardiovascular system. Evaluative performance situations with potential control over outcomes, or active coping conditions, tend to provoke large, beta-adrenergically mediated increases in systolic blood pressure (SBP) and heart rate (HR) with smaller or no effects on diastolic blood pressure (DBP) and vascular resistance. In situations with little or no action opportunities, or passive coping conditions, the cardiovascular system appears to be primarily under alpha-adrenergic control (Allen, Obrist, Sherwood & Crowell, 1987; Lovallo et al., 1985; Sherwood, Dolan & Light, 1990) resulting in enhanced vascular resistance and DBP reactivity. The myocardial effects of active coping, which have been observed in nonsocial (Bongard, 1995) and social contexts (Gramer & Huber, 1996; Hartley, Ginsburg & Heffner, 1999; Smith, Ruiz & Uchino, 2000), are considered to reflect energy mobilization and efforts to facilitate coping with behavioral demands rather than emotional intensity (Wright, 1996). Consistent with this hypothesis cardiac activation in active performance situations was found to be moderated by factors that are likely to influence task engagement such as intermediate task difficulty (Smith, Baldwin & Christensen, 1990; Eubanks, Wright & Williams, 2002), incentives (Gramer & Huber, 1996; Smith, Allred, Morrison & Carlson, 1989) and evaluative observation (Wright, Dill, Geen & Anderson, 1998; Kelsey et al., 2000).

Although certain tasks allow for active coping, not all individuals may display a cardiovascular response pattern characteristic for active task engagement (Lawler, Wilcox & Anderson, 1995; Gregg, Matyas & James, 2002). Some individuals were found to exhibit only moderate cardiac activity but enhanced vascular resistance or substantial increases in both myocardial and vascular activity, response patterns that were found to be characteristic for the passive experience of stress (Sherwood, Dolan & Light, 1990) and/or the presence of distress emotions (Tomaka, Blascovich, Kelsey & Leitten, 1993). Research on potential moderators has identified constitutional factors, vascular effects were found to be more likely in females (Lawler, et al., 2001) and Black Americans (Llabre, Klein, Saab, McCalla & Schneiderman, 1998; Anderson, McNeilly & Myers, 1993). Of interest are also dispositional attributes that may relate to behavioral inhibition rather than active coping.

Theoretical contributions from different sources (Clark & Wells, 1995; Rapee & Heimberg, 1997) indicate the potential relevance of trait social anxiety in this respect. Socially anxious individuals are characterized by a heightened concern with self-presentation and a strong fear of negative interpersonal evaluation. To reduce evaluation potential they tend to engage in subtle avoidance behaviors which may result in less effective social performance and reduced on-task effort. Drawing from research on the cardiovascular effects of active vs. passive coping, socially anxious compared to nonanxious individuals might be expected to display lower cardiac arousal in trait-relevant active performance situations, indicated by less pronounced elevations in SBP and HR and possibly enhanced DBP activity. Consistent with these predictions some authors did observe greater DBP reactivity in socially anxious individuals (Burns, 1995; Gramer & Huber, 1992), the majority of recent research, however, found social anxiety unrelated to cardiovascular reactivity (Baggett, Saab & Carver, 1996; Edelmann & Baker, 2002; Grossman, Wilhelm, Kawachi & Sparrow, 2001; Mauss, Wilhelm
Social anxiety and cardiovascular responses to active coping conditions

Considering that cardiovascular reactivity is more likely to be driven by differences in task engagement than emotions (Obrist, 1981; Wright, 1996), the relative lack of cardiovascular effects might have a basis in task features. Social anxiety research has mainly utilized moderately demanding interpersonal stressors: recall of emotionally involving events (Grossman, Wilhelm, Kawachi & Sparrow, 2001), unstructured conversations (Edelmann & Baker, 2002), speeches without demands to be persuasive or an in-person audience (Buggett, Saab & Carver, 1996; Mauss, Wilhelm & Gross, 2003). Active coping effects in the social context can primarily be expected in situations requiring effortful attempts to influence or control others (Smith, Allred, Morrison & Carlson, 1989; Smith, Ruiz & Uchino, 2000). The low demand conditions mentioned above may not have sufficiently enhanced task engagement in nonanxious participants to produce group differences in cardiovascular effects.

