Cardiovascular reactivity evolution during an active coping task and recovery

Quirós P.*
Conde-Guzón, P. A.**
Grzib, G.*
Cabestrero, R.*
Crespo, A.*
Conde-Pastor, M*

Abstract: The aim of this work was to measure the evolution of heart period and blood pressure during an active coping task and recovery. The following three conditions were compared: two baselines (pre and post) and a task based on Sidman avoidance paradigm, lasting five minutes each. Cardiovascular reactivity was measured by means of heart period and systolic and diastolic blood pressure recording. Though efficacy of the employed task to evoke cardiovascular reactivity was observed in all variables, a different pattern was obtained in a minute by minute analysis. The shortest value of heart period occurred during the first minute, but blood pressure (systolic and diastolic) peak values took place during second task minute. Comparing both baselines there is also another pattern of heart period and blood pressure. The longest heart period was observed during second baseline, and the blood pressure was higher in the second baseline than in first. Subjects' performance had no influence on individual reactivity.
Key words: Active coping task, cardiovascular reactivity, blood pressure, cardiac period.

Introduction

The reactivity hypothesis holds that an exaggerated response to physical and psychological stress over the time, allows identifying subjects with higher cardiovascular disease risk. Taken this hypothesis to the extreme consider the exaggerated stress responses as a cardiovascular disease cause. The weakest version of this hypothesis suggests that the trend to respond in that way points the existence of cardiovascular risk and can be considered as a marker of risk for future hypertension, (Gerin *et al*., 2000). Other authors (Light *et al*., 1999; Schwartz et al., 2003) also admit previous hypothesis, but only in addition with a frequent exposure to stress situations or a genetic susceptibility.

Researches that relate exaggerated cardiovascular reactivity to the development of a future hypertension were initiated by P. Obrist (1974), who showed that certain situations that require subjects to cope actively, evoke a similar reaction to the one described by Cannon as fight/flight reaction. In this situation occurs what Obrist has called cardiac somatic uncoupling. That means, that cardiac output is exaggerated compared to the organism

*Departamento de Psicología Básica II, Universidad Nacional de Educación a Distancia, Madrid (Spain).
**Área de Personalidad, Evaluación y Tratamiento Psicológico. Universidad de León (Spain).

metabolic needs. Experimental situations used in the research of cardiac reactivity that evoke a heightened pressure response in most of the subjects may be classified in two categories: active (e.g. reaction time, mental arithmetic, video games and public speaking) and passive coping (e.g. cold pressor and distressing films). Cardiovascular reactivity evoked by active coping (such as Video Games) contrary to passive coping, plays a significant etiological role in the development of hypertension (Fredrikson, 1991; Markovitz, *et al*., 1998).

The typical reactivity pattern evoked by active coping tasks is similar to the one observed in the defence reaction of fight/ flight described by Cannon. A series of studies have shown that this reaction pattern is primarily mediated by the sympathetic nervous system (Dimsdale & Moss, 1980). It is a reaction that is preparatory for action and that is disproportionate as to the metabolic needs required for the performance of the task. That means that the adjustment is ineffective and different to the optimal adjustment that takes place during moderate physical exercise.

Another complementary classification of the reactivity tasks is the one based on the hemodynamic response pattern evoked and related with the adrenergic receptors (alpha and beta-adrenergic) to the stress reaction. Generally in the active coping tasks beta-receptors located in the heart and vascular beds are implicated. The stimulation of beta-adrenergic receptors accelerates heart rate and enhances contractile force, while the vascular system reacts with vasodilatation. Alfa-adrenergic reactions prevail in passive coping tasks, inducing vasoconstriction. A good example of β-adrenergic tasks is reaction time while cold pressor can be considered as an α-adrenergic one. In the other hand, there is an individual trend to respond with a particular cardiovascular patter (cardiac or vascular), that last throughout the tasks. For example, the subjects considered as cardiac or vascular on a mental arithmetic task, will show the same pattern than in the cold pressor test, despite this last one use to generate a bigger peripherical vascular response in the whole sample. The cardiac pattern is characterised by a heightened cardiac output and the vascular pattern is characterised by a heightened peripheral resistance (Sherwood, Dolan & Light, 1990; Heartley, Ginsburg & Heffner, 1999).

One of the main aims in the present work was to establish the efficacy of an active coping task based on a Sidman avoidance procedure to evoke reactivity. In animal research, the Sidman avoidance task has evoked hemodynamic patterns similar to those observed in borderline hypertension (Forsyth, 1976). For these reasons, it is expected that the proposed task will also evoke significant changes with respect to baseline conditions in the cardiovascular variables. Another aim was to check if the cardiovascular reactions observed initially are maintained during the five minutes that the task lasts and if there is recovery during a second baseline.

