The Effects of Repeated Trials on the Cardiovascular Responses to Reading Aloud and Non-Stressful Conversation

George S. Renfrey
Western Michigan University

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THE EFFECTS OF REPEATED TRIALS ON THE CARDIOVASCULAR RESPONSES TO READING ALOUD AND NON-STRESSFUL CONVERSATION

by

George S. Renfrey

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Psychology

Western Michigan University
Kalamazoo, Michigan
June 1990

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THE EFFECTS OF REPEATED TRIALS ON THE CARDIOVASCULAR RESPONSES TO READING ALOUD AND NON-STRESSFUL CONVERSATION

George S. Renfrey, M.A.
Western Michigan University, 1990

This study assessed changes in blood pressure, heart rate, skin conductance, frontalis muscle tension, and breathing rates associated with repeated reading aloud and non-stressful conversation. Four male and 3 female normotensive subjects participated. Sixteen presentations of both verbal tasks, each preceded by a quiet rest period, were made across 8 sessions.

The results indicate that: (a) when compared with resting levels, statistically significant increases in heart rate, blood pressure, skin conductance, and frontalis muscle tension, and decreases in breathing rates may be produced by reading aloud and non-stressful conversation; (b) systolic blood pressure changes attenuate with repeated trials; and (c) subjects present unique profiles of responses to the two verbal tasks for the six dependent measures employed. It was concluded that reading aloud, non-stressful conversation, or counting forward aloud should be employed as a control condition in investigations of cardiovascular reactivity.
ACKNOWLEDGEMENTS

I wish to express appreciation to Dr. Brad Huitema for the time and effort he gave to this research. His consultation was essential to the completion of the study.

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I wish to extend a special note of appreciation to the late Dr. Fredrick Gault for his technical assistance, without which this research effort would have been exceedingly difficult.

George S. Renfrey
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Renfrey, George Stephen, M.A.
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INTRODUCTION

Since advances in medical science have decreased the prevalence of infectious diseases that once were the major killers in our culture, chronic degenerative diseases have taken over as the major causes of premature death. Of these, cardiovascular disease (CD) is the leading cause of premature mortality in the United States, accounting for about one million deaths and a total health care expenditure of $100 billion in 1985 (Weis, 1986). The etiologies of this class of diseases are thought by most medical authorities to be heavily influenced by lifestyle factors, and accordingly, to be amenable to delay in onset if not prevention (cf. Dembroski, 1986; Eliot & Buell, 1981).

Of the cardiovascular diseases that factor into these statistics, coronary heart disease (CHD) is the largest contributor. Though the etiology of CHD is not completely understood, it is believed that injury to the arterial endothelium plays an important role in atherosclerotic plaque formation (cf. Ross & Glomset, 1973). Hence, excessive reactivity of the cardiovascular system to environmental stressors has been identified as one possible pathogenic factor (Krantz & Manuck, 1984; Schneiderman, 1983; Williams, 1985). Just what
constitutes "excessive" reactivity, however, has not been clearly identified, and the precise mechanisms through which excessive reactivity may contribute to atherogenesis is not known.

As part of an ongoing effort by researchers to gain a more complete understanding of atherogenesis, and more generally of cardiovascular reactivity (CVR), reactivity to a wide range of stressors has been researched. In such investigations, subjects are typically exposed to one or more stressor tasks while various indices of CV function, such as heart rate (HR) and blood pressure (BP), and indices of general sympathetic arousal, such as galvanic skin response (GSR) and electromyographic activity (EMG), are monitored (see Matthews, Manuck, & Saab, 1986, for extensive discussions). The effects of such stressor tasks are usually assessed by comparing levels of these cardiovascular indices during exposure to the tasks with levels during pre-task and/or post-task rest periods.

Krantz, Manuck, and Wing (1986) have classified such experimental tasks (stressors) according to three broad types: those involving high degrees of mental challenge, such as mental arithmetic, reaction time, and vigilance tasks; those involving passive participation, such as watching stressful films and hearing loud sounds; and those that involve some form of interpersonal
interaction, such as structured interviews, public speaking, and role-playing. Of these types of stressor tasks those involving interpersonal exchanges are considered by some to yield particularly important information as they are presumed to produce effects similar to those of relatively common real-life stressors (cf. Krantz et al., 1986).

Since stressor tasks based on interpersonal exchanges typically involve a verbal component, any cardiovascular responses to the act of verbalization alone would represent a confound in such research employing verbally based stressor tasks; any observed responses would be attributable, to an unknown extent, to the act of verbalizing alone. The extent to which verbalizations alone do elicit cardiovascular responses therefore becomes an important methodological issue in this area of research.

Though it has been recognized for some time that stressful clinical interviews can produce significant increases in BP and HR (Adler et al., 1976; Gottschalk, Gleser, D'Zmura, & Hanenson, 1964; Thaler, Weiner, & Reiser, 1957; Wolf, Cardon, Shepard, & Wolff, 1955), some findings suggest that such increases may be produced by putatively less stressful interpersonal interactions such as those involved in the administration of word association tasks and Thematic Apperception Tests.
(McKegney & Williams, 1967; Weiner, Singer, & Reiser, 1962; Williams, Kimball, & Willard, 1972). More recent findings suggest that significant increases in HR and BP are reliably produced by simply speaking aloud (Friedmann, Thomas, Kulick-Ciuffo, Lynch, & Sugino-hara, 1982; Hellmann & Grimm, 1984; Long, Lynch, Machiran, Thomas, & Malinow, 1982; Lynch, Long, Thomas, Malinow, & Katcher, 1981; Lynch et al., 1980; Lynch, Thomas, Paskewitz, et al., 1982; Thomas et al., 1984). These changes in HR and BP have not been found to be a function of age, sex, or race, but have been found to be positively correlated with resting baseline levels of those indices (Lynch, Thomas, Paskewitz, et al. 1982).

Some investigators have reported that seemingly non-stressful verbal tasks typically lead to 10-20% increases from resting levels in the cardiovascular indices used. For example, Lynch, Thomas, Long, et al. (1982) reported increases of 6.56 mm Hg systolic blood pressure (SBP), 8.01 mm Hg diastolic blood pressure (DBP), and 7.87 beats per minute (bpm) HR in response to casual conversation and reading aloud. Changes in these same indices during verbally based stressor tasks are often greater in magnitude but this is not always the case. For example, Warwick-Evans, Walker, and Evans (1988) reported increases in HR of 11.6 to 33.8 bpm over baseline levels in normotensives during a verbalized
mental arithmetic task, a commonly employed stressor, while Matthews et al. (1986) reported increases of 20.4 bpm in normotensive adolescents during a speech-before-peers task. Increases in SBP and DBP during this same task were reported to be 23.6 mm Hg and 1.8 mm Hg respectively. Increases in systolic blood pressure (SBP) and diastolic blood pressure (DBP) during verbalized mental arithmetic tasks of 5-10 mm Hg in normotensives and 10-15 mm Hg in hypertensives have been reported (Dimsdale, Stern, & Dillon, 1988). Dembroski, MacDougall, and Lushene (1979) reported increases in SBP and DBP during a "stressful" interview of 5-25 mm Hg SBP and 5-15 mm Hg DBP in normotensives over resting levels, while Dimsdale et al. (1988) reported increases in SBP and DBP during a "stressful" interview of 20 mm Hg SBP and 15 mm Hg DBP in normotensives, and of 25 mm Hg SBP and 20 mm Hg DBP in hypertensives. Though the magnitudes of most of the changes in HR and BP reported above tend to be greater than those typically reported to occur during non-stressful verbal tasks, increases in BP as great as 50% from resting levels have been reported to follow "non-stressful" verbalizing (see Friedmann et al., 1982).