To provide further information on this hypothesis the cardiovascular effects of social anxiety were evaluated in interpersonal situations representing social equivalents of active coping: conflictual role-played interactions requiring self-assertion and the display of convincing and persuasive behavior during an evaluated speech task. A secondary aim was to evaluate the generalizability of effects across social and cognitive demands. Mental Arithmetic was included as additional stressor. There have been few efforts to characterize the responses to cognitive tasks in socially anxious subjects. Available research (Gramer & Huber, 1992) noted comparable cardiovascular reactivity to mental arithmetic in high and low socially anxious subjects, whereas a speech stressor clearly differentiated groups. Furthermore, reduced confidence in socially anxious individuals was found to be confined to social/evaluative situations, whereas cognitive tasks seem to elicit comparable success expectations in high and low socially anxious individuals, even in the presence of an evaluative audience (Efran & Korn, 1969). Social anxiety also does not seem to be a significant predictor of academic performance (Strahan, 2003).

A much debated issue in social anxiety research concerns the question whether social anxiety has a basis in social skills deficits. Empirical results are not quite consistent in this area. Several studies did observe lower social competence in high socially anxious subjects (Creed & Funder, 1998; Thompson & Rapee, 2002; Wenzel, Graff-Dolezal, Macho & Brendle, 2005) but social anxiety was also found unrelated to behavioral measures (Strahan & Conger, 1998; Sheffer, Penn & Cassisi, 2001). Furthermore, some authors (Clark & Wells, 1995; Rapee & Heimberg, 1997) suggested that group differences in social performance need not necessarily indicate an actual lack of skills. Impaired social performance might also be the result of heightened state anxiety and indicate skill inhibition or subtle avoidance behavior. Empirical support for this avoidance hypothesis is not very strong, however, as several studies found self-reported state anxiety unrelated to social competence (Thompson & Rapee, 2002; Sheffer et al., 2001).

There have been few efforts to investigate the relation between behavioral indicators of social competence and cardiovascular reactivity. The assessment of potential behavioral mediators is, in general, a largely neglected area in cardiovascular reactivity research. Available evidence suggests stronger cardiac effects in subjects with greater social competence, indicated by enhanced HR (Sheffer, Penn & Cassisi, 2001) or SBP reactivity (Morrison, Bellack & Manuck, 1985), possibly due to greater task engagement. Considering these results, the present study also examined whether potential group differences in overt behav-
ioral responses exhibited during Role-played Interactions mediated the effect of trait social anxiety on cardiovascular reactivity.

Another issue of some importance pertains to gender differences in the psychophysiological effects of social anxiety. Studies attending to this aspect have produced inconsistent results. A reaction time task with a strong evaluative component (threats to be critiqued in person) elicited differential responses in males but not females (Burns, 1995) and the cardiovascular effects of a speech task (recall of an emotionally involving situation) were related to social anxiety in females only (Grossman, Wilhelm, Kawachi & Sparrow, 2001). Several studies suggest that these discrepancies might partly be attributable to the gender relevance of stressors. Males appear to be more responsive to agentic or achievement-oriented stressors and females to communal or interpersonal stressors (Smith, Gallo, Goble,Ngu & Stark, 1998). Accordingly, this study also examined potential gender differences in trait by situation interactions.

Considering research on the cardiovascular effects of active coping (Obrist, 1981; Wright, 1996; Smith, Ruiz & Uchino, 2000) and theoretical contributions on social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997), socially anxious subjects were expected to respond to interpersonal situations involving demands to exert influence or control with enhanced distress and reduced cardiac activation (indicated by smaller elevations in HR and/or SBP and eventually increased DBP effects) compared to nonanxious subjects. The inhibited coping approach of socially anxious subjects might also result in less effective social performance. Mental Arithmetic was not expected to elicit differential psychophysiological responses in social anxiety groups (Gramer & Huber, 1992; Efran & Korn, 1969).

