Cardiovascular Response of Young and Older Males to Mental Challenge

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Blood pressure, heart rate, rate pressure product, heart rate variability, stroke volume, cardiac output, peripheral resistance, and cardiac contractility derived from impedance cardiography were obtained from 15 young and 15 old males during and after the Stroop task. The old group demonstrated significantly higher absolute heart rate, systolic and mean arterial pressure, peripheral resistance, and rate pressure product, and lower cardiac output, stroke volume, and heart rate variability both during and recovering from Stroop. The young group showed significantly greater relative heart rate increase at the start of Stroop, higher relative levels of contractility during and recovering, and greater relative levels of peripheral resistance during and recovering from Stroop. Overall, old compared to young subjects possessed greater absolute but smaller relative cardiovascular responses during and recovering from Stroop. These results suggest that although the aging cardiovascular may be less reactive, it may be under greater hemodynamic stress both during rest and mental challenge.

Cardiovascular response to psychological stressors such as the Stroop test, reaction time, mental arithmetic, and public speaking tasks typically includes an increase in heart rate (Boutcher, Nugent, & Weltman, 1995), plasma norepinephrine levels (Dimsdale, 1980), systolic and diastolic blood pressure (Burker, Fredrikson, Rifai, Siegel, & Blumenthal, 1994), and total peripheral resistance (van Doornen & de Geus, 1989). Although the cardiovascular response to psychological stressors has been documented in numerous studies, the great majority of subjects tested have been young males (Matthews et al., 1986). In contrast, results of studies examining cardiovascular reactivity to mental challenge in older individuals have been inconsistent in a number of cardiovascular responses.

That the old would possess a dissimilar cardiovascular response to mental challenge compared to the young would not be surprising, as major changes in cardiovascular function of older people have been documented. For example, neural and receptor age-related changes have been shown to influence the regulation of cardiac output, myocardial contractility, and peripheral resistance (Baker, Marchand, O’Neil, Nelson, & Posner, 1985; Garwood, Engel, & Capriott, 1982). Also, there is evidence that beta-adrenergic influence on the myocardium and vasculature becomes blunted with age (Buhler et al., 1980; Joseph & Engel, 1980). For example, maximal heart rate typically decreases at the rate of 10 beats per minute (bpm) per decade as a result of a decreased responsiveness of cardiovascular tissue to beta-adrenergic stimulation and to a reduced catecholamine concentration (Astrand, 1960; Hagberg et al., 1983; Rodeheffer et al., 1984; van Camp & Boyer, 1989). Also, systolic and diastolic blood pressure and total peripheral resistance all rise with age, due to decreased distensibility of vessels and possibly a reduced vasodilative capacity resulting from decreased beta-adrenergic sensitivity (Lakatta, 1980; van Camp & Boyer, 1989). Furthermore, the sensitivity of the heart to vagal stimulation significantly decreases with age (Schwartz, Gibb, & Tran, 1991; Simpson & Wicks, 1988).

Although young males have been predominately used in cardiovascular reactivity research, there is increasing interest in the reactivity of older individuals. Studies examining cardiovascular reactivity in older populations have typically examined heart rate, blood pressure, and catecholamine response to mental challenge (Jennings & Yovetich, 1991). For example, it has been shown that heart rate response to a variety of stressors is attenuated in older subjects. Gintner, Hollandsworth, and Intrieri (1986) measured heart rate to a shock-avoidance reaction time task in subjects aged between 15 and 55 years and found that heart rate response was less for older subjects. Similarly, Barnes, Raskind, Gumbrecht, and Halter (1982) found that old compared to young males exhibited significantly smaller heart rate increase to a mental arithmetic task.

Those studies examining blood pressure response of older subjects to mental challenge have produced equivocal results. For example, Gintner et al. (1986) and Steptoe and Ross (1981) found no association with age and blood pressure response. Also Jennings, Brock, and Nebes (1989), using a series of vascular measures, found similar vascular reactivity to mental challenge in college males and men in their sixties. In contrast, other studies have found that old compared to young subjects demonstrate an increased blood pressure response to mental challenge (Garwood et al., 1982; Johansson & Hjalmarson, 1988; Palmer, Ziegler, & Lake, 1978).