In contrast to the above findings, Henderson, Bakal, and Dunn (1990) found more modest increases in cardiovascular indices (2.65% increases in peripheral
pulse interval, a measure highly correlated with changes in blood pressure, and 3.98% increases in HR) in air traffic controllers in response to speaking aloud. It should be noted though, that generalization of these latter results to the population as a whole is questionable because of the special population from which subjects were selected (air traffic controllers). Linden (1987), in a review of the literature, concluded that cardiovascular stress reactivity to speech can be expected to range from 5- to 10-point increases in SBP (mm Hg), DBP (mm Hg), and HR (bpm). It would appear therefore, that the effect of cardiovascular reactivity to verbalizing per se does represent a potential confound in investigations employing verbally based stressors.

As an aside, though such changes in cardiovascular status are reported to be statistically significant, their clinical significance is difficult to determine. Since the relationship between reactivity and CHD is unclear at this time, and since the magnitude of such changes associated with increased risk has not been firmly established, it would be premature to address their clinical significance at this time.

Unfortunately, these findings have not seen adequate replication by independent researchers. If they can be reproduced by other investigators, if they prove to be reliable, the interpretation of a growing body of
literature on cardiovascular reactivity may be called into question. For example, as mentioned above, if significant increases in BP and HR can be reliably produced by speaking aloud per se, then observed HR and BP responses to verbally based stressors will be attributable to verbalizing to an unknown extent, making interpretations of "stress responses" difficult at best. Furthermore, if these responses to the act of verbalizing habituate with repeated exposure to the tasks employed, then the results of investigations conducted to evaluate varied psychological interventions designed to attenuate reactivity to stressors may require reevaluation. For example, results of investigations designed to assess the effects that biofeedback, relaxation training, or other interventions have on reactivity to specific stressors will require careful interpretation to separate attenuation due to the intervention per se, and attenuation due to this habituation to the extent that they employ repeated exposure to verbally based stressor tasks. Decreases in reactivity across the course of the investigation could be due to the effects of the intervention (i.e., could represent a decline in stressor-specific reactivity), the effects of the aforementioned habituation effect, or some combination thereof. Accordingly, investigators conducting such studies in the future would need to control for an
apparent decline in cardiovascular reactivity that is due to this habituation. Such a decline might otherwise be interpreted as a reduction in stressor-specific reactivity, and attributed erroneously to whatever intervention(s) is being evaluated.

Aside from the above implications for completed and future research into cardiovascular reactivity, reliable productions of significant increases in HR and BP to putatively non-stressful verbal tasks would have important implications as for our current conceptualizations of stress. For one, notions of what constitutes stress may need to be reexamined; if an act as simple as reading aloud can produce increases in HR and BP of a magnitude that is comparable to that associated with putative stressors, then it follows that apparently innocuous forms of activity may well be classified as stressful and that our concepts of what constitute stressors may need to be expanded. Alternatively, the adequacy of physiological indices of stress typically employed in reactivity research (e.g., HR and BP) may require reexamination. If "non-stressful" tasks, such as reading aloud, can produce changes in these variables that are normally considered indicative of stress responses, then the utility of such variables becomes questionable. Despite the importance of these implications, adequate replications of Lynch's findings
(cf. Lynch, Thomas, Long, et al., 1982) have not been published. Replication as such would clarify the need to consider the above implications. The research reported here is, in part, an attempt at just such a replication. Additionally, no study has yet been conducted to test the stability of such changes in BP and HR across repeated exposures to the testing procedures employed.

The purpose of this study was to investigate the magnitude and reliability of the changes in BP and HR associated with two putatively non-stressful verbal tasks (reading aloud, and casual conversation), and to determine whether such responses habituate with repeated exposure to those tasks in normotensive subjects. These two tasks were employed because both involve verbal responding, neither has been identified as a stressor task in the literature, and both have been employed in the investigations of the Lynch and his colleagues (cf. Lynch, Thomas, Long, et al., 1982) cited above. Collateral changes in electrodermal responses (GSR), frontalis muscle tension (EMG), and breathing rates (BR) were also assessed in order to determine if there are any consistent changes in them during the tasks employed in the study. The demonstration of such changes would have methodological implications similar to those discussed above for blood pressure and heart rate.
METHOD

Subjects

Subjects were students and faculty from the psychology departments of two colleges who responded to posted advertisements and personal solicitations for subjects. All subjects were pre-screened for hypertension and medication use. Exclusion criteria were an age of less than 18 years-of-age, a resting SBP of 140 mm Hg or greater and a resting DBP of 90 mm Hg or greater, and the use of prescribed medications that might affect blood pressure. No subjects were screened from the study because of age, resting blood pressure, or the use of pharmacological agents. Seven normotensive Caucasians (4 male, 3 female) ranging in age from 19 to 36 years (mean age, 27 years), participated in the study. Subjects were informed that they were committing themselves to eight 45-minute sessions, during which they would be asked to alternately sit quietly, engage in casual conversation, and read aloud while various physiological measures were taken. All subjects read and signed an approved informed consent form, and were paid for their participation.
Apparatus

Blood pressure and heart rate were recorded unobtrusively at regular intervals using a Carolina (model 69-1118) self-inflating digital sphygmomanometer. Initial cuff inflations were preset at 150 mm Hg, which proved to be in excess of 15 mm Hg above the highest systolic blood pressure reading recorded during the experiment, and the cuff deflation rate was preset at 2-3 mm Hg/sec. The instrument displayed BP readings digitally, and printed hardcopy records.

Electrodermal activity was recorded at the same times blood pressure was assessed using a J & J model R-72 electrodermograph. The instrument was set to read skin conductance (GSR) and was connected to the underpads of the left-hand middle and index fingers of subjects using silver/silver chloride electrode assemblies and J & J #JE-20 electrode gel. The instrument was connected to a J & J dual digital integrator (model D-200) which provided digitalized readouts of GSR averaged over a time base of 60 secs.

Frontalis muscle tension was monitored using a J & J model M-52 EMG connected to subjects through silver/silver chloride electrodes (J & J #SE-25) and J & J #JE-20 electrode gel. The instrument was set at wide filter and was connected to a J & J dual digital
integrator (model D-200) to provide digitalized readouts of EMG activity averaged over a 60 sec time base.

Breathing rates were monitored using a thoracic strain gauge connected to a Grass model 5B polygraph equipped with a model 5D D.C. driver amplifier, and a model 5PIF low-level D.C. amplifier. The strain gauge was constructed from 2-1/2 inch seat-belt webbing connected to a potentiometer-spring mechanism. It was initially placed on subjects about 2 inches below the bottom of the sternum, at the level of the eighth to eleventh ribs. The circumference of the gauge was adjusted so as to eliminate slack in the spring mechanism when subjects exhaled fully, and so as not to restrict breathing during inhalation. After this initial placement, gauge circumference and caudal-rostral position were adjusted during the initial rest period if necessary, in order to ensure responsivity of the instrument to the particular breathing patterns of the subject at hand. Amplifier sensitivity was adjusted on each subject to provide the clearest readings possible.