Method

Participants

Seventy-two students (36 male, 36 female) attending different faculties of the university of Graz were recruited by bulletin board advertisements. Subjects ranged in age from 19 to 29 years. The Social Anxiety Scale (SAP) developed by Lück (1971) was used for selection. To ensure comparability of social anxiety scores across genders pairs with largely equivalent social anxiety scores were formed (females $M = 9.69$, males $M = 9.78$). Participants were then assigned to high and low socially anxious groups on the basis of a median split of the final distribution of test scores. Mean levels of high anxious groups varied between 12.67 for females ($n = 18$) and 13.44 for males ($n = 18$); mean levels of low anxious groups varied between 6.72 for females ($n = 18$) and 6.11 for males ($n = 18$). All interactions involving gender were nonsignificant, $p > .30$.

Experimental tasks and procedure

The session was initiated by a 10-min rest period. Then each subject was exposed to four experimental conditions (Mental Arithmetic, Speech Preparation, Speech Performance, Role-played Interpersonal Interactions) in a counterbalanced order.
Mental arithmetic. The items of this task were selected from the concentration test developed by Düker and Lienert (1959). They consisted of two triplets of one-digit numbers which were to be added or subtracted (e.g. \(5 - 2 + 9; 2 + 6 - 4\)). Subjects were required first to calculate the triplet totals and then to subtract the smaller from the bigger triplet total. Over a period of five minutes 22 of these problems were presented at constant time intervals by means of a slide projector. Operations were performed without paper and pencil. The final answers were given verbally. Participants were informed that their performance was recorded by the experimenter.

Speech preparation/speech performance. Subjects were required to prepare and deliver a pleading for a handicapped (blind) student taking the role of a students’ representative. A five-minute preparation period led directly into a 5-min speech talking period (Baggett, Saab & Carver, 1996; Llabre et al., 1998). Subjects were informed that their presentations would be videotaped and evaluated according to the quality and persuasiveness of their arguments.

Role-played interpersonal interaction. Two conflictual role-play scenes requiring assertive responding were utilized: refusing an unreasonable request (a student research assistant was repeatedly asked to work over time) and challenging an unjustified evaluation in a written examination. Subjects were asked to respond to the prompts delivered by a confederate of the experimenter as though they were actually engaged in a real-life occurrence. Each scene was scheduled to last at least 2 minutes and involved an extended interchange including four standard verbal prompts by the confederate who was blind to experimental group designation. The interscene interval was held constant at 3 minutes. Interactions were videotaped and subjects were informed that their performance would be rated according to the quality and persuasiveness of their responses.

Tasks were separated by a 10-min rest period. Experimenter and confederate were present during performance of each task to hold potential audience effects on task engagement constant (Wright, Dill, Geen & Anderson, 1998; Kelsey et al., 2000). During rest periods subjects were alone.

Measures

Cardiovascular assessment

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were assessed by means of a portable microprocessor based multichannel system (PAR-PHYSIO-PORT). This device uses auscultatory detection and is equipped to detect artifact caused by movement or poor cuff placement. HR in bpm was determined from the ECG which was recorded by disposable silver-silver chloride chest electrodes (leads V1 – V5). Blood pressure (BP) readings were taken at 5-min intervals during the rest periods (that is immediately at rest onset, 5 min later, and at the end of the rest period). The final reading of each rest period constituted the pretask baseline. During Mental Arithmetic, Speech Preparation and Speech Performance BP readings were taken 1 and 4 min after task onset, during Role-played Interactions 1 min after onset of each scene. As several subjects did not speak long enough to collect a minute-4 BP reading for Speech Performance, analyses of task-specific effects were based on min-1 values for Mental Arithmetic, Speech Preparation/ Speech and the first scene of Role-played Interactions, only. HR was monitored continuously throughout
baseline and task periods at 10-sec intervals. Programming of the instrument’s memory and reading of the recorded data was done by a personal computer.

**Psychological assessment**

*Assessment of social anxiety*. Trait social anxiety was assessed with the social anxiety scale (SAP) developed by Lück (1971). This 26-item comprehensive device involves a wide range of social situations and has an alpha reliability of .74. Subjects with high scores appear to be particularly afraid of self-assertion and public appearance situations (Becker, 1997).