Studies examining catecholamine response to mental challenge of young and older individuals have shown that the plasma norepinephrine response to mental stress is greater in older individuals (Lakatta, 1980, 1983). Barnes et al. (1982) found that older compared to younger subjects had significantly greater increase in norepinephrine plasma levels but a similar epinephrine response to mental arithmetic. Faucheux
et al. (1980) also found that norepinephrine response to a series of psychological stressors was higher in older compared to younger male subjects. Thus, it is well documented that the resting plasma level of norepinephrine increases with age, and also that the plasma norepinephrine response to mental stress is greater in older individuals. Johansson and Hjalmarson (1988) have suggested that the decreased beta-adrenergic sensitivity of older individuals is the basis of their greater norepinephrine reactivity to mental stress.

Collectively, these results suggest that tonic heart rate reactivity is attenuated and beta-adrenergic response exaggerated with aging, whereas the vascular response is unclear. To further elucidate the effects of age on cardiac and vascular response to mental challenge, it would be advantageous to simultaneously assess the factors underlying heart rate and blood pressure change (e.g., autonomic activity, cardiac output, and total peripheral resistance) on a beat-by-beat basis. This kind of assessment should provide a clearer picture of the differences in cardiac and vascular response of young and older males to mental challenge.

In summary, an increase in cardiovascular response to psychological stressors in young subjects is well documented. However, the differences in cardiovascular response to mental challenge of older compared to young individuals are less clear. Consequently, the purpose of this study was to compare young and older subjects' cardiovascular response to a psychological stressor using multiple cardiac and vascular assessment. It was predicted that older compared to younger subjects would exhibit less heart rate and cardiac contractility, greater blood pressure, total peripheral resistance and rate pressure product, and a smaller reduction in vagal influence on the heart during exposure to the Stroop test.

**Method**

**Subjects.** — Asymptomatic, young (M = 21; SEM = .72 yrs) and old males (M = 59; SEM = .78 yrs) acted as subjects. Criteria for entry into either group was a self-reported absence of current pathology (e.g., cardiovascular disease), an absence of confounding medications, and no past history of aerobic training or smoking for the last five years. Prior to testing, subjects were also screened for normal cardiac function at rest and compatibility with the Finapres blood monitor. All subjects read and signed a consent form prior to participation. Subjects' characteristics are presented in Table 1.

**Physiological recording.** — Cardiac performance was measured noninvasively through impedance cardiography (Sherwood, Allen, Obrist, & Langer, 1986) using a Minnesota Impedance Cardiograph (Model 304B) with a tetrapolar aluminum band electrode configuration (Kubicek et al., 1974). The inner two measuring electrodes were located at the base of the neck and at the level of the xiphisternal point of the thorax (Kubicek et al., 1974). The two outer current electrodes were placed 3–5 cm outside of the measuring electrodes, imposing a sinusoidal current of 4 mA with a frequency of 100 KHz. The electrocardiogram was recorded through a Washington Physiograph (400 MD-4C) using spot electrodes. A computer-based system processed and recorded the ECG, basal thoracic impedance (Zo), and the first derivative of the pulsatile impedance (dZ/dt). Software using ensemble averaging was used to process the impedance cardiogram (COP, Microtronics Inc., Chapel Hill, NC). This system was used to measure heart rate, stroke volume, cardiac output, and cardiac contractility. Cardiac contractility was assessed by first measuring pre-ejection period (PEP) and left ventricular ejection time (LVET) and then calculating the ratio between these two variables (PEP/LVET ratio). The equation used to calculate stroke volume was that developed by Kubicek et al. (1974). A fixed value of 135 ohm.cm was used for blood resistivity.

Blood pressure was recorded on-line, every beat, using an Ohmeda Finapres continuous blood pressure monitor (Model 2300). A cuff was attached to the subject's third finger on the left hand, which was positioned at heart level. Subjects possessing poor peripheral circulation were excluded from the study during subject recruitment and cardiac function screening. Also, each subject's Finapres resting blood pressure was verified by blood pressure assessment with a manual sphygmomanometer. Total peripheral resistance (TPR) was calculated by simultaneously measuring blood pressure and cardiac output using the equation TPR (dynes.s.cm^-5) = (mean arterial pressure/cardiac output) × 80. Data were collected for 25-sec periods during the Stroop task.

