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Cardiovascular reactivity in real life settings: Measurement, mechanisms and meaning

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ABSTRACT

Cardiovascular reactivity to stress is most commonly studied in the laboratory. Laboratory stressors may have limited ecological validity due to the many constraints, operating in controlled environments. This paper will focus on paradigms that involve the measurement of cardiovascular reactions to stress in real life using ambulatory monitors. Probably the most commonly used paradigm in this field is to measure the response to a specific real life stressor, such as sitting an exam or public speaking. A more general approach has been to derive a measure of CV variability testing the hypothesis that more reactive participants will have more variable heart rate or blood pressure. Alternatively, self-reports of the participants' perceived stress, emotion or demands may be linked to simultaneously collected ambulatory measures of cardiovascular parameters.

This paper examines the following four questions: (1) What is the form and what are the determinants of stress-induced CV reactivity in real life? (2) What are the psychophysiological processes underlying heart rate and blood pressure reactivity in real life? (3) Does CV reactivity determined in the laboratory predict CV reactivity in real life? (4) Are ambulatory cardiovascular measures predictive of cardiovascular disease?

It is concluded that the hemodynamic processes that underlie the blood pressure response can reliably be measured in real life and the psychophysiological relationships seen in the laboratory have been obtained in real life as well. Studies examining the effects of specific real life stressors show that responses obtained in real life are often larger than those obtained in the laboratory. Subjective ratings of stress, emotion and cognitive determinants of real life stress (e.g. demand, reward and control) also relate to real life CV responses. Surprisingly, ambulatory studies on real life cardiovascular reactivity to stress as a predictor of cardiovascular disease are rare. Measuring the CV response to stress in real life may provide a better measure of the stress-related process that are hypothesized to cause disease than is possible in the laboratory. In addressing these questions, below we review the studies that we believe are representative of the field. Therefore, this review is not comprehensive.

1. Introduction

The highly influential cardiovascular reactivity hypothesis states that individuals showing exaggerated cardiovascular reactivity (CVR) to stress are at higher risk of developing cardiovascular disease (CVD) (Krantz and Manuck, 1984; Treiber et al., 2003). Most studies of the cardiovascular response to stress are conducted under controlled laboratory conditions. There are excellent practical and scientific reasons for this, centered on issues of measurement, design and control but the laboratory is a particularly difficult environment in which to study stress. There are severe ethical constraints on the nature, severity and duration of the stresses that can be studied in the human laboratory. As a result, most investigations are limited to a rather limited range of predominantly cognitive stressors (reaction time, mental arithmetic, video games, vigilance tasks). Some of these laboratory stressors have a social component (e.g. public speaking). Finally, a commonly used stressor is the rather bizarre, psychologically and physiologically complex, cold pressor test. Participants in laboratory studies are volunteers often fulfilling course requirements and the extent to which the laboratory tasks are experienced as stressful depends to a large extent on how far the participant collaborates with the experimenter and treats the task (e.g. playing a video game) seriously and as personally important. This is perhaps task since the tasks seldom involve significant objective reward or punishment. Such constraints means that laboratory stress tasks may not faithfully

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represent the stressors that are encountered in real life, i.e. they may have limited ecological validity. Furthermore, cardiovascular (CV) responses obtained in the laboratory may not be representative of the responses seen in everyday live with respect to size, duration or even mechanism. This is different from other areas of psychological study where, for example, it seems likely that the processes of executive function studied in the laboratory represent in a pure form processes that also occur frequently in everyday life. These restrictions on laboratory-based studies of stress are potentially substantial and could severely restrict our understanding of the psychological and physiological processes that underpin CV reactivity and critically limit the potential of laboratory-based CV reactions to predict future disease.

In this paper we wish to consider the study of the CV response to stress in everyday life with respect to four questions (1) What is the form and what are the determinants of stress-induced CV reactivity in real life? (2) What are the psychophysiological processes underlying heart rate and blood pressure reactivity in real life? (3) Does CV reactivity determined in the laboratory predict CV reactivity in real life? (4) Are ambulatory cardiovascular measures predictive of cardiovascular disease?

2. What is the form and what are the determinants of stress-induced CV reactivity in real life?

2.1. Situational determinants

Stress reactions may be studied in relation to discrete, objectively stressful situations. The advantage of this approach is that it does not rely on the participant's own perceptions of stress or emotional arousal and therefore the measure of stress and the effects of stress are not confounded. It has many of the advantages of a laboratory stressor without some of the constraints. Below, such paradigms will be elaborated as well as their use in stress research.