Method

Participants

Forty two undergraduate psychology students (11 men and 31 women), with a mean age of 23.81 (ranging form 18 to 43 years) were used. Mean weight was 64.10 kg, and the body mass index (weight/ height^2) was 22.69. Subjects with cardiovascular problems or acute metabolic illness were not included in this study.

Apparatus

During the experiment subjects were seated in a Faraday cabin. EKG was continuously recorded during experimental session. The electrode placement was the Standard Lead II configuration. Blood pressure was also recorded continuously with the Fin. A. Pres. Ohmeda 2300. This instrument record calibrated pulse wave at the finger, maximum corresponding to systolic pressure and minimum to diastolic. This device has a high reliability while comparing the variation of blood pressure during different conditions or moments. Absolute values of blood pressure may be influenced by different circumstances (body and arm position or cuff placement). For this reason, the finger cuff may not be removed during experimental conditions. If this requirement is not fulfilled, the comparison between conditions may be seriously compromised (Grzib, Quirós & Briales, 1993). The physiological signals were inspected during the whole experiment. There are two different display devices that should be controlled: the oscilloscope for the EKG and the Fin. A. Pres. monitor for blood pressure. All signals were stored digitally on a video tape, this require and analogical-digital converter (Neurocorder, model DR890). Conversion rate in both way (analogical to digital or reverse), was one data per ms. None of the signal conversions implies any information loss nor phase shift. By storing signal into video tape, it is possible to check afterwards if a given missrecording is due to an information loss or due to an artifact. The EKG was processed by computer software to detect R-waves, which indicate the peak of ventricular depolarization. Once the EKG was analyzed the blood pressure processed, indicating the maximum (systolic) and minimum (diastolic) for each cardiac period. The missing data caused by the adjustments of the Fin.A.Pres. were estimated by an interpolation of a polynomic trend analysis to the power of five.

Procedure

Once the subjects signed a consent form, they completed a personal data, health and lifestyle questionnaire. After that, participants were led into the experimental room and the pertinent sensors to record EKG and blood pressure were attached. After a habituation period of approximately 15 minutes when measures on the oscilloscope and the monitor of the Fin. A. Pres. were stable, the first baseline of 5 minutes was taken. The instructions given to the subjects for habituation and baseline were to stay as calm and steady as they can.

The task used to induce cardiovascular reactivity was a videogame reaction time task based on Sidman's avoidance paradigm (Sidman, 1953). It may be conceived as a complex operant, including two responses (r_1-r_2) that should be performed one after the other within a prefixed interval marked by means of a visual cue. Subjects were presented a yellow background strip and two moving black lines coming from the edges to meet at the center of a computer screen. Those lines appear by the time the subject call for the task pressing a keypad button (r_1) and should be detained before they reach each other at the center of the screen also by pressing another (r_2). The keypad has three response keys: a red one placed at the center used to call for the task, beneath that another two yellow ones used to stop the lines. Those two buttons were used for the same porpoise but only one of them should be used. To increase task difficulty and prior to the response phase the words “LEFT” or “RIGHT” displayed, indicating which of the response buttons should be used.

The line speed and the temporal window (when the responses were considered as correct), could be programmed. Both parameters (as well as those imposed by Sidman’s paradigm) served to determine task difficulty. Lines reach each other at the center of the screen 720 ms after r_1, and the temporal window lasted 90 ms. Therefore r_2 should be given between 630 and 720 ms to be considered as correct. Sidman’s avoidance task requires two reinforcement schedules of variable interval: the shock-shock interval (S-S) and the response-shock interval (R-S). The S-S interval was programmed within 3-5 seconds and was active while subject’s response was not correct. If the interval reaches the end without a correct response by the subject, an aversive tone, as well as, a flashing red light was given. Also, one point was taken from those 10 given to the subject at the beginning of the task. Once a correct response occurs the R-S interval started lasting variably from 4 thru 8 seconds. After that period of time the first correct response was reinforced (avoiding all the aversive consequences). If the R-S interval were not followed by a correct response S-S interval became active. Otherwise R-S interval starts again. All subjects were instructed to keep as many points as the can.

Each condition of the task lasted 5 minutes. Three minutes after completion of the task a second baseline of another 5 minutes was taken, in order to study recovery.

Data analysis

The arithmetic mean was calculated for each experimental condition and for each of the physiological variables recorded: heart period, systolic and diastolic blood pressure. The first thing that had to be established was to check if the task evoked cardiovascular reactivity. In this case, the values obtained for the different physiological variables should change significantly during the task as compared to baselines. This result was expected especially with respect to systolic blood pressure.