A motorcycle maintenance and repair manual (Clew, 1974) was selected to provide the subjects with reading material because of its rather simple writing style and its emotionally neutral content. A battery of putatively non-stressful conversation topics was established, including such items as, "what foods did you eat within
the past 24 hours," "what sort of books do you like to read," and "what sort of activities do you like to engage in as a pastime." Prior to each session, subjects were asked if they had one or more topics they would feel comfortable talking about for about four minutes. Any reported topics were added to the topic battery for that session.

Procedures

The investigator was known to each of the subjects at least casually. Because Long et al. (1982) found that formal attire and high status on the part of an investigator may be associated with greater increases in blood pressure in subjects during verbal communication, the investigator dressed casually, and affected an informal comportment. Subjects were told that the purpose of the study was to monitor some of the physiological changes that might accompany reading aloud and conversation. Subjects were scheduled to complete the eight sessions within a four-week period and were asked not to make any major changes in their diet or exercise habits during that time. Prior to the first session, subjects were introduced to the experimental setting, were connected to the apparatus, and were asked to read aloud and sign an informed consent form while an initial assessment of blood pressure was performed. As mentioned,
this screening procedure resulted in no subjects being excluded from the study because of hypertension.

The experimental setting consisted of a small room equipped with an easy chair, and a partition behind which the experimental apparatus was housed. During sessions, the experimenter remained in the room behind the partition for all phases but the conversation phase, during which he sat within view of the subject.

During each session, subjects were allowed a few moments to relax in the easy chair prior to being connected to the apparatus. At this point, they were asked if they could identify non-distressing items for conversation. Once connected to the apparatus, subjects were instructed to relax and sit quietly for ten minutes, during which time, each of the five physiological measures was recorded at two-minute intervals. The last two readings served as baseline measures. Subjects were then asked to either read aloud or converse with the investigator for four minutes. Subjects were always asked if they were comfortable with or otherwise interested in any of the topics selected for conversation. In this and all subsequent four-minute phases, the five physiological readings were recorded between minutes one and two, and between minutes three and four. Subjects were then asked to relax and sit quietly for four minutes, after which another reading or conversing task was introduced. This
procedure continued until subjects were exposed to two reading and two conversing tasks per session. The order of presentation of these two tasks was counterbalanced across the eight sessions.

Individual and group data were subjected to simple t-tests. Averaging across the eight sessions, the means and standard deviations for each dependent variable for all reading tasks, conversation tasks, pre-reading resting tasks, and pre-conversation resting tasks were calculated for both individual and pooled group data. For both individual subject and pooled group data, simple t-tests were performed on the differences between mean pre-reading resting task levels of each dependent variable averaged across eight sessions and their corresponding mean reading task levels averaged across eight sessions, and between mean pre-conversation resting task levels of each dependent variable averaged across eight sessions and their corresponding mean conversation task levels averaged across eight sessions. Additionally, for pooled group data on each dependent variable, the differences between mean level of the pre-reading resting task and mean level of the reading task, and the differences between mean level of the pre-conversation resting task and mean level of the conversation task were calculated for each of the eight sessions and plotted for visual analyses.
RESULTS

The results indicate that when subjects engaged in either verbal task, the six dependent variables tended to display changes compared to levels during the preceding resting phase. Though in the case of pooled data the changes in SBP, DBP, HR, and GSR were suggestive of increased sympathetic nervous system activity (see Table 1), this was not always so in individual cases (see Tables 2 through 5). Additionally, as can be seen in Figures 1 through 6, these changes tended to fluctuate appreciably in magnitude as a function of repeated trials. Only in changes in SBP, in response to the reading task, was there a clear attenuation of effect across sessions suggesting habituation with repeated exposure to the paradigm.

According to the correlated t-tests employed, pooled data (see Table 1) displayed statistically significant changes in the dependent variables more consistently than the data of individual subjects (see Tables 2 through 8).

Systolic Blood Pressure

Mean group SBP averaged across the eight sessions increased by 1.881 mmHg (+1.8%) during reading tasks over levels displayed during preceding resting tasks, and
Table 1

Mean Changes in all Dependent Variables During Rest to Read and During Rest to Conversation Task Shifts and Associated t-Test Values

<table>
<thead>
<tr>
<th>Variable</th>
<th>Task Shift</th>
<th>Mean Change Score</th>
<th>SD</th>
<th>df</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td>Rt-Rd</td>
<td>+1.881</td>
<td>4.04</td>
<td>222</td>
<td>3.478 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+2.667</td>
<td>4.04</td>
<td>222</td>
<td>4.929 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP</td>
<td>Rt-Rd</td>
<td>+4.634</td>
<td>4.08</td>
<td>222</td>
<td>8.487 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+3.401</td>
<td>4.08</td>
<td>222</td>
<td>6.230 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>Rt-Rd</td>
<td>+7.763</td>
<td>4.81</td>
<td>222</td>
<td>12.057 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+6.062</td>
<td>4.81</td>
<td>222</td>
<td>9.416 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSR</td>
<td>Rt-Rd</td>
<td>+2.418</td>
<td>1.87</td>
<td>222</td>
<td>9.644 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+3.539</td>
<td>1.87</td>
<td>222</td>
<td>14.109 ***</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>EMG</td>
<td>Rt-Rd</td>
<td>+0.081</td>
<td>1.59</td>
<td>222</td>
<td>0.378</td>
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<tr>
<td></td>
<td>Rt-Cn</td>
<td>+2.131</td>
<td>1.59</td>
<td>222</td>
<td>9.998 ***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>Rt-Rd</td>
<td>-2.210</td>
<td>1.47</td>
<td>158</td>
<td>9.444 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>-2.181</td>
<td>1.47</td>
<td>158</td>
<td>9.322 ***</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.

Note: Change Scores obtained by subtracting mean resting task values from mean verbal task values.