*Mood states*. On completion of each task participants rated the emotional states they experienced during task exposure by means of 17 six-point bipolar adjective scales. To reduce post task emotion ratings the average of the entries of each of the mood states was subjected to principal components analysis (PCA) with varimax rotation of factors exceeding unity. Three factors accounting for 70.17% of the variance emerged. The first factor consisted of ten items describing anxiety related states (e.g. balanced vs. nervous) and was labelled “Anxiety” (α = .92), the second factor consisted of five items describing anger related states (e.g. calm vs. aggressive) and was labelled “Anger” (α = .87) and the third factor consisted of two items referring to task engagement (e.g. passive vs. active) and was labelled “Activation” (α = .71).

*Behavioral measures*. The videotapes of the role-played interactions were coded by two independent raters (one male, one female) on a variety of response components adapted from Keane et al. (1982). Raters were blind to group assignment. Behavioral categories comprised: eye contact, loudness of speech, affect, requests for new behavior, compliance, inappropriate verbalizations, spontaneous positive behavior and finally, overall assertiveness. Like in most previous studies, overall assertiveness was utilized for further analyses. It was rated on a five-point Likert scale, where 1 = submissive, 3 = assertive and 5 = aggressive. The correlation coefficient of inter-rater reliability was .78.

**Data reduction and statistical analyses**

For further analyses, HR data of rest and task periods were transformed into 1-min averages and values concomitant to blood pressure measurements were utilized in further analyses. To evaluate responses to experimental tasks change (delta) scores computed as differences between minute-1 task levels and task-preceding resting levels were subjected to 2 (Gender) by 2 (Social Anxiety) by 4 (Tasks) analyses of covariance (ANCOVAs) with repeated measures. Baseline measurements were included as covariate. For effects involving repeated measures Greenhouse-Geisser adjusted degrees of freedom and probability values were used. Tukeys HSD post hoc comparisons were utilized for a-posteriori comparisons among means (Kirk, 1995). Where significant interactions involving a-priori hypotheses were obtained simple effects analyses were performed. Possible mediating influences of behavioral measures and emotional states were analysed with a series of regression analyses.
Results

Group comparisons at baseline

Analyses of variance revealed a significant gender main effect for baseline levels in SBP \( F(1, 68) = 35.42; P < .0001 \), with males exhibiting higher baseline SBP than females \((M_s 126.55 \text{ vs. } 110.23)\). Baseline levels for DBP \((M_s 74.31 \text{ vs. } 75.27)\) and HR \((M_s 72.54 \text{ vs. } 75.49)\) did not differ across gender groups. As regards social anxiety neither the main effect \((F_s < 1; P_s > .47)\) nor the interaction term gender by social anxiety \((F_s < 1; P_s > .44)\) achieved significance.

Cardiovascular reactivity, gender and social anxiety

Changes from pre-task rest to task conditions were found to be significant for all cardiovascular measures, \(F_s > 45; P_s < .0001\). Further analyses were performed on change scores \((\Delta SBP, \Delta DBP, \Delta HR)\).

ANCOVAs with repeated measures (Gender by Social Anxiety by Tasks) yielded significant Social Anxiety by Tasks interactions for all response measures \((SBP: F(3, 201) = 4.65; P < .004; \varepsilon = .7518, \text{ adjusted } P < .009; DBP: F(3, 201) = 2.73; P < .05; \varepsilon = .9580, \text{ adjusted } P < .05; HR: F(3, 201) = 3.41; P < .02; \varepsilon = .7780, \text{ adjusted } P < .03)\), see Table 1. Simple effects analyses performed on \(\Delta SBP\) revealed that social anxiety did not substantially influence SBP responses during Mental Arithmetic, Speech Preparation and Speech Performance. For Role-played Interactions, however, the contrast was significant \([F(1, 67) = 5.06; P < .03]\), indicating higher SBP increases in low socially anxious compared to high.

Table 1:
Mean (SD) blood pressure and heart rate changes from baseline during experimental tasks in low \((n = 36)\) and high socially anxious \((n = 36)\) participants

<table>
<thead>
<tr>
<th>Social Anxiety</th>
<th>Mental Arithmetic</th>
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<tbody>
<tr>
<td></td>
<td>(\Delta SBP) (mmHg)</td>
<td>(\Delta DBP) (mmHg)</td>
<td>(\Delta HR) (bpm)</td>
</tr>
<tr>
<td>Low</td>
<td>16.00 (13.69)</td>
<td>8.61 (8.66)</td>
<td>9.73 (10.58)</td>
</tr>
<tr>
<td>High</td>
<td>19.75 (11.14)</td>
<td>5.14 (8.72)</td>
<td>14.24 (10.44)</td>
</tr>
<tr>
<td>Low</td>
<td>16.14 (13.40)</td>
<td>7.42 (6.58)</td>
<td>11.51 (12.32)</td>
</tr>
<tr>
<td>High</td>
<td>14.06 (12.43)</td>
<td>8.36 (7.30)</td>
<td>11.97 (10.80)</td>
</tr>
<tr>
<td>Low</td>
<td>37.03 (17.01)</td>
<td>13.56 (10.01)</td>
<td>22.40 (16.49)</td>
</tr>
<tr>
<td>High</td>
<td>30.75 (15.30)</td>
<td>16.03 (8.77)</td>
<td>21.37 (12.80)</td>
</tr>
<tr>
<td>Low</td>
<td>29.94 (16.26)</td>
<td>13.47 (7.44)</td>
<td>15.42 (12.28)</td>
</tr>
<tr>
<td>High</td>
<td>22.17 (12.64)</td>
<td>12.56 (9.12)</td>
<td>11.63 (9.56)</td>
</tr>
</tbody>
</table>

Note: SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate
socially anxious subjects ($M\Delta = 29.94$ vs. $22.17$). Contrasts computed for $\Delta DBP$ were non-significant for all tasks. As regards HR reactivity, analyses revealed a significant group effect for Mental Arithmetic [$F(1, 67) = 4.14, P < .05$]. This task elicited higher increases in socially anxious than non-socially anxious subjects ($M\Delta = 14.24$ vs. 9.73). All interactions involving gender were non-significant. Females, however, overall exhibited higher DBP increases ($M\Delta = 12.59$) than males ($M\Delta = 8.69$), $F(1, 67) = 8.19; P < .006$.

Retrospective mood assessment

The means for retrospective appraisals of experienced emotions in low and high socially anxious participants are presented in Table 2. ANOVAs with repeated measures (Gender by Social Anxiety by Tasks) revealed a social anxiety main effect for the “Anxiety” scale [$F(1, 68 = 3.99; P = .05$], indicating higher experienced anxiety in socially anxious compared to non-anxious participants (3.54 vs. 3.31). A closer inspection of mean values revealed that the group difference was most pronounced during the Speech task ($P = .01$) Significant task Effects for the “Anger” [$F(2, 136) = 6.64; P < .002; \epsilon = .9709$, adjusted $P = .002$] and “Anxiety” scale [$F(2, 136) = 6.22; P < .003; \epsilon = .8853$, adjusted $P = .004$] further suggest that participants experienced lower Anxiety during Role-played Interactions than Mental Arithmetic, but higher Anger during Role-played Interactions than Mental Arithmetic and Speech Performance.

As self-reports of affective experiences were unrelated to cardiovascular reactivity no mediational analyses were performed.