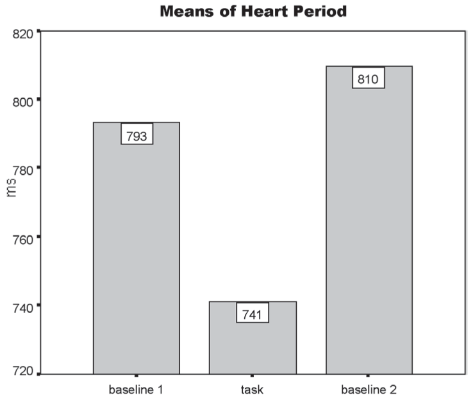
As a second analysis we calculated the means for each minute of the three conditions (a total of 15 mean values) for each physiological variable. The purpose of this analysis was to get information about the evolution of the reactivity.

Results

In order to proof if the task evoked cardiovascular changes, for each physiological variable the three experimental conditions were compared, performing a repeated measures ANOVA (baseline1, task and baseline 2). The results showed significant differences for each of the three physiological variables

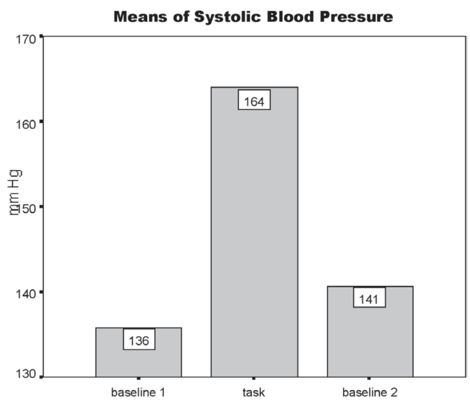
For heart period comparisons showed significant differences between all experimental conditions ($F_{1.494,\ 61.242}$ = 26.585; $P < 0.001$; $\varepsilon = 0.747$). Post hoc comparisons by means of Bonferroni’s test were performed, indicating that all the means for all conditions were significantly different from each other ($P < 0.05$). Figure1 shows that the lowest mean of heart period occurs during the execution of the task while the highest value of heart period corresponds to baseline 2.

Fig. 1. Means of heart period during the three experimental conditions



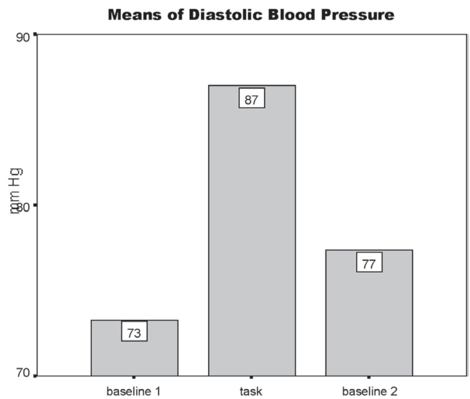
For systolic blood pressure a value of ($F_{2, 82}$ = 136.088; $P < 0.001$) was obtained. Post hoc comparisons by means of Bonferroni's test were performed, indicating that all the means for all conditions were significantly different from each other ($P < 0.03$). Figure 2 shows that the highest value of systolic pressure is obtained during the task. In this case the values for baseline 2 are significantly higher than for baseline 1.

Fig. 2. Means of systolic blood pressure during three experimental conditions.



The diastolic blood pressure obtained a value of ($F_{1.638, 67.172}$ = 123.039; $P < 0.001$; $\varepsilon = 0.819$). Post hoc comparisons by means of Bonferroni's test were performed, indicating that all the means for all conditions were significantly different from each other ($P < 0.001$). Figure 3 indicates that the diastolic pressure responds similarly to systolic.

Fig. 3. Means of diastolic blood pressure during three experimental conditions.



According to these results, it may be concluded that the used task evoked significant changes with respect to baselines in the three physiological variables studied. The different pattern of heart period and blood pressure with regard to the comparison of baselines is noteworthy. For heart period the significantly higher values for baseline 2 compared to baseline 1 indicated that subjects recover. On the other hand, blood pressure continues to show higher values at baseline 2, than in baseline 1, what means that subjects did not recuperate. In order to study the effects of the time evolution on the three experimental conditions for all physiological variables, a repeated measure ANOVA was performed. The following results were obtained:

Heart period

There were not found any effects of time on heart period during baseline 1 ($F_{2.796, 114.648} < 1$) and baseline 2 ($F_{3.278, 134.392} < 1$). Means remained stable without any changes during the five minutes.

