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Sensitivity of primary phasic heart rate deceleration to stimulus repetition in an habituation procedure: influence of a subjective measure of activation/arousal on the evoked cardiac response

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Abstract

The post-stimulus primary bradycardia—sometimes labelled as the first evoked cardiac response, ECR1—is regarded as a response which is independent of the stimulus novelty factor. Despite this however, in our previous research we have observed a noticeable variation of this response, which made us suspect that there could be some additional factor influencing it. To test this, we designed a habituation procedure to measure susceptibility of the ECR1 to stimulus repetition. In our experimental design, we also included a measure of the level of activation (arousal) as a possible additional factor influencing the time-course of the cardiac response. The level of arousal over the study was measured by the Activation–Deactivation Adjective Check List (AD ACL). Our results show that mere stimulus repetition does not influence the time-course of ECR1. However, another pattern of results appeared when one of the dimensions of AD ACL, namely Tense Arousal, was taken into account. We observed different ECR time-courses during the initial stimulus presentations for subjects with high and low levels of Tense Arousal. These results are interpreted within the framework of Preliminary Process Theory in terms of the different attentional patterns in subjects with high and low levels of Tense Arousal.

Keywords: Evoked cardiac response; Heart rate; Orienting reflex; Activation; Arousal; AD ACL; Habituation; Electrodermal activity; Preliminary process theory

1. Introduction

The goal of the present experiment was to answer the question of whether the brief phasic post-stimulus cardiac deceleration, peaking about 1–2 s after stimulus onset, is susceptible to factors other than mere stimulus occurrence. Previous experiments, where the effect of stimulus repetition was examined as part of the stimulus train, have failed to show any significant results (e.g., Barry and James, 1981; Barry, 1984b). However, variability of the cardiac responses

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observed in our recent studies suggested that there could be some additional factor in operation, which was not adequately captured by the experimental procedure. We decided to test the influence of the combination of two putative factors: stimulus repetition and the subject's activation state.

The traditional western view has considered heart rate (HR) phasic deceleration as an index of the Orienting Response (OR), with phasic HR acceleration identified as an index of the Defensive Response (Graham and Clifton, 1966). This view has been challenged in a number of studies. Barry and Maltzman (1985) re-examined the studies reviewed by Graham and Clifton (1966), and concluded that interpretation of HR deceleration as an index of the OR was not supported by that literature. A number of empirical studies (e.g., Barry, 1982, 1984a) showed that the deceleration component of the evoked cardiac response (ECR1) fails to reflect the stimulus parameters in the manner expected of an OR index. A more recent theory of preliminary processes in OR elicitation (Barry, 1987b) relates the phasic HR deceleration component to an early pre-attentive process of stimulus registration. This is regarded as an obligatory response, which occurs regardless of stimulus characteristics and modality, and always precedes eventual elicitation of the OR, whose best physiological index is the skin conductance response (SCR). Preliminary Process Theory has not been without criticism (e.g., see Graham, 1987; Turpin, 1989), but these criticisms have generally been explicitly addressed (e.g., Barry, 1987a, 1989), and it remains the only theory which can accommodate a substantial proportion of the extant data, including a wide range of autonomic variables.

Beyond the OR context, there are two other important theories which describe the function of HR deceleration, although these generally relate to more-prolonged *tonic* changes rather than the brief phasic responses to discrete stimuli discussed above. Lacey (1967), on the basis of the idea of "directional fractionation", argued that prestimulus tonic HR decreases reflect the processing of external information requiring "stimulus or environmental intake". On the other hand, tonic HR increases are observed when an anticipated stimulus is aversive or requires cognitive elaboration. This condition was described as "stimulus or environmental rejection". According to a competing theory put forth by Obrist (1976) and his colleagues, such tonic HR changes reflect two types of individual involvement with the experimental task. The first of these, "passive coping", can be observed when the individual has little control over the environment. HR deceleration is the index of this type of coping and, according to Obrist, is mediated by the parasympathetic branch of the autonomic nervous system. The second type, "active coping", involves exertion of sustained mental activity to meet the required task demands, and is correlated with significant HR acceleration, which in turn is caused by the sympathetic influence on cardiac activity.

Barry (1996) recently extended his Preliminary Process Theory by including tonic state measures. In this extension, shown schematically in Fig. 1, lowered HR level is considered to index an increase in vigilance, a preparatory state associated with cognitive anticipation, while skin conductance level is considered as an index of the state variable of arousal. The former proposition is compatible with Lacey's work described above, and the latter with the traditional concept of arousal or activation (Barry and Sokolov, 1993). Recent applied work by Tremayne and Barry (2001) has confirmed the relative independence of these state measures and their different roles in perceptual functioning.

Although the magnitude of the phasic HR deceleration evoked by the transient processing of a stimulus (occurring in the permanent feature detection system) is regarded in Preliminary Process Theory as invariant with stimulus repetition, Barry (1996) has suggested connections between ECR1 and state variables. One connection is between the vigilance system and the permanent feature detection system, by which increased vigilance is predicted to result in a larger ECR1. He also includes a two-way connection between the arousal system and the permanent feature detection system, the mechanism of which parallels the S process of dual-process theory (see Barry and Sokolov, 1993). This amplifying process has not been specifically linked to ECR1. As was mentioned above, in our recent research (e.g., within the data sets reported in Kaiser et al., 1997; Unrug et al., 1997) we have observed between-subject variability in HR deceleration which made us suspect that there could be some such additional factor, or factors, influencing this response. We examined two possibilities here: