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Differences Among Age and Sex Groups With Respect to Cardiovascular Conditioning and Reactivity[1]

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AGE and sex differences in cardiovascular reactivity and conditioning have received rather scanty attention in the recent literature. Shmavonian, Yarmat, and Cohen (1965) demonstrated sex differences within young Ss and age differences within male Ss. In this study Young Males exhibited consistent vasomotor conditioning; the Young Females did not mainly because of the great variability in their responses. Aged Males were the poorest of the three groups in terms of reactivity and failed to condition. This experiment did not include Aged Females, which makes the comparisons of age and sex groups somewhat incomplete, since age X sex interactions were lacking.

Some justifiable criticism has been leveled at the above experiment and at the original vasomotor conditioning study by Shmavonian (1959) for failure to control for sensitization (Stoltz, 1963). Inspection of the records obtained in the course of vasomotor conditioning studies, however, indicates that much more than sensitization is taking place. The discrimination paradigm, which appears to afford adequate controls for sensitization effects, does not appear to have been utilized to any great extent in vasomotor conditioning studies to date.

In recent years, studies dealing with conditioned heart rate responses have been rife in the literature. Again, age and sex differences have received little attention and sensitization effects have been poorly controlled. A further difficulty with many of these studies lies in their failure to evaluate heart rate responses in relation to other measures of cardiovascular activity.

When dealing with a dynamic system such as the cardiovascular, it seems somewhat pointless to examine a single parameter of its activity in isolation. Cardiovascular physiologists are somewhat agreed that cardiac output and peripheral resistance to the flow of blood are functionally related to mean arterial blood pressure and that heart rate and blood pressure are often reciprocally related via a complex system of pressure sensitive reflexes. In view of these relationships, the authors deemed it advisable to examine superficially accessible parameters of vascular resistance and cardiac output, such as the digital plethysmogram and heart rate, concurrently, rather than separately and in isolation.

This paper constitutes a report on the analysis of the cardiovascular variables in an autonomic conditioning study. Electrodermal data from this study are discussed in detail elsewhere (Shmavonian, Miller, & Cohen, 1968) and are not relevant to the present discussion.

Materials and Methods

Subjects

Ten Young Male Ss (YMs), ranging in age from 18 to 25 with a mean age of 19.6, and 14 Young Female Ss (YFs), ranging in age from 17 to 21 with a mean age of 18.6, were drawn from the Introductory Psychology classes at Duke University. Twelve Aged Male Ss (AMs), ranging in age from 61 to 73 with

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a mean age of 66, and 10 Aged Female Ss (AFs), ranging in age from 68 to 76 with a mean age of 69.8, were recruited from the Durham, North Carolina State Employment Commission and the local Golden Age Clubs. Student Ss chose money or credit toward course requirements, whereas the Aged Ss were paid for their participation. The extra four YFs and two AMs were added to the sample as replacements for Ss dropped because of equipment failure and incomplete data in order to provide 10 Ss for each cell of the 2 × 2 design.

Ss were limited to those with normal hearing and no history of cardiovascular problems. All Ss were advised not to eat bananas within 24 hours prior to the experiment and not to drink coffee prior to coming to the lab on the day of the experiment. These precautions were taken in order to avoid artifactually elevated catechol amine levels. All Ss were informed that the experiment involved electric shock.

Procedure

The Ss arrived at the Duke University Psychophysiology Laboratory at an appointed time and were asked to provide a urine sample, which was discarded, and to wash their hands. They were then given an 8-oz. glass of water to drink, seated in a comfortable reclining chair in a quiet, dimly lighted room, and instructed to rest quietly for 1 hour. At the end of this 1-hour rest period Ss were again asked to produce a urine sample, which served to provide resting urinary cathechol amine levels, and were given another 8-oz. glass of water to drink. Ss were then conducted to an 80db sound-attenuated chamber where they were again seated in a comfortable reclining chair. A young female technician then proceeded to attach the various transducers. Shock thresholds and tolerance levels, with an upper limit of 2MA to avoid burning any Ss, were established. Ss were informed that the light would dim, that they would hear a series of tones, that they would receive some electric shock, and that they were to move as little as possible. At this point, the technician left the chamber and the conditioning procedure began.