Rt-Rd indicates a Rest to Read task shift.
Rt-Cn indicates a Rest to Conversation task shift.
Table 2
Mean Changes in Systolic Blood Pressure (mmHg) During Rest to Read and During Rest to Conversation Task Shifts and Associated t-Test Values for all Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Task Shift</th>
<th>Mean Change Score</th>
<th>SD</th>
<th>df</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rt-Rd</td>
<td>+2.590</td>
<td>4.14</td>
<td>30</td>
<td>1.768</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+2.000</td>
<td>4.14</td>
<td>30</td>
<td>1.363</td>
</tr>
<tr>
<td>B</td>
<td>Rt-Rd</td>
<td>+1.688</td>
<td>3.24</td>
<td>30</td>
<td>1.470</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+0.625</td>
<td>3.24</td>
<td>30</td>
<td>0.544</td>
</tr>
<tr>
<td>C</td>
<td>Rt-Rd</td>
<td>+2.875</td>
<td>3.68</td>
<td>30</td>
<td>2.206 *</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+3.531</td>
<td>3.58</td>
<td>30</td>
<td>2.709 *</td>
</tr>
<tr>
<td>D</td>
<td>Rt-Rd</td>
<td>+0.687</td>
<td>3.71</td>
<td>30</td>
<td>0.528</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>-0.812</td>
<td>3.71</td>
<td>30</td>
<td>0.625</td>
</tr>
<tr>
<td>E</td>
<td>Rt-Rd</td>
<td>+0.500</td>
<td>4.96</td>
<td>30</td>
<td>0.284</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+2.469</td>
<td>4.96</td>
<td>30</td>
<td>1.405</td>
</tr>
<tr>
<td>F</td>
<td>Rt-Rd</td>
<td>+2.781</td>
<td>4.55</td>
<td>30</td>
<td>1.073</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+4.375</td>
<td>4.55</td>
<td>30</td>
<td>1.689</td>
</tr>
<tr>
<td>G</td>
<td>Rt-Rd</td>
<td>-0.312</td>
<td>3.79</td>
<td>30</td>
<td>0.232</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+6.844</td>
<td>3.79</td>
<td>30</td>
<td>5.093 ***</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.

Note: Change Scores obtained by subtracting mean resting task values from mean verbal task values.

Rt-Rd indicates a Rest to Read task shift.
Rt-Cn indicates a Rest to Conversation task shift.
### Table 3

Mean Changes in Diastolic Blood Pressure (mmHg) During Rest to Read and During Rest to Conversation Task Shifts and Associated t-Test Values for all Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Task Shift</th>
<th>Mean Change Score</th>
<th>SD</th>
<th>df</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rt-Rd</td>
<td>+3.562</td>
<td>3.44</td>
<td>30</td>
<td>2.919 **</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>-0.593</td>
<td>3.44</td>
<td>30</td>
<td>0.486</td>
</tr>
<tr>
<td>B</td>
<td>Rt-Rd</td>
<td>+3.656</td>
<td>2.79</td>
<td>30</td>
<td>3.705 **</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+1.250</td>
<td>2.79</td>
<td>30</td>
<td>1.266</td>
</tr>
<tr>
<td>C</td>
<td>Rt-Rd</td>
<td>+6.781</td>
<td>3.72</td>
<td>30</td>
<td>5.146 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+5.968</td>
<td>3.72</td>
<td>30</td>
<td>4.530 ***</td>
</tr>
<tr>
<td>D</td>
<td>Rt-Rd</td>
<td>+1.375</td>
<td>4.61</td>
<td>30</td>
<td>0.842</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>-1.875</td>
<td>4.61</td>
<td>30</td>
<td>1.148</td>
</tr>
<tr>
<td>E</td>
<td>Rt-Rd</td>
<td>+6.000</td>
<td>4.23</td>
<td>30</td>
<td>4.007 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+3.718</td>
<td>4.23</td>
<td>30</td>
<td>2.483 *</td>
</tr>
<tr>
<td>F</td>
<td>Rt-Rd</td>
<td>+10.375</td>
<td>5.88</td>
<td>30</td>
<td>4.988 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+8.750</td>
<td>5.88</td>
<td>30</td>
<td>4.207 ***</td>
</tr>
<tr>
<td>G</td>
<td>Rt-Rd</td>
<td>+1.843</td>
<td>3.06</td>
<td>30</td>
<td>1.809</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+6.562</td>
<td>3.06</td>
<td>30</td>
<td>6.440 ***</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.

Note: Change Scores obtained by subtracting mean resting task values from mean verbal task values.

Rt-Rd indicates a Rest to Read task shift.
Rt-Cn indicates a Rest to Conversation task shift.
Table 4
Mean Changes in Heart Rate (Beats per Minute) During Rest to Read and During Rest to Conversation Task Shiftings and Associated t-Test Values for all Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Task Shift</th>
<th>Mean Change Score</th>
<th>SD</th>
<th>df</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rt-Rd</td>
<td>+3.188</td>
<td>3.37</td>
<td>30</td>
<td>2.673 *</td>
</tr>
<tr>
<td>A</td>
<td>Rt-Cn</td>
<td>+2.598</td>
<td>3.37</td>
<td>30</td>
<td>2.175 *</td>
</tr>
<tr>
<td>B</td>
<td>Rt-Rd</td>
<td>+7.375</td>
<td>2.88</td>
<td>30</td>
<td>7.235 ***</td>
</tr>
<tr>
<td>B</td>
<td>Rt-Cn</td>
<td>+6.938</td>
<td>2.88</td>
<td>30</td>
<td>6.806 ***</td>
</tr>
<tr>
<td>C</td>
<td>Rt-Rd</td>
<td>+15.40</td>
<td>6.28</td>
<td>30</td>
<td>6.936 ***</td>
</tr>
<tr>
<td>C</td>
<td>Rt-Cn</td>
<td>+10.062</td>
<td>6.28</td>
<td>30</td>
<td>4.531 ***</td>
</tr>
<tr>
<td>D</td>
<td>Rt-Rd</td>
<td>+1.906</td>
<td>4.47</td>
<td>30</td>
<td>1.704</td>
</tr>
<tr>
<td>D</td>
<td>Rt-Cn</td>
<td>+0.125</td>
<td>4.47</td>
<td>30</td>
<td>0.112</td>
</tr>
<tr>
<td>E</td>
<td>Rt-Rd</td>
<td>+14.062</td>
<td>6.50</td>
<td>30</td>
<td>6.118 ***</td>
</tr>
<tr>
<td>E</td>
<td>Rt-Cn</td>
<td>+10.938</td>
<td>6.50</td>
<td>30</td>
<td>4.531 ***</td>
</tr>
<tr>
<td>F</td>
<td>Rt-Rd</td>
<td>+9.875</td>
<td>4.67</td>
<td>30</td>
<td>5.974 ***</td>
</tr>
<tr>
<td>F</td>
<td>Rt-Cn</td>
<td>+8.406</td>
<td>4.67</td>
<td>30</td>
<td>5.086 ***</td>
</tr>
<tr>
<td>G</td>
<td>Rt-Rd</td>
<td>+3.094</td>
<td>4.38</td>
<td>30</td>
<td>1.997</td>
</tr>
<tr>
<td>G</td>
<td>Rt-Cn</td>
<td>+3.375</td>
<td>4.38</td>
<td>30</td>
<td>2.178 *</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.

Note: Change Scores obtained by subtracting mean resting task values from mean verbal task values.

Rt-Rd indicates a Rest to Read task shift.
Rt-Cn indicates a Rest to Conversation task shift.