**Interbeat interval and heart rate.** — Interbeat interval (IBI) was determined on a beat-by-beat basis as the difference in the time of peak voltage of the R-wave and the peak voltage of the subsequent R-wave. Heart rate was calculated from the IBI. Data were stored on a hard disk, and the IBI was calculated by the Datapac analysis program (Run Technology, CA).

**Heart rate variability.** — Heart rate variability (HRV) was calculated using a time series method (HRV<sub>2</sub>) through the MXEDIT software package (Delta-Biometrics, Inc., Bethesda, MD). IBI's, timed to the nearest msec, were converted into time-based data by sampling successive 200-msec intervals. The IBI's were then plotted and edited to remove artifact and outlying values. This technique has been developed to control for the statistical limitations when extracting HRV amplitude that is superimposed on a fluctuating baseline trend (Porges, 1985). Leakage of nonstationarities and slow periodicities into the frequency component were avoided by detrending the time-based data with a 51-point cubic polynomial. A band-pass filter was used to remove sources of variance below the two major oscillatory heart rate spectral components. One of these components,

<table>
<thead>
<tr>
<th>Variable</th>
<th>Young (n = 15)</th>
<th>Old (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M (SE)</td>
<td>M (SE)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>20.9 (.72)</td>
<td>*58.8 (.78)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176.8 (1.9)</td>
<td>177.6 (1.4)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>72.1 (2.0)</td>
<td>*84.9 (3.4)</td>
</tr>
</tbody>
</table>

*Old significantly greater than Young (p < .05).
termed high frequency, is synchronized with respiration and typically occurs at frequencies at 0.12 Hz and above. The other component, called Mayer waves, is termed low frequency and is centered at around 0.10 Hz and below. The slow frequency characteristics of the Mayer waves correspond to the slow oscillations present in arterial pressure variability (Furlan et al., 1993). The natural logarithm of the band-passed variance (in msec²) was calculated and used as high frequency measures (.12-.40 Hz) of HRV. These estimates of HRV appear as a linear scale ranging from 0 (minimal HRV) to 10 (maximal HRV; Porges, 1985).

**Task**

**Stroop.** — The Stroop is an active coping task (Stroop, 1935). Subjects were shown a series of slides, on each of which was printed a word denoting a color, such as GREEN. The ink color of each slide, however, was printed in a different color, such as red. Slides were projected at the rate of 1/sec from 1 meter behind the subject, on to a wall 4 meters in front of the subject. Each word appeared directly in front of the subject at eye level and was 15 cm high at the wall. Subjects were instructed to clearly state, in their normal speaking voice, the ink color of the word that appeared on each slide. Performance on the Stroop task was measured by counting the number of incorrect responses made by each subject. The Stroop task was 2 min long, followed by a recovery period of 4 min.

**Procedure.** — Subjects were asked to refrain from eating, smoking, and ingesting caffeine and alcohol for at least 4 hours before testing. On arrival at the laboratory, subjects read and completed a human subjects consent form and a personal health and exercise history questionnaire. All instructions from the beginning of the laboratory baseline period were tape recorded. Laboratory temperature was maintained at between 22.5 and 25.8°C during all testing sessions. Following these preliminaries, subjects were prepared for measurement. Subjects were then seated in an experimental chair, in which they remained until the conclusion of the session.

After preparation, a 15-min baseline period in which subjects were instructed to rest quietly began each experimental session. Physiological recording commenced after the 10th minute of this period. Immediately following this baseline period, each subject underwent the Stroop task followed by a recovery period. A brief outline of the Stroop was given, and the subject spent 10 sec practicing. The task difficulty rating system and experimental protocol were explained. Finally, each subject’s state anxiety level was assessed using the State version of the Spielberger State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). During the experiment, a taped message was used to remind subjects of the requirements of the upcoming stressor, when the stressor began, and when it ended. Ratings of task difficulty checks were made 2 min after the completion of the stressor and during the recovery period. The manipulation check, based on a 15-point Rating of Perceived Exertion scale (Borg, 1961), was used to assess whether groups differed on the amount of perceived challenge generated by the task.