Ss were presented with 10 300 CPS tones of 15-sec. duration and 10 1100 CPS tones of 15-sec. duration in random order during the habituation period of the discrimination conditioning paradigm. During the acquisition period, the last 5 sec. of the 15-sec. 300 CPS tone (CS+) was overlapped with electric shock for a 10-sec. Inter-Stimulus Interval (ISI). The 1100 CPS tone (CS−) was not coupled with shock at any time. Fifteen CS+ and 15 CS− were presented in random order during the acquisition period. The extinction period consisted of 10 CS+ and 10 CS− presented in random order with no electric shock. Both tones were of moderate and subjectively equal intensity.

A final urine sample was obtained upon completion of the conditioning procedure and Ss were given a Cognitive Questionnaire designed to evaluate the verdicability of their perception of the conditioning procedure and some aspects of their anxiety and boredom.

Apparatus

Respiration.—The respirometer consisted of a sliding piston arrangement mounted on an elastic band placed around the S's chest. A photocrystal in one end of the piston served as one arm of a resistance bridge. The resistance of the photocrystal itself was modulated by a small light in the opposite end of the piston as a function of the distance between the light and the photocrystal. The distance between light and photocrystal, then, becomes a function of excursions of S's chest wall relating chiefly to respiration. The varying voltage of this resistance bridge was written out on a Grass oscillograph providing a graphic representation of the S's respiratory activities.

Heart rate.—Grass EEG cup electrodes filled with bentonite paste were utilized in a left mastoid-left kneecap placement. The signal was amplified by a Fels cardiotachometer which, when written out on the Grass oscillograph, provided a beat-by-beat record of heart rate.

Plethysmograph.—A photoelectric plethysmograph mounted in a metal ring (Shmavonian, 1959) was placed on the forefinger. A varying voltage output of the plethysmograph bridge was written out on the Grass oscillograph providing a graphic analog of the pulse pressure wave of the digit of regard.

EEG.—One Grass needle EEG electrode was placed 2 in. to the left of the centrum and the other placed 2 in. to the left of the midline and 3 in. above the inion. The EEG signal produced by this parieto-occipital placement was amplified via a Grass 3D EEG in-

strument and analyzed by means of a Birch frequency analyzer.

Data Reduction

Respiration.—Respiration served as a monitor on gross respiratory maneuvers and was not reduced in a systematic manner.

Plethysmograph.—Shifts in the baseline component of the pulse pressure wave occurring ISI were measured in terms of mm pen deflection, with upward deflections reflecting dilatation and downward deflections reflecting constriction.

Heart rate.—The fastest and the slowest heartbeats for the first 5″ pre-CS, second 5″ pre-CS, first 5″ CS, and second 5″ CS were averaged and change scores, in terms of these mean or mid-range values, were calculated by subtracting the value for each 5″ period from the value for the preceding 5″ period.

Catechol amines.—Determinations for urinary epinephrine and norepinephrine were calculated by the flourimetric method and reported in terms of micrograms per hour.

The cognitive questionnaire was reduced in terms of the number of objective bits of information the *S* could provide either in the course of the interview or in response to direct questioning.

Statistical Treatment

The data were analyzed within the framework of a 2 × 2 × 2 factorial design with Sex & Age serving as the independent factors and Trials and Stimuli serving as within-*Ss* factors. A separate analysis was conducted for each of the three experimental periods. Thus, adaptation was analyzed within a 2 ×2 × 2 × 20 matrix, conditioning was analyzed within a 2 × 2 × 2 × 30 matrix, and extinction was analyzed within a 2 × 2 × 2 × 20 matrix.

Results

Plethysmograph-DC Shifts During the 10-sec. Inter-Stimulus Interval (ISI)

All responses were consistent with vasoconstriction in that all baseline shifts were downward in direction.

During the adaptation period the only significant difference in evidence (Table 1) was between the age groups with the YMs and YFs exhibiting significantly greater ($F_{1,36}=7.1$) reactivity than the AMs and AFs. While not statistically significant, the response in all groups during adaptation was greater to the CS− than to the CS+.

During conditioning the age difference became even greater ($F_{1,36}=7.4$) with the Young *Ss* being much more reactive than the Aged. The Age X Sex X Stimulus Interaction was also significant during conditioning ($F_{1,36}=3.4$). Examination of the individual groups showed that the YMs were the only group to exhibit discriminant conditioning. The increased responsivity of the other three groups was not all selective and was taken to be a reflection of sensitization effects.