Examples of such situations are giving a speech and oral examinations. Oral presentations are relatively common, useful and are still relatively controllable (Johnston et al., 2008). Classroom examinations and oral presentations may not be directly related to the etiology of cardiovascular disease, as these are infrequent stressors. In addition, they may only be relevant to a subgroup of the population and may only occur during a relatively short part of their life (e.g. academics, students). However, these situations are important because these stressors represent a particular class of situations that are stressful and potentially harmful (interpersonal communication in an evaluative context). Matthews et al. (1986) measured blood pressure and heart rate in adolescents that were giving a speech in a high school English class. In addition to cardiovascular measures, they also obtained self-reports such as anxiety and hostility (these are discussed below). In addition the grades for the speeches that were assigned by their teacher were obtained and the speech was recorded. BP and HR were recorded before performance of the speech, just prior to giving the speech, immediately after the speech and during the next English class and these values were compared to a laboratory baseline. The authors comment that both the state anxiety and the CV reactivity data show that a naturally occurring stressor such as giving a speech is a particularly potent stressor and CV stress levels approached levels that are usually regarded as indicative of borderline hypertension (Matthews et al., 1986).

In a study aiming to compare laboratory and field measures of stress, Turner et al. (1990) measured ambulatory CV reactivity to a realistic speech stressor. Ambulatory blood pressure and heart rate were measured while participants presented their research in front of an audience in a situation that was meant to closely resemble a seminar. Presentations lasted for 10–15 min. The audience was gender balanced. Two members of the audience took notes during the presentation and talks were rated for clarity and organization. Ratings were used as the basis of monetary bonuses that were awarded to those giving the best speech (Turner et al., 1990).

Although the stressor in this study appears to be a naturalistic one, the situational characteristics have been controlled and the stressor resembles the speech stressor that has been generally used as part of the Trier Social Stress Test (Kirschbaum et al., 1993). Despite this "real world" reactivity scores were not correlated with laboratory reactivity scores, even though baseline values were correlated (Turner et al., 1990). Further analyses did suggest that the differential effects of posture explained part of the lack of association between laboratory and speech stressors but the associations did not reach significance, which may suggest that real world speech stressors are different from laboratory stressors. Judging by the baseline and task values that were reported for the laboratory stressor and the real life stressor, it would appear that, on average, participants were more reactive during the real world stressor. This would be in line with the assumption that ecological validity of the realistic speech stressor would be greater than that of the laboratory stressor, as the former may be expected to be a more potent stressor.

Kamarck et al. (2000) conducted a study involving ambulatory measurement of HR and BP during delivery of a classroom speech. Participants were students who were enrolled in a public speaking class. Participants' CV measures were monitored before and during two speeches delivered in two different sessions. Additionally, two consecutive laboratory stress sessions were held, which included a Stroop task and a speech task. Within those laboratory sessions, test–retest reliability was highest for the speech task. Based on their reported generalizability coefficients, it would appear that reliability for the classroom speech measures are generally lower than those for the laboratory measures. Reliability of the classroom speech stressor was improved when ambulatory measures were aggregated over the anticipatory and the speech delivery stages (Kamarck et al., 2000).

Examinations are another example of a discrete, real life stressor. Hazlett et al. (1997) argue that examinations are a useful tool to measure CVR as these stressors have (1) a discrete start and end, (2) occur repeatedly, (3) situational characteristics are consistent across participants, (4) allow the measurement of a pre-stress baseline.

Sausen et al. (1992) conducted a study in which HR and BP were measured in students, before, during and after a written exam. In comparison to measures obtained during a nonstressful period, participants show significantly elevated BP and HR. Interestingly, CV levels were similar before and during the exam, suggesting anticipatory stress (Sausen et al., 1992).

Hazlett et al. (1997) obtained three baseline and three stressor measures of HR and BP. The exam was associated with significantly elevated CV levels. Temporal stability was examined by obtaining the same measures on a second occasion, about a month later. The authors concluded that test–retest reliability was 'fairly high', although it has to be noted that the reported correlations between measure 1 and measure 2 ranged between .23 and .67 for baseline and stressor BP and HR measures and correlations were only reported for absolute values, not for reactivity scores (Hazlett et al., 1997). Test–retest reliability tends to be higher for absolute values than for change scores (e.g. McKinney et al., 1985). Finally, judging by the HR and BP values reported, the exam only seemed to elicit a mild stress response; elevations of 5 mm Hg in diastolic and systolic blood pressure and 4 bpm for heart rate compared to baseline. Perhaps written examinations are not stressful enough to allow reliable measurement of CV reactivity. Similar values were reported by Warwick-Evans et al. (1988) in a study examining CV arousal levels before and after a written academic exam.