**Data analysis.** — Stroke volume, cardiac output, PEP, LVET, and PEP/LVET ratio were recorded and processed over a 25-sec period during and recovering from the Stroop. Heart rate and blood pressure were initially recorded beat-by-beat and then averaged to catch the 25-sec periods described above. HRV was determined for high frequencies (.12-.40 Hz) during and recovering from the Stroop. As the two groups differed in weight, body mass index was initially covaried with all cardiovascular responses to the Stroop. No influence of body mass index was found; thus, all results are reported as comparisons between the two groups.

**Statistical analysis.** — A 2 (group: Young, Old) × 8 (time: four 25-sec periods during and four 50-sec periods recovering) mixed design was used to determine whether the pattern of responding across variables differed as a function of age. Analysis was conducted on both absolute and relative scores (calculated by subtracting the baseline measure from each response during and recovering from the task). HRV responses were analyzed using a 2 (group: Young, Old) × 2 (stressor: task, recovery) mixed design. Where ANOVA yielded significant results, a Bonferroni post hoc procedure was employed. For these tests, a probability of <.05 was considered significant. For analyses that involved repeated measures, the conservative F-test correction for degrees of freedom (Geisser & Greenhouse, 1958) was applied when symmetry assumptions were violated.

**RESULTS**

**State anxiety.** — No significant differences between groups were observed for State Anxiety, measured immediately prior to commencement of the experiment. Mean score for young subjects was 30.7 (SEM = 3.87) and for old subjects was 28.9 (SEM = 2.64).

**Baseline measures.** — Baseline measures for all variables, for both young and old groups, appear in Table 2. The old group compared to the young possessed significantly higher heart rate, LVET, PEP/LVET ratio, blood pressure, TPR, rate pressure product levels, and significantly lower cardiac output, stroke volume (Table 2), and HRV during upright rest, ts(28) = >2.96, p < .05 (Table 3).

**Stroop performance.** — No differences were observed between groups on number of errors made during the Stroop task (Young, M = 1.5; SEM = .67; Old, M = 1.7; SEM = .62). In addition, no differences were observed between groups on rating of task difficulty for the Stroop task (Young, M = 12.53; SEM = .54; Old, M = 11.53; SEM = .52).

**Cardiovascular response to the Stroop task.** — Analysis on cardiovascular response to the Stroop task for all subjects combined revealed significant Time main effects for heart rate, stroke volume, cardiac output, PEP, LVET, PEP/LVET ratio, systolic, diastolic, and mean blood pressure, TPR, and rate pressure product, F(6,174) = >3.45, p <
Table 2. Pretask Baseline and Stroop Means for Stroke Volume, Cardiac Output, Total Peripheral Resistance, PEP/LVET Ratio, PEP, LVET, Heart Rate, Blood Pressure, and Rate Pressure Product for Young and Old Males (SEs in parentheses)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline</th>
<th>During Stroop</th>
<th>Stroop Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Old</td>
<td>Young</td>
<td>Young</td>
</tr>
<tr>
<td></td>
<td>M (SE)</td>
<td>M (SE)</td>
<td>M (SE)</td>
</tr>
<tr>
<td>Stroke Volume (ml)</td>
<td>73* (5.1)</td>
<td>81* (6.3)</td>
<td>84* (6.9)</td>
</tr>
<tr>
<td></td>
<td>105</td>
<td>108 (6.4)</td>
<td>109 (8.9)</td>
</tr>
<tr>
<td>Cardiac Output (L/min)</td>
<td>5.3* (.34)</td>
<td>6.5* (.50)</td>
<td>7.0 (.54)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>6.8 (1.36)</td>
<td>8.4 (.64)</td>
</tr>
<tr>
<td>Total Peripheral Resistance</td>
<td>Old</td>
<td>1659* (136)</td>
<td>1514* (102)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>1104 (67)</td>
<td>1035 (84)</td>
</tr>
<tr>
<td>PEP/LVET (ms)</td>
<td>Old</td>
<td>.48* (.02)</td>
<td>.47 (.03)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>.54 (.01)</td>
<td>.48 (.02)</td>
</tr>
<tr>
<td>PEP (ms)</td>
<td>Old</td>
<td>138 (3.8)</td>
<td>130 (5.1)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>140 (1.8)</td>
<td>122 (3.7)</td>
</tr>
<tr>
<td>LVET (ms)</td>
<td>Old</td>
<td>287* (3.8)</td>
<td>277* (8.7)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>260 (4.1)</td>
<td>252 (5.2)</td>
</tr>
<tr>
<td>Heart Rate (bpm)</td>
<td>Old</td>
<td>73* (2.6)</td>
<td>81 (3.9)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>66 (2.6)</td>
<td>79 (3.9)</td>
</tr>
<tr>
<td>Systolic Blood Pressure (mmHg)</td>
<td>Old</td>
<td>139* (3.6)</td>
<td>158* (4.6)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>122 (2.6)</td>
<td>133 (3.9)</td>
</tr>
<tr>
<td>Diastolic Blood Pressure (mmHg)</td>
<td>Old</td>
<td>84* (2.3)</td>
<td>94 (3.0)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>76 (2.1)</td>
<td>85 (2.8)</td>
</tr>
<tr>
<td>Mean Arterial Blood Pressure (mmHg)</td>
<td>Old</td>
<td>101* (2.7)</td>
<td>115* (3.6)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>89 (2.1)</td>
<td>100 (3.1)</td>
</tr>
<tr>
<td>Rate Pressure Product (SBP x HR/100)</td>
<td>Old</td>
<td>102* (4.3)</td>
<td>129* (8.6)</td>
</tr>
<tr>
<td></td>
<td>Young</td>
<td>80 (3.0)</td>
<td>106 (6.0)</td>
</tr>
</tbody>
</table>