Table 1. Analysis of Variance: Plethysmograph Alpha mm x 10.

	Adaptation				Conditioning				Extinction			
Source	*d.f.*	MSS	*F*	*p*	*d.f.*	MSS	*F*	*p*	*d.f.*	MSS	*F*	*p*
Between *Ss'*												
Age: A	1	133645.	7.1	*	1	155041.	7.4	**	1	111983.	10.5	**
Sex: B	1	5512.5	<1		1	33602.	1.6		1	1968.78	<1	
AB	1	21217.5	<1		1	1180.	<1		1	1001.22	<1	
e1	36	671375.			36	21001.9			36	10678.08		
Within *Ss'*												
Stimulus: C	1	45.12	<1		1	90.74	<1		1	457.54	<1	
AC	1	36.12	<1		1	70.14	<1		1	427.78	<1	
BC	1	903.12	<1		1	972.02	1.45		1	344.52	<1	
ABC	1	1378.14	1.06		1	2286.97	3.4	**	1	2.57	<1	
e2	36	1305.69			36	671.60			36	655.2		
Order: D	9	1528.47			14	858.01	<1		9	939.66	<1	
AD	9	434.54	<1		14	580.76	<1		9	742.08	<1	
BD	9	758.67	<1		14	1028.74	1.15		9	1201.68	1.16	
ABD	9	985.00	<1		14	1353.51	1.51	<.1	9	715.30	<1	
e3	324	1021.66			504	898.23			324	1032.84		
CD	9	874.21	1.36		14	1053.47	1.14		9	1057.38	1.09	
ACD	9	1193.55	1.87		14	602.70	<1		9	614.01	<1	
BCD	9	950.4	1.46		14	764.62	<1		9	1102.43	1.13	
ABCD	9	535.7	<1		14	743.13	<1		9	946.	<1	
e4	324	638.6			504	923.65			324	972.5		

*$p \leq 0.05$
**$p \leq 0.01$

During the extinction period the previously mentioned age differences were again in evidence. It is noteworthy that the differences between the age groups were of greater statistical significance during this period ($F_{1,36}$= 10.5), mainly due to the failure of the Aged to respond at all during this period.

Cardiac Responses (Heart Rate)

During the adaptation period the reactivity of the Young Ss was significantly greater than the reactivity of the Aged Ss ($F_{1,36}$=20.14). The Aged Ss demonstrated no systematic variability to either stimulus; whereas, Young Ss exhibited a significant acceleration in the first 5 sec. of the ISI with an abrupt deceleration in the second 5 sec. of the ISI ($F_{1,36}$=27.36).

During the conditioning period the age differences remained significant ($F_{1,36}$=17.32). Again, in the first 5 sec. of the ISI Young Ss exhibited marked cardio-acceleration (Tables 2 & 3).

Table 2. Comparison of Median Heart Rate First 5 Seconds of the Stimulus (CS) as Compared to Pre-Stimulus 5-Seconds Median Heart Rate.

	Adaptation				Conditioning				Extinction			
Source	*d.f.*	MSS	*F*	*p*	*d.f.*	MSS	*F*	*p*	*d.f.*	MSS	*F*	*p*
Between *Ss'*												
Age: A	1	497.7	20.14	**	1	1283.4	17.42	**	1	348.48	8.51	**
Sex: B	1	4.65	<1		1	16.57	<1		1	3.92	<1	
AB	1	82.56	3.34	<.08	1	6.9	<1		1	4.50	<1	
e_1	36	24.68			36	73.69			36	40.95		
Within *Ss'*												
Stimulus: C	1	12.75	1.13		1	37.10	<1		1	11.04	<1	
AC	1	4.35	<1		1	19.0	<1		1	26.64	<1	
BC	1	1.20	<1		1	37.81	<1		1	6.12	<1	
ABC	1	5.61	<1		1	36.40	<1		1	21.13	<1	
e_2	36	11.30			36	42.62			36	27.34		
Order: D	9	39.33			14	15.88	<1		9	32.58		
AD	9	26.45	1.63		14	16.61	<1		9	18.76	1.01	
BD	9	10.33	<1		14	20.82	1.05		9	11.36	<1	
ABD	9	4.83	<1		14	18.03	<1		9	18.68	1.01	
e_3	324	16.21			504	19.8			324	16.19		
CD	9	8.24	<1		14	11.61	<1		9	11.66	<1	
ACD	9	8.49	<1		14	14.38	<1		9	8.51	<1	
BCD	9	4.94	<1		14	9.39	<1		9	5.16	<1	
ABCD	9	5.29	<1		14	15.97	<1		9	13.74	<1	
e_4	324	16.07			504	18.14			324	18.64		

*$p \leq 0.05$
**$p \leq 0.01$

Table 3. Comparison of Median Heart Rate Second 5 Seconds of the Stimulus (CS) as Compared to Pre-Stimulus 5-Seconds Median Heart Rate.