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Table 5
Mean Changes in Galvanic Skin Response (micro-Ohms) During Rest to Read and During Rest to Conversation Task Shifts and Associated t-Test Values for all Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Task Shift</th>
<th>Mean Change Score</th>
<th>SD</th>
<th>df</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rt-Rd</td>
<td>+2.591</td>
<td>1.72</td>
<td>30</td>
<td>4.248 ***</td>
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<tr>
<td></td>
<td>Rt-Cn</td>
<td>+2.703</td>
<td>1.72</td>
<td>30</td>
<td>4.433 ***</td>
</tr>
<tr>
<td>B</td>
<td>Rt-Rd</td>
<td>+3.406</td>
<td>1.37</td>
<td>30</td>
<td>9.914 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+5.466</td>
<td>1.37</td>
<td>30</td>
<td>15.908 ***</td>
</tr>
<tr>
<td>C</td>
<td>Rt-Rd</td>
<td>+1.144</td>
<td>2.74</td>
<td>30</td>
<td>1.179</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+6.431</td>
<td>2.74</td>
<td>30</td>
<td>6.632 ***</td>
</tr>
<tr>
<td>D</td>
<td>Rt-Rd</td>
<td>+4.603</td>
<td>2.17</td>
<td>30</td>
<td>5.972 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+3.391</td>
<td>2.17</td>
<td>30</td>
<td>4.399 ***</td>
</tr>
<tr>
<td>E</td>
<td>Rt-Rd</td>
<td>+0.631</td>
<td>1.37</td>
<td>30</td>
<td>1.836</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+0.562</td>
<td>1.37</td>
<td>30</td>
<td>1.636</td>
</tr>
<tr>
<td>F</td>
<td>Rt-Rd</td>
<td>+4.909</td>
<td>2.24</td>
<td>30</td>
<td>6.172 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+5.052</td>
<td>2.24</td>
<td>30</td>
<td>6.314 ***</td>
</tr>
<tr>
<td>G</td>
<td>Rt-Rd</td>
<td>+1.112</td>
<td>0.74</td>
<td>30</td>
<td>4.210 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+1.328</td>
<td>0.74</td>
<td>30</td>
<td>5.026 ***</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.

Note: Change Scores obtained by subtracting mean resting task values from mean verbal task values.

Rt-Rd indicates a Rest to Read task shift.
Rt-Cn indicates a Rest to Conversation task shift.

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Table 6
Mean Changes in Electromyograph Levels (micro-Volts) During Rest to Read and During Rest to Conversation Task Shifts and Associated t-Test Values for all Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Task Shift</th>
<th>Mean Change Score</th>
<th>SD</th>
<th>df</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Rt-Rd</td>
<td>-0.525</td>
<td>1.12</td>
<td>30</td>
<td>3.327 **</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+1.428</td>
<td>1.12</td>
<td>30</td>
<td>9.052 ***</td>
</tr>
<tr>
<td>B</td>
<td>Rt-Rd</td>
<td>+0.859</td>
<td>0.53</td>
<td>30</td>
<td>4.508 ***</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+1.591</td>
<td>0.53</td>
<td>30</td>
<td>8.345 ***</td>
</tr>
<tr>
<td>C</td>
<td>Rt-Rd</td>
<td>-1.372</td>
<td>2.94</td>
<td>30</td>
<td>1.319</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>+4.865</td>
<td>2.94</td>
<td>30</td>
<td>4.679 ***</td>
</tr>
<tr>
<td>D</td>
<td>Rt-Rd</td>
<td>+2.291</td>
<td>0.84</td>
<td>30</td>
<td>25.849 ***</td>
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<tr>
<td></td>
<td>Rt-Cn</td>
<td>+2.875</td>
<td>0.84</td>
<td>30</td>
<td>32.443 ***</td>
</tr>
<tr>
<td>E</td>
<td>Rt-Rd</td>
<td>+0.362</td>
<td>0.47</td>
<td>30</td>
<td>3.103 **</td>
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<tr>
<td></td>
<td>Rt-Cn</td>
<td>+0.909</td>
<td>0.47</td>
<td>30</td>
<td>7.785 ***</td>
</tr>
<tr>
<td>F</td>
<td>Rt-Rd</td>
<td>-0.065</td>
<td>1.23</td>
<td>30</td>
<td>0.342</td>
</tr>
<tr>
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<td>Rt-Cn</td>
<td>+1.346</td>
<td>1.23</td>
<td>30</td>
<td>7.049 ***</td>
</tr>
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<td>G</td>
<td>Rt-Rd</td>
<td>+0.968</td>
<td>2.27</td>
<td>30</td>
<td>1.205</td>
</tr>
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<td>Rt-Cn</td>
<td>+2.484</td>
<td>2.27</td>
<td>30</td>
<td>3.091 **</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.

Note: Change Scores obtained by subtracting mean resting task values from mean verbal task values.

Rt-Rd indicates a Rest to Read task shift.
Rt-Cn indicates a Rest to Conversation task shift.
Table 7

Mean Changes in Breathing Rate (Inhalations per Minute)
During Rest to Read and During Rest to Conversation
Task Shifts and Associated t-Test Values
for all Subjects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Task Shift</th>
<th>Mean Change Score</th>
<th>SD</th>
<th>df</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Rt-Rd</td>
<td>-3.625</td>
<td>1.97</td>
<td>30</td>
<td>5.201 ***</td>
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<tr>
<td></td>
<td>Rt-Cn</td>
<td>-2.531</td>
<td>1.97</td>
<td>30</td>
<td>3.632 **</td>
</tr>
<tr>
<td>D</td>
<td>Rt-Rd</td>
<td>-0.312</td>
<td>1.36</td>
<td>30</td>
<td>0.645</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>-1.188</td>
<td>1.36</td>
<td>30</td>
<td>2.453 *</td>
</tr>
<tr>
<td>E</td>
<td>Rt-Rd</td>
<td>-1.062</td>
<td>1.17</td>
<td>30</td>
<td>2.568 *</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>-0.750</td>
<td>1.17</td>
<td>30</td>
<td>1.813</td>
</tr>
<tr>
<td>F</td>
<td>Rt-Rd</td>
<td>-4.812</td>
<td>1.31</td>
<td>30</td>
<td>14.647 ***</td>
</tr>
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<td></td>
<td>Rt-Cn</td>
<td>-4.437</td>
<td>1.31</td>
<td>30</td>
<td>13.506 ***</td>
</tr>
<tr>
<td>G</td>
<td>Rt-Rd</td>
<td>-0.487</td>
<td>1.44</td>
<td>30</td>
<td>0.952</td>
</tr>
<tr>
<td></td>
<td>Rt-Cn</td>
<td>-2.000</td>
<td>1.44</td>
<td>30</td>
<td>3.908 ***</td>
</tr>
</tbody>
</table>

* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.

Note: Change Scores obtained by subtracting mean resting task values from mean verbal task values.