During the task, heart period did not behave in the same way during the five minutes the task lasted ($F_{2.4936, 102.323} = 25.139$; $P < 0.001$; $\varepsilon = 0.624$). Post hoc comparisons by means of Bonferroni's test were performed, indicating that there were significant differences of minute 1 with respect to the rest ($P < 0.001$). There were also significant differences between minutes 2 and 3 ($P < 0.003$). The lowest value of heart period corresponds to the first minute.

Blood Pressure

As in heart period no significant differences were obtained in both baselines for systolic blood pressure ($F_{2.743, 112.462} < 1.2$ for baseline 1 and $F_{2.566, 10.212} < 2.1$ for baseline 2). For the task condition significant time effects were found ($F_{1.858, 76.176} = 11.828$; $P < 0.001$; $\varepsilon = 0.464$). Post hoc comparisons by means of Bonferroni's test were performed, indicating significant differences between minute 2 and the rest of minutes ($P < 0.02$), and between minute 3 and minutes 4 ($P < 0.002$) and 5 ($P < 0.002$). The highest elevation of systolic pressure corresponds to minute 2, while during minute 4 the values return to the ones observed during the first minute. This means that the highest reactions occur during minutes 2 and 3.

Diastolic blood pressure during baseline was analogue to heart period and systolic pressure. There were no significant time effects ($F_{2.798, 114.724} < 2$ for baseline 1 and $F_{3.285, 134.673} < 1$ for baseline 2).

Regarding to the task, a significant time effect was found ($F_{2.18, 89.37} = 85.13$; $P < 0.001$; $\varepsilon = 0.545$). Post hoc comparisons by means of Bonferroni's test were performed, showing significant differences between minute 1 and minutes 2 ($P < 0.001$) and 3 ($P < 0.02$) and between minute 2 and minute 5 ($P < 0.008$) and between minute 3 and minute 5 ($P < 0.015$). The highest mean value of diastolic blood pressure occurred in minute 2.

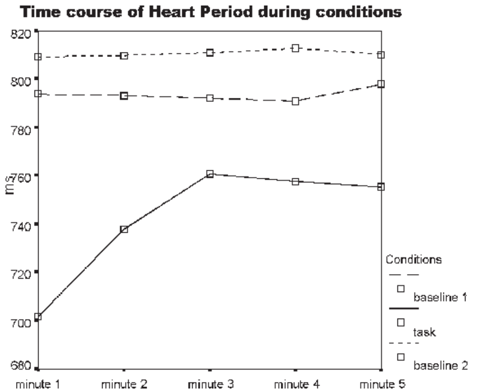
These results indicate that the three cardiovascular variables were stable during baselines; there were no significant differences between means made minute by minute. During the task, heart period and blood pressure showed different patterns: for heart period the highest reaction occurs during the first minute, there were significant differences between the first minute and the rest minutes. On the other hand, blood pressure showed the highest reaction occurred during minute 2. This effect was more marked for systolic than for diastolic pressure. The second minute was significantly different from all the other minutes in systolic pressure. During the third minute, the elevation of systolic pressure continued to be high and was significantly different with respect to minutes 4 and 5. For diastolic pressure, the second minute, corresponding to the highest reaction is only significantly different from minutes 1 and 5, though this variable remained also elevated during minute 3 and there were also significant differences between minutes 1 and 5.

Taking into account the 2 factors: conditions (baseline 1, task , baseline 2) and time period (minutes 1, 2, 3, 4, and 5) a 3 x 5 repeated measures ANOVA was performed with the purpose of studding the interaction effects.

Heart period

There was a significant effect for the interaction condition x time ($F_{4.16, 170.579}$ = 13.654; $P < 0.001$; $\varepsilon = 0.520$). Post hoc comparisons by means of Bonferroni's test were performed, showing significant effects between task and baselines during all minutes ($P < 0.021$). These differences were greater with respect to baseline 2 than to baseline 1. Both baselines differed only between minutes 3 ($P < 0.034$) and 4 ($P < 0.030$). These effects may be observed in figure 4.

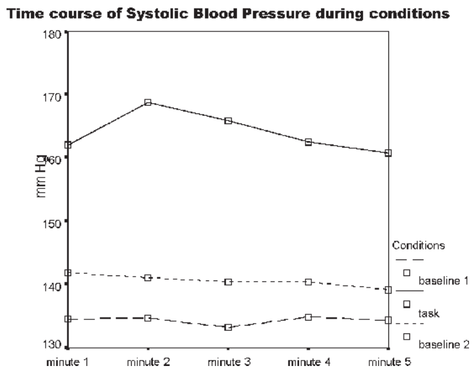
Fig. 4. Representation of the interaction condition x time for heart period



Systolic blood pressure

The interaction condition x time was significant ($F_{3.711, 152.139} = 6.247$; $P < 0.001$; $\varepsilon = 0.464$). Post hoc comparisons by means of Bonferroni's test were performed, showing the existence of significant differences between all conditions and for all minutes ($P < 0.009$). The greatest differences were found between the task and baseline 1 during minutes 2 and 3. The interaction effect may be observed in figure 5.