	Adaptation				Conditioning				Extinction			
Source	*d.f.*	MSS	*F*	*p*	*d.f.*	MSS	*F*	*p*	*d.f.*	MSS	*F*	*p*
Between *Ss'*												
Age: A	1	1081.72	27.36	**	1	3724.16	55.19	**	1	1090.44	16.07	**
Sex: B	1	12.5	<1		1	228.81	3.39	<.08	1	204.02	3.0	<.09
AB	1	55.13	1.39		1	345.62	5.12	<.02	1	235.45	3.47	<.08
e_1	36	39.51			36	67.48			36	67.86		
Within *Ss'*												
Stimulus: C	1	74.42	3.85	<.08	1	4.81	<1		1	8.82	<1	
AC	1	.12	<1		1	1.33	<1		1	.6	<1	
BC	1	6.48	<1		1	18.75	1.03		1	16.82	1.33	
ABC	1	34.45	1.78		1	4.09	<1		1	6.13	<1	
e_2	36	19.34			36	18.18			36	12.68		
Order: D	9	12.11	<1		14	12.05	<1		9	8.86	<1	
AD	9	9.38	<1		14	19.65	1.09		9	8.51	<1	
BD	9	16.43	<1		14	31.40	1.74	*	9	27.59	1.6	
ABD	9	18.28	1.12		14	22.81	1.27		9	19.87	1.16	
e_3	324	16.35			504	18.02			324	17.2		
CD	9	8.46	<1		14	18.68	1.09		9	16.8	<1	
ACD	9	7.05	<1		14	20.56	1.2		9	5.18	<1	
BCD	9	15.98	<1		14	18.46	1.08		9	12.12	<1	
ABCD	9	9.29	<1		14	23.65	1.35		9	16.54	<1	
e_4	324	16.31			504	17.07			324	18.67		

*$p \leq 0.05$
**$p \leq 0.01$

During the second 5 sec. of the ISI, however, the Young *Ss* exhibited an even more pronounced deceleration than during the same portion of the ISI during adaptation, whereas the Aged *Ss* essentially exhibited acceleration. Inspection of Figures 1 and 2 makes the statistical statement ($F_{1,36}=55.19$) of this comparison superfluous.

Males displayed nonsignificantly greater deceleration than Females ($F_{1,36}=3.19$) with far and away the greater portion of the deceleration being contributed by the Young Males who displayed significantly greater ($F_{1,36}=5.12$) deceleration than the Young Females. In no case, however, was there a significant stimulus effect in evidence, which indicates the cardio-deceleration to be something other than a discriminantly conditioned response.

During the extinction period, the same general pattern of response was in effect. Young *Ss* exhibited significantly greater ($F_{1,36}=8.51$) acceleration in the first 5 sec. of the ISI than the Aged *Ss* and exhibited significantly greater ($F_{1,36}=16.07$) deceleration during the second 5 sec. of the ISI. Young Males continue to show greater, but nonsignificant, deceleration as indicated by the Sex X Age F value of 3.47 ($p<0.08$).

In summary, the Young Males exhibited discriminant vasomotor conditioning and approached discriminant cardio-deceleration; Young Females, while quite reactive, failed to demonstrate either discriminant vasomotor conditioning or discriminant cardio-deceleration; and finally, both Aged Males and Aged Females were essentially poor cardiovascular reactors and failed to demonstrate any sort of discriminant conditioning.

EEG

Due to difficulties with the period analyzer, the EEG data were not reduced in a systematic fashion for all *Ss*. However, the findings were consistent with the original study (Shmavonian et al., 1965) and with Kogan (1960). These findings indicated that the Aged *Ss* produced a low voltage fast (lvf) pattern throughout the experiment; whereas, the Young *Ss* exhibited a much more variable EEG pattern consisting of low voltage fast and alpha patterns.