*p < .05.

0.5. The Stroop task also resulted in a significant decrease in HRV_a, r(28) = 3.96, p < .05, for all subjects.

Cardiovascular response to the Stroop task of old and young. — The means and standard errors of the baseline and responses during and after Stroop for all parameters, except HRV_a, are presented in Table 2 for the old and young separately. The baseline and task scores for heart rate, PEP/LVET ratio, TPR, and rate pressure product are presented in Figure 1.

For absolute response during the Stroop task, the old
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**Figure 1.** Heart rate, PEP/LVET ratio, total peripheral resistance, and rate pressure product responses during and recovering from the Stroop task for Old and Young subjects (mean with standard error of the means; B = baseline, 1-4 = during Stroop, 1-4 = recovering from Stroop).

The means and standard errors of the pretask baseline and responses during and after Stroop for HRV\textsubscript{sa} are presented in Table 3 for the old and young. For absolute HRV\textsubscript{sa} response, the old group showed significantly lower levels of HRV\textsubscript{sa} during, \(t(28) = 3.96, p < .05\), and recovering, \(t(28) = 5.65, p < .05\), from the Stroop (Table 3), whereas no difference existed for relative HRV\textsubscript{sa} response during or recovering from the Stroop.

**DISCUSSION**

The purpose of this study was to examine the relationship between age and relative and absolute cardiovascular response during and recovering from exposure to the Stroop task. Young compared to old subjects tended to display a quicker relative heart rate response and a greater relative increase in cardiac contractility that remained elevated throughout the recovery period. For absolute cardiovascular response, the old group demonstrated significantly higher heart rate, systolic and mean arterial blood pressure, rate pressure product, TPR levels, and significantly lower cardiac output, stroke volume, and HRV\textsubscript{sa} both during and recovering from the Stroop task.

During the Stroop, heart rate, cardiac output, cardiac contractility, blood pressure, and TPR increased significantly and HRV\textsubscript{sa} decreased significantly for all subjects, demonstrating that this information processing task had a significant impact on the cardiovasculature (Dembroski,
However, although both groups exhibited a significant cardiovascular response to the Stroop task, there were also differences in the patterns of the relative and absolute responses of the young and old subjects.

The major differences in relative response between the young and old groups were that young subjects exhibited more rapid heart rate response and greater increase in cardiac contractility than old subjects. The diminished heart rate response of the older subjects parallels the results of other studies (Jennings, Brock, & Nebes, 1989; Morris & Thompson, 1969; Pfeifer et al., 1983).