<table>
<thead>
<tr>
<th></th>
<th>Social Anxiety Low (n = 36)</th>
<th>Social Anxiety High (n = 36)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Anxiety</td>
<td>Anger</td>
</tr>
<tr>
<td>Mental Arithmetic</td>
<td>3.57 (0.76)</td>
<td>3.14 (0.70)</td>
</tr>
<tr>
<td>Speech</td>
<td>3.24 (0.69)</td>
<td>3.22 (0.67)</td>
</tr>
<tr>
<td>Role-played Interactions</td>
<td>3.13 (0.49)</td>
<td>3.49 (0.61)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental Arithmetic</td>
<td>3.62 (0.92)</td>
<td>3.23 (0.80)</td>
</tr>
<tr>
<td>Speech</td>
<td>3.69 (0.76)</td>
<td>3.21 (0.62)</td>
</tr>
<tr>
<td>Role-played Interactions</td>
<td>3.31 (0.54)</td>
<td>3.49 (0.71)</td>
</tr>
</tbody>
</table>

Note: Appraisals of the bipolar adjective scales could range from 1 to 6; values above 3 indicate degrees of the pole named in the table.
Social anxiety and cardiovascular responses to active coping conditions

Behavioral assessment of social competence

Socially anxious participants overall were found to display a significantly lower level of social competence than nonanxious participants (Ms 2.79 vs. 3.01), $F(1, 68) = 7.28; P < .009$. There was no difference in rated social competence across gender groups. Partial correlations computed between behavioral ratings and cardiovascular reactivity to Role-played Interactions revealed significant relationships for $\Delta$SBP ($r = .31, P < .008$) and $\Delta$HR ($r = .36, P < .003$), indicating cardiac influences and greater task engagement in subjects with higher levels of social competence. These data suggest that assertive behavior might have mediated the effect of social anxiety on cardiovascular reactivity to Role-played Interactions. Entering the effect of assertive behavior into the regression model reduced the direct effect of social anxiety on SBP reactivity ($\beta$ before mediation = -.26; $P < .03$; $\beta$ after mediation = -.18; $P = .12$).

Discussion

The present results provide preliminary evidence for a differential effect of social anxiety on cardiovascular responses to active performance situations that appears largely unrelated to affective experiences but seems to be consistent with the subtle avoidance hypothesis (Rapee & Heimberg, 1997) and predictions derived from active coping research (Hartley, Ginsburg & Heffner, 1999; Obrist, 1981; Wright, 1996). Findings further indicate the importance of considering situational factors.

As expected, Role-played Interactions requiring assertive behavior elicited more pronounced SBP increases in low compared to high socially anxious participants. For Speech Performance a comparable, though not significant, response tendency was observed. Research has identified enhanced SBP reactivity as a reliable indicator of active coping effects in interpersonal contexts (Smith, Allred, Morrison & Carlson, 1989; Smith, Baldwin & Christensen, 1990; Smith, Gallo, Goble, Ngu & Stark, 1998) and several authors found cardiac activity to be the most likely source of systolic elevations (Kelsey et al., 2000; Smith, Ruiz & Uchino, 2000). Thus, response differences between social anxiety groups might result from differential task engagement with socially anxious subjects displaying a more inhibited approach. Subjective effort ratings do not seem to support this interpretation, though, high and low socially anxious participants reported comparable levels of activation. On the other hand, effort reports rarely correspond with cardiovascular effects and some authors have suggested that they should be evaluated cautiously as indices of actual task engagement (e.g. Wright & Dismukes, 1995). Observed group differences in behavioral measures of social competence, however, seem to corroborate the assumption of greater behavioral inhibition in high socially anxious subjects.

Like previous research (Morrison, Bellack & Manuck, 1985; Sheffer, Penn & Cassisi, 2001), the present results suggest that greater social competence is related to enhanced cardiac activity, indicated by more pronounced elevations in both SBP and HR. Furthermore, differential effects in behavioral responses seem to have partially mediated the relation between social anxiety and SBP reactivity during Role-played Interpersonal Interaction, further strengthening the active coping interpretation of the social anxiety effects. As indicated above, impaired social performance during interpersonal interaction does not necessarily
suggest an actual lack of social skills. Socially anxious individuals may also display inhibited behavior as a result of heightened state anxiety (Rapee & Heimberg, 1997). This situational view did not receive strong empirical support, however. Self reported state anxiety levels were only marginally related to behavioral indicators of social competence ($r = -.21; P < .08$).