Cathechol Amines (Fig. 3)

Male *Ss* produce significantly more total urinary amines ($F_{1,38}=4.03$), principally noradrenalin ($F_{1,38}=20.7$), than Female *Ss* when the pre-experiment and post-experiment

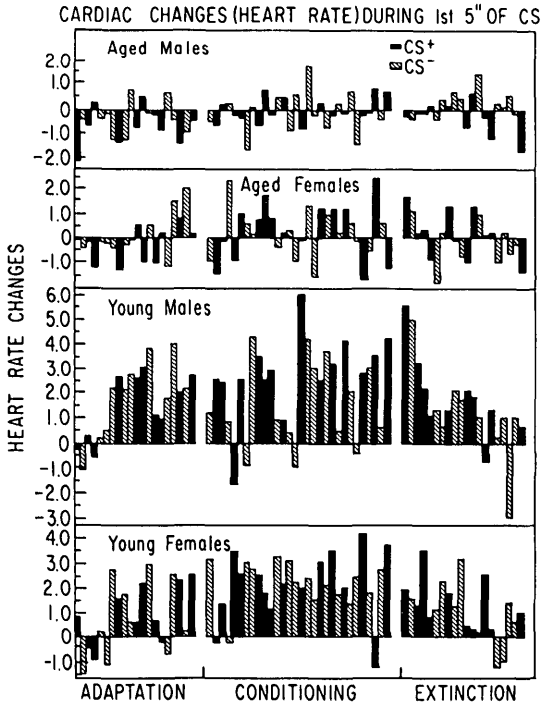

Figure 1.

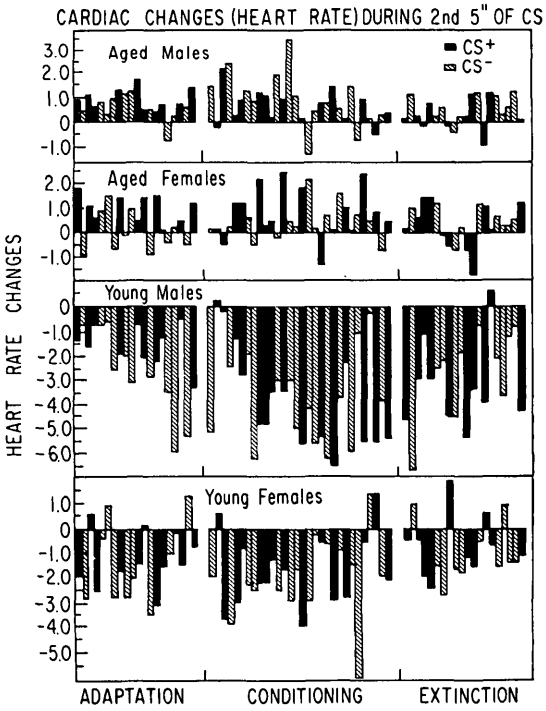

Figure 2.

values were pooled. There was a significant ($F_{1,38}=8.60$) decrease in total urinary amines, noradrenalin, and adrenalin from pre-experiment and post-experiment for all groups except the Aged Females. An Age × Sex × Order interaction approaching significance at the $p<0.09$ level ($F_{1,38}=3.7$) reflected a tendency for Young Males and Aged Females to exhibit less of a decline in total urinary amines, particularly adrenalin, than Aged Males and Young Females.

Discussion

It is apparent from the results of the plethysmograph analysis that there were clear-cut age differences across all three experimental periods with the Aged Ss exhibiting much poorer reactivity than the Young Ss and failing to condition at all. The sex difference within the Young Ss consisted of a failure on the part of the YFs to condition discriminantly even though they were quite reactive, while YMs were even more strongly reactive and did condition discriminantly. These findings seem crucial for the selection of Ss in studies directed toward evaluating the conditionability of vasomotor responses.

These essential age and sex differences have been demonstrated within a straightforward classical conditioning paradigm (Shmavonian et al., 1965) and appear to be stable and replicable phenomena. Obviously, then, a heterogeneous group of males and females would be far less likely to exhibit clear-cut discriminant conditioning than would a homogeneous group of Young Male Ss. It is quite possible that Stoltz's (1963) negative findings were the result of such a demonstrably unwarranted pooling of Ss.