Young compared to old subjects experienced significantly greater increase in relative beta-adrenergic activity of the myocardium as shown by greater decreases in the PEP/LVET ratio during the Stroop task. During Stroop recovery, in contrast to the old, young subjects’ relative contractility levels did not return to baseline. Interestingly, absolute LVET was significantly greater for the old group during the baseline, Stroop, and recovery. The increased LVET of older subjects supports prior research that has shown that beta-adrenergic influence on the myocardium becomes blunted with age (Buhler et al., 1980; Joseph & Engel, 1980).

Also, relative systolic and diastolic and mean arterial pressure in young subjects tended to remain elevated during recovery, perhaps because of an abundance of beta-adrenergically mediated catecholamines in the blood. The greater relative blood pressure response of young subjects during recovery appears to be the result of differences in the TPR of the two groups. The TPR of young subjects returned to baseline levels, whereas old subjects’ TPR returned below baseline during Stroop recovery. In turn, the different relative TPR levels between groups during recovery may have also been influenced by beta-adrenergic effects on the vasculature, which, as mentioned, may have affected young more so than old subjects. Although relative blood pressure reactivity during Stroop was not significant, there were trends for the old to display greater SBP reactivity compared to that of the young. With a larger sample size these differences may have become significant.

That the old compared to young possessed smaller heart rate and cardiac contractility to mental challenge suggests that the beta-adrenergic response of the old to mental challenge was blunted. It is possible that the reduced beta-adrenergic reactivity of the older subjects represents an adaptive response to aging. However, the increased plasma norepinephrine response to mental challenge typically found in older individuals (Barnes et al., 1982) implies that the more sluggish heart rate and reduced contractility of the older subjects during mental stress in the present study was a result of decreased beta-adrenergic sensitivity. Thus, with advancing age the ability of the beta-adrenergically initiated cardiovascular response to stress may decline.

For absolute response, the old group demonstrated significantly higher heart rate, systolic and mean arterial blood pressure, LVET, TPR, and rate pressure product, and significantly lower cardiac output, stroke volume, and HRV, both during and recovering from the Stroop task. These higher and lower absolute responses reflect the differences in resting values between the young and old. Thus, although there were few relative differences between these variables for the two groups, in absolute terms, the cardiovascular differences during and after the Stroop task were substantial. These greater absolute cardiovascular levels may suggest that the old subjects’ cardiovascular response was under greater strain during mental challenge. For example, one of the best indicators of myocardial strain is the rate pressure product which is linearly related to myocardial oxygen consumption (Lehmann & Keul, 1986). At rest and during and recovering from the Stroop, the rate pressure product of the old subjects was over 21% greater than that of the young (see Figure 1), suggesting that their myocardium was under greater stress both during rest and during mental challenge. Thus, although these age-related changes observed at rest may not inhibit the performance of the aging cardiovascular system during stress (Lakatta, 1983), they may have important clinical implications. For example, Krantz et al. (1991) found that both relative and absolute systolic blood pressure levels predicted the magnitude of ischemia during exposure to mental stress. However, until future research establishes the relationship between absolute cardiovascular levels and health, the absolute scores in the present study need to be interpreted with caution.

The pattern of vagal sensitivity, as measured by assessment of heart rate variability, indicates that the older heart was under less vagal control during mental challenge. For example, old subjects demonstrated significantly lower levels of heart rate variability during baseline and during and recovering from mental stress. As low levels of vagal tone have been associated with higher incidence of malignant arrhythmias (Bigger, Klieger, & Fleiss, 1988), older individuals possessing low vagal tone may be at greater risk during mental challenge. In addition, old subjects possessed significantly higher baseline TPR and blood pressure. They also showed a greater increase in absolute TPR and blood pressure compared to young subjects during the Stroop task, suggesting their vasculature was under greater hemodynamic stress both during rest and during challenge. The greater TPR and systolic blood pressure levels of the old subjects may have been brought about by the stiffer vascular bed typically found in older individuals (van Camp & Boyer, 1989).

In conclusion, it was hypothesized that older compared to younger subjects would exhibit greater absolute cardiovascular response but a reduced beta-adrenergic response both during and after exposure to the Stroop test. Results of this study support these hypotheses and suggest that although the aging cardiovascular system may be less reactive, it may be under greater hemodynamic stress both during rest and during exposure to mental challenge.

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