Rt-Rd indicates a Rest to Read task shift.
Rt-Cn indicates a Rest to Conversation task shift.
Table 8
Mean Group Level and Individual Subject Ranges for all Dependent Variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Task</th>
<th>Mean Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td>Rest</td>
<td>102.898</td>
<td>82.688 - 117.141</td>
</tr>
<tr>
<td></td>
<td>Read</td>
<td>105.017</td>
<td>83.250 - 120.969</td>
</tr>
<tr>
<td></td>
<td>Converse</td>
<td>105.328</td>
<td>83.656 - 119.718</td>
</tr>
<tr>
<td>DBP</td>
<td>Rest</td>
<td>71.100</td>
<td>65.875 - 82.719</td>
</tr>
<tr>
<td></td>
<td>Read</td>
<td>75.536</td>
<td>68.312 - 89.625</td>
</tr>
<tr>
<td></td>
<td>Converse</td>
<td>74.701</td>
<td>65.688 - 88.562</td>
</tr>
<tr>
<td>HR</td>
<td>Rest</td>
<td>69.442</td>
<td>66.562 - 74.531</td>
</tr>
<tr>
<td></td>
<td>Read</td>
<td>77.138</td>
<td>71.062 - 82.281</td>
</tr>
<tr>
<td></td>
<td>Converse</td>
<td>75.571</td>
<td>69.000 - 80.625</td>
</tr>
<tr>
<td>GSR</td>
<td>Rest</td>
<td>13.358</td>
<td>7.022 - 17.020</td>
</tr>
<tr>
<td></td>
<td>Read</td>
<td>15.909</td>
<td>10.303 - 20.981</td>
</tr>
<tr>
<td></td>
<td>Converse</td>
<td>16.763</td>
<td>12.612 - 21.647</td>
</tr>
<tr>
<td>EMG</td>
<td>Rest</td>
<td>3.798</td>
<td>2.084 - 6.631</td>
</tr>
<tr>
<td></td>
<td>Read</td>
<td>3.813</td>
<td>2.534 - 5.444</td>
</tr>
<tr>
<td></td>
<td>Converse</td>
<td>5.996</td>
<td>3.306 - 10.497</td>
</tr>
<tr>
<td>BR</td>
<td>Rest</td>
<td>10.228</td>
<td>7.297 - 13.281</td>
</tr>
<tr>
<td></td>
<td>Read</td>
<td>8.156</td>
<td>6.312 - 9.500</td>
</tr>
<tr>
<td></td>
<td>Converse</td>
<td>8.031</td>
<td>6.469 - 9.031</td>
</tr>
</tbody>
</table>
Figure 1. Mean Changes in Systolic Blood Pressure Plotted by Session for Pooled Data.

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Figure 2. Mean Changes in Diastolic Blood Pressure Plotted by Session for Pooled Data.

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Figure 3. Mean Changes in Heart Rate Plotted by Session for Pooled Data.
Figure 4. Mean Changes in Galvanic Skin Response Plotted by Session for Pooled Data.
Figure 5. Mean Changes in Electromyographic Activity Plotted by Session for Pooled Data.
Figure 6. Mean Changes in Breathing Rates Plotted by Session for Pooled Data.
2.667 mmHg (+2.6%) during conversation tasks over preceding resting task levels. According to the correlated t-tests conducted, these changes were statistically significant (t = 3.478, p < 0.001; and t = 4.929, p < 0.001, respectively; see Table 1).

Changes in SBP in response to task changes proved to be varied in the case of individual subjects. Subjects D and G displayed a mean decrease in SBP during conversation and reading respectively when data were averaged across the eight sessions. All other subjects displayed SBP increases during both tasks in comparison to resting task levels. These changes were statistically significant for both verbal tasks for Subject C (t = 2.206, p < 0.05 for rest to read shifts, and t = 2.709, p < 0.05 for rest to conversation shifts). For Subject G the shifts from resting to conversation were statistically significant (t = 5.093, p < 0.001). No other mean changes in SBP were statistically significant (see Table 2).

Diastolic Blood Pressure

Mean group DBP averaged across the eight sessions increased by 4.634 mmHg (+6.5%) during reading tasks in comparison to preceding resting task levels, and by 3.401 mm Hg (+4.8%) during conversation tasks over preceding resting task levels. According to the correlated t-tests conducted, these changes were statistically significant.
Diastolic BP changes displayed by individual subjects were also somewhat varied but reached statistical significance more consistently than changes in SBP. For Subjects A, B, C, E, and F, DBP increased significantly during reading tasks as compared to preceding resting task levels when averaged across eight sessions \((t = 2.919, p < 0.01; t = 3.705, p < 0.01; t = 5.146, p < 0.001; t = 4.007, p < 0.001; t = 4.988, p < 0.001, \text{ respectively}; \text{ see Table 3})\). Subjects C, E, F, and G displayed significant increases in DBP during conversation tasks as compared to preceding resting level tasks when averaged across eight sessions \((t = 4.530, p < 0.001; t = 2.483, p < 0.05; t = 4.207, p < 0.001; \text{ and } t = 6.440, p < 0.001, \text{ respectively}; \text{ see Table 3})\). Subjects A and D displayed statistically insignificant decreases in DBP during conversation tasks.

**Heart Rate**

In comparison to preceding resting task levels, mean group HR averaged across eight sessions increased by 7.763 bpm (+11.1%) during reading tasks, and by 6.062 beats per minute (bpm) (+8.7%) during conversation tasks. According to the correlated \(t\)-tests performed, these changes were statistically significant \((t = 12.057, p < \)
0.001, and \( t = 9.416, p < 0.001 \), respectively; see Table 1).

When data were averaged across eight sessions, Subjects A, B, C, E, and F displayed statistically significant increases in HR during reading tasks as compared to preceding resting task levels (\( t = 2.673, p < 0.05; t = 7.235, p < 0.001; t = 6.936, p < 0.001; t = 6.118, p < 0.001; t = 5.974, p < 0.001 \), respectively; see Table 4). Subjects A, B, C, E, F, and G displayed significant increases in HR during conversation tasks (\( t = 2.175, p < 0.05; t = 6.809, p < 0.001; t = 4.531, p < 0.001; t = 4.531, p < 0.001; t = 5.086, p < 0.001; \) and \( t = 2.178, p < 0.05 \), respectively; see Table 4). Subject D displayed insignificant increases in HR during both verbal tasks while Subject G displayed an insignificant mean increase in HR during the reading task.

**Galvanic Skin Response**

In comparison to resting levels averaged across eight sessions, mean group GSR levels increased by 2.418 micro-Ohms (micOhm) (+17.9%) during reading tasks compared to preceding resting task levels, and by 3.539 micOhm (+26.8%) during conversation tasks. These changes were found to be statistically significant using correlated \( t \)-tests (\( t = 9.644, p < 0.001 \), and \( t = 14.109, p < 0.001 \), respectively; see Table 1).
When GSR data were averaged across eight sessions for each task type and exposed to correlated t-tests, GSR levels during reading tasks were significantly greater than during preceding resting levels for Subjects A, B, D, F, and G ($t_1 = 4.248, p < 0.001; t_2 = 9.914, p < 0.001; t_3 = 5.972, p < 0.001; t_4 = 6.172, p < 0.001$; and $t_5 = 4.210, p < 0.001$, respectively; see Table 5). Galvanic SR levels during conversation tasks were significantly greater than preceding resting tasks for Subjects A, B, C, D, F, and G ($t_1 = 4.433, p < 0.001; t_2 = 15.908, p < 0.001; t_3 = 6.632, p < 0.001; t_4 = 4.399, p < 0.001; t_5 = 6.314, p < 0.001; t_6 = 5.026, p < 0.001$, respectively; see Table 5).

**Electromyograph**

In comparison to resting levels averaged across eight sessions, mean group EMG levels increased by 0.081 micro-Volts (micV) (+2.2%) during reading tasks compared to preceding resting task levels, and by 2.131 micV (+55.2%) during conversation tasks. Only the changes in response to the conversation task proved to be statistically significant ($t_1 = 9.998, p < 0.001$).