Findings for Mental Arithmetic do not seem to indicate behavioral inhibition in socially anxious subjects. In fact, results were in the opposite direction. High socially anxious subjects displayed greater HR effects, and their response pattern (substantial elevations in both HR and SBP accompanied by rather low DBP effects), overall, suggests cardiac influences. As the level of state anxiety did not significantly differ between social anxiety groups for this task, the cardiovascular effects might result from increased effort, possibly due to a stronger audience effect on task motivation in high socially anxious subjects (Wenzel & Holt, 2003). It should also be noted that active coping effects in HR seem to be more likely in cognitive tasks (Bongard, 1995; Wright, Dill, Geen & Anderson, 1998; Eubanks, Wright & Williams, 2002). On the other hand, physiological response differences in the absence of differential state reports may reflect a measurement issue, that is, the retrospective nature of psychological assessments (Uchino & Garvey, 1997). Thus, the anxiety interpretation cannot be ruled out with certainty. Research by Tomaka and colleagues (Tomaka, Blascovich, Kelsey & Leitzen, 1993; Tomaka et al., 1999), however, indicates that distress emotions in the context of active coping paradigms should affect vascular reactivity rather than cardiac reactivity.

Overall, these findings seem to strengthen the view that active performance situations evoke cardiovascular effects that are largely attributable to differences in effort or task engagement (Obrist, 1981; Wright, 1996; Wright, Dill, Geen & Anderson, 1998). The study also indicates that the concomitant assessment of behavioral responses might contribute to the understanding of cardiovascular effects. Possibly, there are other factors accounting for the differential responses of high and low socially anxious subjects. Several authors stress the importance of cognitive mechanisms (Clark & Wells, 1995; Leary & Kowalski, 1995) in social anxiety. The assessment of perceived coping ability and success expectations might have contributed to the understanding of results. Recent research on assertiveness and trait dominance (Gramer, 2003; Gramer & Berner, 2005; Tomaka et al., 1999), however, indicates that cognitive appraisals, although substantially related to trait characteristics, need not necessarily mediate physiological response differences.

It should be kept in mind that these results were based on the cardiovascular responses of the first task minute, only. Cardiac reactivity in active coping paradigms usually is most pronounced during the initial task minutes and declines with continued or repeated task exposure (Kelsey, 1993). Potential differences of social anxiety groups in psychophysiological profiles over time have not been the focus of much research and available results are inconsistent. Whereas Eckman and Shean (1997) noted impaired response habituation on psychological and physiological parameters in socially anxious compared to nonsocially anxious subjects, no differences in response attenuation were observed by Mauss, Wilhelm and Gross (2003). Both studies utilized short speech tasks. Potential differences of habituation effects across varying task conditions await further study. Variations in evaluative threat might be of particular importance in this respect (Kelsey et al., 2000).

Another issue of some relevance concerns the generalizability of the noted effects to phobic populations. At present, research suggests that severity of social anxiety is accounted
for by a quantitative increase in symptoms, no evidence of qualitative differences seems to exist (Leary & Kowalski, 1995). Studies on the cardiovascular effects of social anxiety have been mainly performed with nonclinical populations (Baggett, Saab & Carver, 1996; Burns, 1995; Eckman & Shean, 1997; Gramer & Huber, 1992; Mauss, Wilhelm & Gross, 2003; Wilhelm, Kochar, Roth & Gross, 2001) but studies on phobics (Edelman & Baker, 2002; Grossman, Wilhelm, Kawachi & Sparrow, 2001) do not indicate that differential cardiovascular responses are more likely in clinical populations.

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Franz-Peter Liebel

Computation of Causal Networks

We introduce a procedure to compute the probabilities of all events which could be causes of a given set of symptoms. We establish a causal network holding events with unknown probabilities as well as deterministic events. For any event with unknown probability a defining equation is constructed. The set of defining equations then forms a system of \( n \) non-linear equations, where \( n \) is the number of unknown probabilities. These non-linear equations contain conditional probabilities of sometimes great complexity, making it unavoidable to realize a decomposition into factors. This is accomplished with the help of certain assumptions, which impose no serious restrictions. The factorization finally yields conditional probabilities, conditioned on just a single event. Consequently, all sampling to obtain numerical values of such probabilities can be carried out easily.