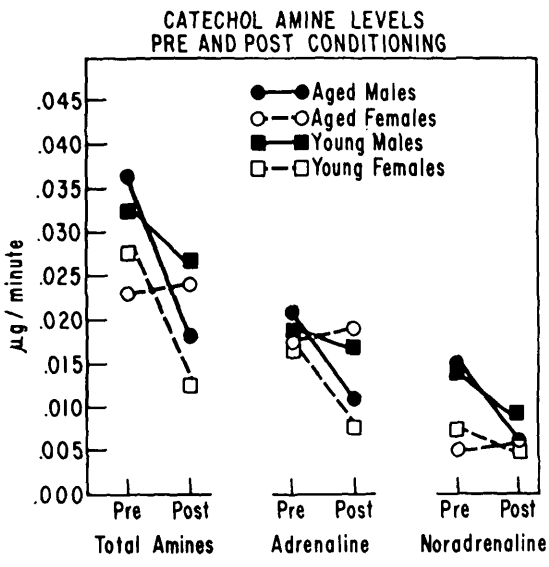

Figure 3.

The failure to demonstrate discriminant cardio-deceleration in this study may also derive from sampling error. Utilizing a somewhat different paradigm, Hein, Cohen, and Shmavonian (1966) found that field-dependent Young Male Ss selected on the basis of Witkin's rod and frame criteria (1954), exhibited discriminant cardio-deceleration during extinction, whereas Field-Independent Ss failed to do so. Although YMs approached discriminant cardio-deceleration (the only group to do so), they did not reach significance, which suggests, perhaps, that failure to control for this perceptual variable served to increase error variance and reduce the possibility of demonstrating significant discriminant conditioning.

There were, however, clear-cut age and sex differences in cardio-vascular reactivity that are of considerable interest in and of themselves and in their relation to the age and sex differences found in other parameters of psychophysiologic activity. Both AMs and AFs failed to display any consistent pattern of cardio-deceleration, whereas both YMs and YFs consistently exhibited cardio-deceleration during the second 5 sec. of both CS+ and CS−. The striking relationship between vasomotor activity and cardio-deceleration, wherein vasomotor activity and cardio-deceleration were found to be almost perfectly and monotonically related, would seem to indicate the involvement of pressure sensitive reflexes in the production of cardio-deceleration. It would seem, both on the basis of physiological studies and more psychologically oriented investigations, that the most likely reflexogenic area to be involved in the generation of such a secondary and compensatory deceleration would be the carotid sinus, which has been repeatedly implicated in reflexic cardiovascular activity and various psychophysiologic interactions involving environmental stimuli: Bonvallet, Dell, and Heibel (1954) have conclusively demonstrated sinus mechanisms to be involved in the modulation of cortical rhythms. The slowing of cortical rhythms observed by these researchers to be a function of sinus pressure was interpreted as being inhibition of

humorally induced Ascending Reticular Arousal System activity.

Previous work by Shmavonian et al. (1965) has shown the same rank order of YM-YF-AM, in terms of vasomotor conditioning and reactivity as was found in the present study. Although heart rate was not a variable of prime concern in their study, Shmavonian et al. (1965) did find the incidence of lvf EEG patterns to be precisely reversed in that the rank order was AM-YF-YM. These lvf patterns are entirely consistent with our observation of the raw records in the present investigation and are quite intriguing in light of the cognitive ranking derived from a post-experiment questionnaire wherein the order of YM-YF-AF-AM was exactly the inverse of the lvf ranking but exactly the same as the rankings for activity and cardio-deceleration.

Although many other explanations might be advanced, the authors feel reflex carotid sinus mechanisms to be major contributors to the cardiovascular, EEG, and cognitive interactions observed in this investigation. No other physiological mechanism has been implicated in the production of cardio-deceleration (Heymans & Neil, 1958), damping of cortical rhythms (Bonvallet et al., 1954), and cognitive activity (Lacey, Kagen, Lacey, & Moss, 1963). Studies attempting to explain cardio-deceleration on the basis of respiration or somatic muscle activity have proved essentially fruitless. The present study, however, indicated that the cardio-deceleration observed by so many researchers may be a carotid sinus mediated response secondary to peripheral vasoconstriction. Obrist, Wood, and Perez-Reyes (1965) found deceleration to be present during alpha blockade and concluded that the decelerative CR could not be the result of carotid sinus reflex mechanisms. Alpha blockade, however, should also effect the tonus of the sinus walls themselves and make them even more distensible with a resultant increase in baroreceptor activity to a given intracarotid pressure. This question seems worthy of pursuit in the unravelling of various cardiovascular dynamics as they relate to psychophysiological phenomena.