Subjects B, D, and E displayed statistically significant increases in frontalis EMG levels during reading tasks as compared to preceding resting tasks when averaged across eight sessions ($t_1 = 4.508, p < 0.001; t_2 = 6.632, p < 0.001; t_3 = 4.399, p < 0.001; t_4 = 6.314, p < 0.001; t_5 = 5.026, p < 0.001$, respectively; see Table 5).
25.849, \( p < 0.001 \); \( t = 3.103, \ p < 0.01 \), respectively; see Table 6). All subjects displayed statistically significant increases in EMG during conversation tasks as compared to preceding resting tasks (\( t = 9.052, \ p < 0.001 \); \( t = 8.345, \ p < 0.001 \); \( t = 4.679, \ p < 0.001 \); \( t = 32.443, \ p < 0.001 \); \( t = 7.785, \ p < 0.001 \); \( t = 7.049, \ p < 0.001 \); \( t = 3.091, \ p < 0.01 \), respectively; see Table 6). Subject A displayed a significant decrease in EMG levels during reading tasks (\( t = 3.327, \ p < 0.01 \)), while Subjects C and F displayed insignificant decreases during reading tasks.

Breathing Rates

Mean BR decreased by 2.210 inhalations per minute (ipm) (-21.1%) during the reading tasks as compared to preceding resting task levels when averaged across eight sessions, while they decreased by 2.181 imp (-21.3%) during conversation tasks. Correlated t-tests indicated that both mean changes were statistically significant (\( t = 9.444, \ p < 0.001 \), and \( t = 9.322, \ p < 0.001 \), respectively; see Table 1).

Strain gauge placements on subjects B and C proved to be problematic and clear polygraph readings were not obtained; hence, no BR data were available for these subjects for analysis. For the remaining subjects, all shifts from resting tasks to either of the verbal tasks
were accompanied by decreases in BR. For Subjects A, E, and F, this decrease was statistically significant during rest to read shifts when averaged across eight sessions according to correlated $t$-test results ($t = 5.201, p < 0.001$; $t = 2.568, p < 0.05$; and $t = 14.647, p < 0.001$), while for Subjects A, D, F, and G, this change was significant during rest to conversation shifts ($t = 3.632, p < 0.001$; $t = 2.453, p < 0.05$; $t = 13.506, p < 0.001$; and $t = 3.908, p < 0.001$; see Table 7).

Habituation

Figures 1 to 6 depict the magnitudes of the changes associated with rest-to-read and the rest-to-conversation task shifts for the six dependent variables plotted across the eight sessions. Visual analyses indicate that a clear attenuation of effect is displayed only by SBP changes in response to rest-to-read task shifts (see Figure 1). Though the corresponding rest-to-conversation task shift changes in SBP display a trend toward habituation, session to session variability in the data obfuscates the analysis. No clear trends or effects are displayed by subjects for any of the other dependent variables.
DISCUSSION

According to the correlated \( t \)-tests performed on pooled data, the results indicate that statistically significant increases in SBP, DBP, HR, and GSR, and significant decreases in BR were associated with both verbal tasks employed in the study. Electromyograph levels increased significantly during the conversation task but not during the reading task. Only SBP changes associated with reading aloud displayed a clear attenuation with repeated exposure.

The magnitude of the mean changes in SBP, DBP, and HR in response to reading aloud (+1.8%, +6.5%, and +11.1% respectively) and to casual conversation (+2.6%, 4.8%, 8.7%) are less than the 10 to 20% increases typically reported by Lynch and coworkers (cf. Lynch, Thomas, Long, et al., 1982), and are considerably less than the increases usually reported to occur during verbally based stressors (cf. Dembroski et al., 1979; Dimsdale et al., 1988; Fredrikson, Blumenthal, Evans, Sherwood, & Light, 1989; Matthews et al., 1986; Warwick-Evans et al., 1988). They are, however, greater than the magnitudes reported by Henderson et al. (1990), and, with the exception of changes in SBP, congruent those predicted by Linden (1987). Of particular interest is the
very modest change in SBP averaged across the eight sessions, particularly its magnitude in comparison to DBP. In previous investigations, changes in SBP in response to speech have been close in magnitude to changes in DBP (see Linden, 1987, for review). A visual analysis of Figure 1, however, reveals that during the first session SBP increased by an average of 4.9 mm Hg and 5.82 mm Hg during reading and conversation tasks respectively. These magnitudes are comparable to the changes observed in DBP (+6.5 mm Hg, and +4.8 mm Hg respectively). The habituation of changes in SBP in response to speech has not previously been reported. The investigations of Lynch and his colleagues (cf. Lynch et al., 1981) have typically employed single session designs and hence such habituation would not be observable.

Another possible reason for the more modest changes in CV indices reported here is that the level of subject anxiety might have been lower from the outset in the present investigation. Previous reports have linked the magnitude of BP and HR elevations in response to verbal tasks to the status of the investigator (Long et al., 1982), to test anxiety (Beidel, 1988), to social anxiety (Beidel, Turner, & Dancu, 1985), and to the presence/absence of a companion pet (Friedmann, Katcher, Thomas, Lynch, & Messent, 1983; Locker, 1986; Jenkins, 1986). In each of these cases, it might reasonably be inferred that
greater increases in BP and HR can be linked to greater subject anxiety, and hence greater sympathetic nervous system activity. Since steps were taken in this study to reduce subject anxiety prior to the first session, lower levels of initial subject sympathetic arousal than have been present in other studies may have resulted. To the extent that changes in GSR readings associated with the experimental tasks reflect changes in sympathetic arousal, Table 5 and Figure 4 would seem to indicate that subjects were responding to the verbal tasks with modest increases in sympathetic activity.

Kamarck, Manuck, and Jennings (1990) report that the presence of a "friend," a subject-selected acquaintance, during "mental arithmetic" and "concept formation" stress tasks, results in an attenuation of CV reactivity to those tasks. Though the mechanisms of this attenuation have not been identified, it has been suggested that the effect might be due to: (a) alterations in the cognitive appraisal of the laboratory demands by subjects that result in altered autonomic responding, (b) reductions in the behavioral activation of subjects that result in lowered autonomic responding, or (c) the presence of a friend functioning as a "safety signal" (see Rachman, 1984a, 1984b, for a discussion of safety signals) that produces a conditioned reduction in sympathetic arousal. Regardless of the mechanisms involved, if this effect of
the presence of a friend is a valid and robust one, the fact that all subjects in the present investigation were acquainted with the investigator might have resulted in an attenuation of the magnitudes of changes in CV indices that would have otherwise been reported. This follows if CV responses to speech are a function of subject anxiety, in other words, increases in sympathetic nervous system activity.

Yet another possible reason for greater CV response magnitudes to speech being reported elsewhere than are reported herein relates to levels of baseline responding. Many investigations that have found significant and consistent increases in cardiovascular indices to verbal tasks have differed from this study in their use of hypertensive subjects (Adler, et al., 1976; Hellmann & Grimm, 1984), or some combination of normotensive and hypertensive subjects (Ulrych, 1969). In light of the finding by Lynch et al. (1981) that hypertensive individuals experience significantly greater increases in BP and HR in response to talking than do normotensives, the failure of this study to produce elevations of the magnitude previously reported could be due to the use of only normotensive subjects (see Table 8).