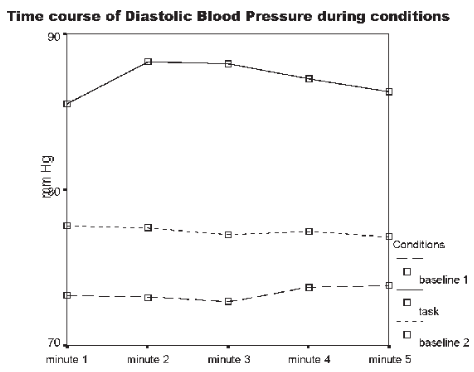
Fig. 5. Representation of the interaction condition x time for systolic blood pressure



Diastolic blood pressure

The interaction condition x time was significant ($F_{5.252, 215.339} = 5.173$; $P < 0.001$; $\varepsilon = 0.657$). Post hoc comparisons by means of Bonferroni's test were performed, showing significant differences between all conditions and minutes ($P < 0.005$). The greatest differences occurred between the task and baseline 1 during minutes 2 and 3. Figure 6 shows the effects of the interaction.

Fig. 6. Representation of the interaction condition x time for diastolic blood pressure



In conclusion the task evoked significant changes with respect to baselines in the three cardiovascular variables with respect to each minute of baseline conditions. However this effect was not the same for heart period and blood pressure. For heart period, values in baseline 2 were longer than in baseline 1, showing significant differences between both baselines during minutes 3 and 4. The shortest heart period, that is the greatest difference between task and baseline, was observed in the first task minute. Significant differences between the three conditions for all minutes were obtained in blood pressure. Values obtained were higher for baseline 2 than for baseline 1, which means that subjects did not recover from task effects. The greatest differences between the task and baseline 1 were obtained for minutes 2 and 3.

Regarding task performance, efficacy was defined as the number of correct answers divided by the number of total responses. There were no significant correlation between this index of task efficacy and cardiovascular reactivity (defined as differential values between task and baseline 1 obtained by each participant in any of the three physiological variables).

Discussion

The task employed to evoke cardiovascular reactivity satisfied this purpose. Participants reacted with a significant change during the task with respect to the first baseline in each of the physiological variables recorded. These changes were more marked during the first minutes and were especially meaningful in systolic blood pressure. The mayor change during the task with respect to baseline 1 took place during the first minute for heart period and the second minute for systolic blood pressure as well as for diastolic blood pressure.

To obtain an adequate record of a baseline is difficult, the expectations that subjects have with respect to the performance that will be required by the following task may influence the measurement. For this reason some authors prefer to record the baseline in a posterior session to the experimental one. In the present study the blood pressure recording requires a stable baseline, therefore measurements should be taken without disconnecting the subject from the recording device, otherwise different levels may be established by the Fin. A. Pres., while rendering the data in the different conditions. The inconvenience of taking the first baseline during the task session is that, some subjects may still exhibit a reaction, despite of an initial adaptation period to the laboratory and measurement devices. Therefore, that may be interpreted as a lower reactivity than the real one due to a ceiling effect.

The second baseline was taken in order to study recovery of the subjects from the task effects. During the second baseline, heart period values were lower than the observed during first baseline, while the values of blood pressure maintained significantly elevated during the second baseline with respect to the first one. This was interpreted as subjects did not recover from elevations of blood pressure due to the task. This patter of reaction in cardiovascular variables indicates that heart period alone is not a reliable reactivity index. The fact that significant effects for diastolic blood pressure were obtained in the task condition that lasted during recovery, seems to indicate that the task, despite of myocardial implications, may have generated an elevation of peripheral resistance. The persistence of blood pressure elevations during baseline two, despite of the heart period recovery could be due to this fact. As observed by some author (Carroll, Cross & Harris, 1990; Miller & Ditto, 1988; Ring, Burns & Carroll, 2002), myocardial effects are only present during the first minutes of a stress tasks. But when the tasks are prolonged, vascular effects seems to occur. However this interpretation has be confirmed in further researches by the use of impedance cardiography.

On the other hand, the lack of reaction found between individual amounts of physiological change and efficacy in the task seems to indicate that subject's performance is not related to cardiovascular reactivity.

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