The most important findings for this paper, as far as the catechol amines are concerned, are that three out of the four groups gave a higher resting level, in the order of AMs, YMs, and YFs. In the post-experimental levels all three of these groups showed lower amines. If the experiment were to be considered a stressful experience, the catechol diminutions make very little sense, since previous experiments have shown catechols to rise with stressful experience. The explanation for this phenomenon is perhaps the fact that the expectancy of being subjected to the experiment was perhaps more strenuous than the experiment itself. Consequently, in order to assess stress values in a conditioning experiment, at least the resting level catechols should be obtained 24 hours earlier in the S's own home environment. This was a highly impractical situation and does not shed any light on the process of conditioning itself. Finally, it is possible that the elevated catechol levels were responsible for the activated EEG patterns through an excitatory influence on the ARAS. Aged Ss, then, with decreased vasomotor activity, would exhibit uninhibited lvf activity throughout, whereas Young Ss with strong vasomotor responsivity should display sinus mediated inhibition of lvf cortical activity. These anticipated patterns of cortical activity have been observed repeatedly.

Summary

Four groups, Young Males, Young Females, Aged Males, and Aged Females were experimented upon in a discrimination conditioning paradigm with a variety of autonomic and central measures. This paper deals primarily with cardiovascular responses, plethysmograph, and heart rate. Some reference is also made to EEG findings, as well as to responses to a cognitive questionnaire and the relative ranking of the Ss in the four above-mentioned groups.

There were clear-cut age and sex differences in cardiovascular reactivity and conditioning: the Aged showed poor conditioning and the Young showed better reactivity and conditioning, both in plethysmographic and heart rate responses. Furthermore, the consistently high-low-voltage fast responses of the Aged were related to these vascular responses, and the possible importance of the interaction via pressure sensitive reflexes was discussed.

References

Bonvallet, M., Dell, P., & Heibel, G. Tonus sympathique et activité electrique corticale. *EEG—Clinical Neurophysiology,* 1954, **6,** 119-144.

Hein, P. L., Cohen, S. I., & Shmavonian, B. M. Perceptual mode and cardiac conditioning. *Psychophysiology,* 1966, **3,** 101-107.

Heymans, C., & Neil, E. *Reflexogenic areas of the cardiovascular system.* London: J. & A. Churchill, 1958.

Kogan, A. The manifestation of processes of higher nervous activity in the electrical potentials of the cortex during free behavior of animals. Moscow Colloquium, *Electroencephalography and Clinical Neurophysiology, Suppl. No. 13,* 1960.

Lacey, J. I., Kagan, J., Lacey, B. C., & Moss, H. A. Situational determinants and behavioral correlates of autonomic response patterns. In P. J. Knapp (Ed.), *Expression of the emotions in man.* New York: International University Press, 1963.

Obrist, P. A., Wood, D. M., & Perez-Reyes, M. Heart rate during conditioning in humans: Effects of UCS intensity, vagal blockade, and adrenergic block of vasomotor activity, *Journal of Experimental Psychology,* 1965, **70,** 32-42.

Shmavonian, B. M. Methodological study of vasomotor conditioning in human subjects. *Journal of Comparative & Physiological Psychology,* 1959, **52,** 315-321.

Shmavonian, B. M., Miller, L. H., & Cohen, S .I. Differences among age and sex groups in electrodermal conditioning. *Psychophysiology,* 1968, **5,** 119-131.

Shmavonian, B. M., Yarmat, A. J., & Cohen, S. I. Relationships between the autonomic nervous system and the central nervous system in age differences in behavior. In A. T. Welford and J. E. Birren (Eds.), *Behavior, aging, and the nervous system.* Springfield, Ill.: Charles C Thomas, 1965.

Stoltz, R. Sensitization in vasomotor conditioning. Paper presented at the meeting of the Midwestern Psychological Association, 1963, Chicago.

Witkin, H. A., Lewis, H. B., Hertman, M., Machover, K., Meissner, P. B., & Wapner, S. *Personality through perception.* New York: Harper, 1954.