In conclusion, though the number of subjects employed in this study is relatively small, these findings suggest that the phenomena of increased blood
pressure and heart rate in response to putatively non-stressful verbal tasks may not be as robust as some previous reports have indicated. Though the current findings replicate those of Lynch and his collaborators (cf. Lynch, Thomas, Long, et al., 1982) in that significant increases in BP and HR during reading aloud and casual conversation were displayed by pooled data, the magnitudes of these increases were not as great. Additionally, such increases were not universally produced in all subjects. This latter point is significant in that previous studies in this area have failed to discuss the data from individual subjects. This omission may give rise to the assumption that the phenomenon of CV mobilization in response to verbalization is more reliable than it really is.

Although EMG levels increased significantly during conversation, it seems likely that this is due to increased muscle activity associated with facial gestures during conversation. It seems reasonable to assume that such gestures are more probable and pronounced during conversation than during resting or reading aloud and this would likely lead to increased frontalis muscle activity, producing higher EMG readings.

Although Conrad & Schonle (cited in Conrad, Thalacker, & Schonle, 1983) found that reading and spontaneous speech produce more rapid rates of
inhalation, inhalation rates in this study decreased significantly during reading aloud and conversation. Additionally, though no quantification of this was attempted, the depth of inhalations tended to increase during these verbal tasks in comparison with resting inhalations, a finding similar to that of Cooke (1980). Reasons for this discrepancy are not offered at this time.

The results of this study would seem to indicate, therefore, that the use of verbally based stressors in the investigation of cardiovascular reactivity presents methodological problems not recognized to date. It would seem that subjects yield varied profiles of reactivity, on the six dependent variables used in this study, to the two verbal tasks employed in this study. Significant changes may occur in some of the dependent measures employed, but not in others, and these changes may occur in response to one type of verbal task but not the other. If reactivity to verbalization and stress are additive, then the results of within-subject investigations of cardiovascular reactivity may be significantly influenced by the choice of dependent measures. For example, if a subject responds to a non-stressful verbal task with significant increases in DBP but not in SBP, then that subject may respond to a similar stressful verbal task with significant increases in DBP but not SBP. If, on the
other hand, mean arterial pressure were to be used to assess the cardiovascular reactivity of this same subject to the same sort of verbal task, it is feasible that little or no reactivity would be indicated. Additionally, it would seem that such varied profiles may add significant variability to the results of studies employing group data analyses.

Furthermore, with repeated exposure to verbally based stressors, the degree of reactivity might appear to fluctuate appreciably or, at least in the case of SBP, attenuate independent of any manipulations to effect such changes (see Figures 1 through 3). As with the choice of dependent measures, this could affect the results of investigations employing such repeated exposures. When employing SBP as a dependent measure, such changes could be erroneously interpreted as decreases in stressor specific reactivity. The fluctuations displayed from session to session by DBP and HR may be interpreted as increases and decreases in stressor specific reactivity, particularly if baseline trends in reactivity are not assessed and appropriate control measures are not employed.

The magnitudes of the changes in the dependent variable employed in this study were not sufficient to call into question our current conceptualizations of stress and of stressors. Though significant, the changes
observed in the present study were of lesser magnitude than those typically reported to occur in response to laboratory stressors. Techniques for separating the effects of specific laboratory based stressors from those of the act of verbalizing await further investigation. It should be noted though, that if CV responses to stressors and verbalization are strictly additive, then the net effects of verbally mediated stressors are less than previously thought. Given that the magnitudes of reported changes in HR and BP to verbally mediated stressors are for some subject/task combinations close to those reported herein (cf. Dembroski et al., 1979; Fredrikson, et al., 1989; Warwick-Evans et al., 1988), the removal of the verbalization component may render the results of some investigations insignificant. On the other hand, the results reported herein may not be a function of the act of verbalization per se, but may be a function of stress. It seems plausible that reading aloud and casual conversation in a contrived setting may elicit modest sympathetic nervous system activation and that this is responsible for the observed effects. Henderson, et al. (1990) have suggested that the use of the occlusion-cuff in clinical/laboratory blood pressure assessments may itself bring about BP elevations and presumably concomitant HR alterations. They suggest that the inflation of an occlusion cuff in conjunction with a
requirement to speak may have a synergistic effect on CV mobilization. This possibility has not been investigated, but if such is the case, it may account for a significant amount of the variation in CV responses to "non-stressful" verbal tasks.

It should be noted that subject diet and exercise habits were not controlled in the present study. Though prior to participation subjects were asked not to make any major alterations in diet or exercise patterns over the course of their participation, no measurement of either was undertaken. It follows that the extent to which changes in diet and exercise patterns of subjects affected the present results is unknown.

At this point in time, it would be premature to suggest the procedural steps necessary to control for these variations in reactivity. Replication of these results with larger numbers of subjects is certainly called for. Additionally, special attention should be paid to which of the indices of cardiovascular reactivity is most stable between- and within-subjects with repeated exposure to putatively non-stressful verbal tasks. In this study, HR was certainly more responsive to the verbal tasks than any of the other dependent measures employed, but it was no more stable or predictable. Investigations into the possible use of predictor variables, such as self-reported anxiety or resting
baseline measures of the cardiovascular indices used, may also prove to be fruitful. Of special interest would be the relationship between cardiovascular responses to putatively non-stressful verbal tasks, and responses to the type of verbally based stressors typically employed in reactivity research. Investigating the differences in response magnitude, and the effects of repeated task exposures on those differences would provide a clearer understanding of the extent to which responses to verbalization per se confound the measurement of stressor specific reactivity using verbally based stressors. Additionally, the investigation of the extent to which occlusion-cuff inflation affects BP and specifically the extent to which it does so during compelled verbalization would determine the extent to which the use of this device may account for observed responses of the CV system to speech.

Finally, investigating the correlations between the effects of non-stressful verbal tasks, and the effects of other task variables such as the cold-pressor tests and oral arithmetic tasks may provide investigators with alternate control procedures. Until the nature of these cardiovascular reactions to the non-stressful verbal tasks employed in this study are better understood, investigators are cautioned to employ multiple control conditions in reactivity studies exposing subjects to
repeated verbal tasks. For this purpose, a reading aloud task and a casual conversation task might prove adequate. It is suggested here, however, that counting forward by ones out loud may prove to be an excellent control task since it would compel the subject to verbalize overtly while involving minimal cognitive demand with little probability of occasioning socially mediated anxiety.
Appendix A

Human Subjects Institutional Review Board Approval Notice
TO: R. Wayne Fuqua  
    George Renfrey  
FROM: Ellen Page-Robin, Chair  
RE: 87-04-05  
DATE: April 1, 1987  

This letter will serve as confirmation that your research protocol, "The Effects of Repeated Trials on the Cardiovascular Responses to Reading and Non-Stressful Conversation" has been approved by the HSIRB with the understanding of the following:  

2. Recommend anyone who is found to have high blood pressure to see a doctor.  
3. If subject is under 18 years of age, parental consent will be needed.*  

Please submit a copy of the revised consent form to the HSIRB.  

*If people under 18 are used, you must submit additional forms: 1) parental consent and b) subject assent.  

If you have any questions, please contact me at 383-4917.
BIBLIOGRAPHY


