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Arousal and Activation in a Sport Shooting Task

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Abstract: Recently, “Arousal” and "Activation" have been differently defined in terms of their origin and their function. The former has been defined as the energetic state at a particular time, reflected in skin conductance level; the latter, as the change in arousal from a resting baseline to the task situation. The present study, aimed to further explore whether the separation of "arousal" and "activation" was useful in describing state effects on a skilled performance in terms of a sport shooting task. A standard air rifle shooting task was used with elite shooters. It was found that all five performance measures which were used in the study decreased with increasing activation, but not with arousal. These findings support our previous suggestions concerning the value of conceptualizing arousal and activation as separable aspects of the energetics of physiological and behavioural function.

Key words: Arousal · Activation · Electro-dermal activity · Sport shooting · Elite shooter

INTRODUCTION

Skin conductance level (SCL) is a sensitive measure of the tonic modulation of sympathetic activity [1] and the “gold standard” in the measurement of arousal [2]. A recent study with children showed that resting SCL was inversely related to alpha power in the simultaneous eyes-closed EEG and directly related to alpha frequency [3]. These data, compatible with traditional EEG arousal concepts [4-5] and can support the use of SCL as a simple measure of CNS arousal. Studies using functional imaging techniques [6-8] and other animal and human experiments, demonstrate descending cortical and sub-cortical influences on hypothalamic and brainstem mechanisms controlling sympathetic arousal. In particular, the amygdala exerts an influence on autonomic measures including skin conductance activity [9-12].

Lesion and electrical stimulation studies also implicate specific brain regions, including orbitofrontal, cingulate and insular cortices, in generating changes in peripheral autonomic measures [13].These specific regions have been recognised as associated with emotional and motivational behaviours [7,14]. Such findings indicate the close association of central and peripheral measures of arousal.

Examination of the literature suggests that arousal/activation affects aspects of performance.For example, early studies reported more than five decades ago, proposed links between performance and arousal/activation level [15-16].There are several hypotheses describing the arousal/performance relationship, among them the inverted-U hypothesis of optimal state, which is commonly applied in sport psychology [17]. But the arousal concept has not been particularly influential in psychophysiology. One reason for this is the lack of consistency reported between a range of measures often taken to apply to arousal, such as heart rate and skin conductance level [18-20]. Barry *et al.* [21] considered that another reason was uncertainty arising from poor definition of the terms “arousal” and “activation”, which have often been used interchangeably. Various terminologies that have been used to describe states of attentiveness in the CNS include arousal, alertness, vigilance and attention. As most terms are used extensively with diverse associations, it seems that none are ideal to describe these cortical states [2-22].

Following the separation proposed by Pribram and McGuiness [22-24], Barry *et al.* [21] used “arousal” to refer to the current energetic state and “activation” to refer to task-related mobilization of arousal. Arousal generally increases from baseline levels when the individual is engaged in a task and this change in arousal (from baseline to task) is identified as task-related activation. The construct of “arousal” is always specific to the time of SCL measurement, either resting

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("baseline") or "activated" (during the task), while "activation" always refers to a *change* in SCL from baseline to task.

Barry *et al*. [21] then linked the effects of arousal to phasic physiological responses and related the effects of activation to behaviour/performance measures. They used this conceptual division to study children's performance in a continuous performance task (CPT). VaezMousavi *et al*. [25] in a follow up study and in an across subjects/between trials approach also used this conceptualization to study adults' performance in a CPT [26]. Using SCL as the index of arousal and its mobilization from the baseline as the index of activation, Barry *et al*.[21] found that performance measures (mean RT and number of errors) was predicted by activation, but not with arousal . Similar finding was reported by VaezMousavi *et al*. [25-26].They concluded that further investigations using arousal and activation as defined separable aspects of energetic function and examining their effects on skilled behaviour, in terms of sport skills would be of value.

Therefore, the present study was designed to explore this conceptualization in a skilled performance task and with elite subjects. The hypothesis was that the performance on the skilled task is dependent on the task-relevant activation, but not on arousal. This hypothesis predicts that task-related activation, defined as the change in arousal level from a resting state to the task, will determine behavioural performance, defined in terms of final points, relative time fixing on the target, deviations of the shots around their means, tracing distance and inter-shots intervals.

MATERIALS AND METHODS

Participants: Twenty-three elite sport shooters, 14 females and 9 males; aged from 21 to 39 years (mean age 27 years and 7 months) participated in this study. Ten of them were the members of air rifle national team and the others had the experience of winning few regional championship titles.

Procedure: After the study was described and written informed consent was obtained, two sessions of data collection were introduced to the subjects: the baseline and the task. During an initial 20 min baseline resting period, the subject was asked to sit quietly with eyes closed. Electrodermal activity was recorded, using a constant voltage device (UFI Bioderm Model 2701) from 7.5 mm diameter Ag/AgCl electrodes on the sole of the participant's non-preferred foot, at a constant voltage of 0.5 V, with an electrolyte of 0.05 M NaCl in an inert viscous ointment base. During the task period, the data were collected from each subject in a standard shooting hall, while they were performing a complete form (60 shots) according to the international shooting sport federation's protocol. Electrodermal activity was sampled continuously at 10 Hz, both in the task and in the baseline.

Data Processing: Baseline arousal level was derived for each subject as the lowest two-min mean SCL within that period. The mean SCL from the 0.5 s epochs immediately before the shot was taken as the activated arousal level. The difference between these two estimated arousal levels (activated-baseline) was taken as the task-related activation. Behavioural measures of performance were taken as the mean points for the shots, the relative time fixing on the target (%), the deviation of the shots around their means, the distance the barrel moves around the target before the shot (mm) and the inter-shots interval. All these recordings were possible using an electronic device (SCATT) which usually expert shooters use to assess their professional capabilities in training sessions.

Statistical Analysis: An initial repeated-measure ANOVA was used to test whether there was a significant increase in arousal from the baseline to activated state. Subsequently, simultaneous multiple-regression analysis was used to investigate the relationships hypothesized in the introduction. Five measures were taken as dependent variables: Total Points, tracing distance (mm), deviation from the mean, inter-shot interval (S) and the relative time on the target (mm). Each of these was regressed on the independent variables-activated arousal level (μS) and task-related activation (μS)-in separate analyses.

RESULTS AND DISCUSSION

Task Related Activation: The overall SCL increased from 3.82 μS in the baseline resting condition to 6.38 μS in the activated task condition. This increase in arousal level was statistically significant ($F_{1,22}$=24.43, P<0.001). As expected, the two within-subject measures of arousal ("baseline" and "activated") were significantly correlated across participants (r=0.35, P<0.05), sharing 12% of their variance. The measure of activation

Within subjects ranged from .35 μS to 7.82 μS, with a mean of 2.55 μS.

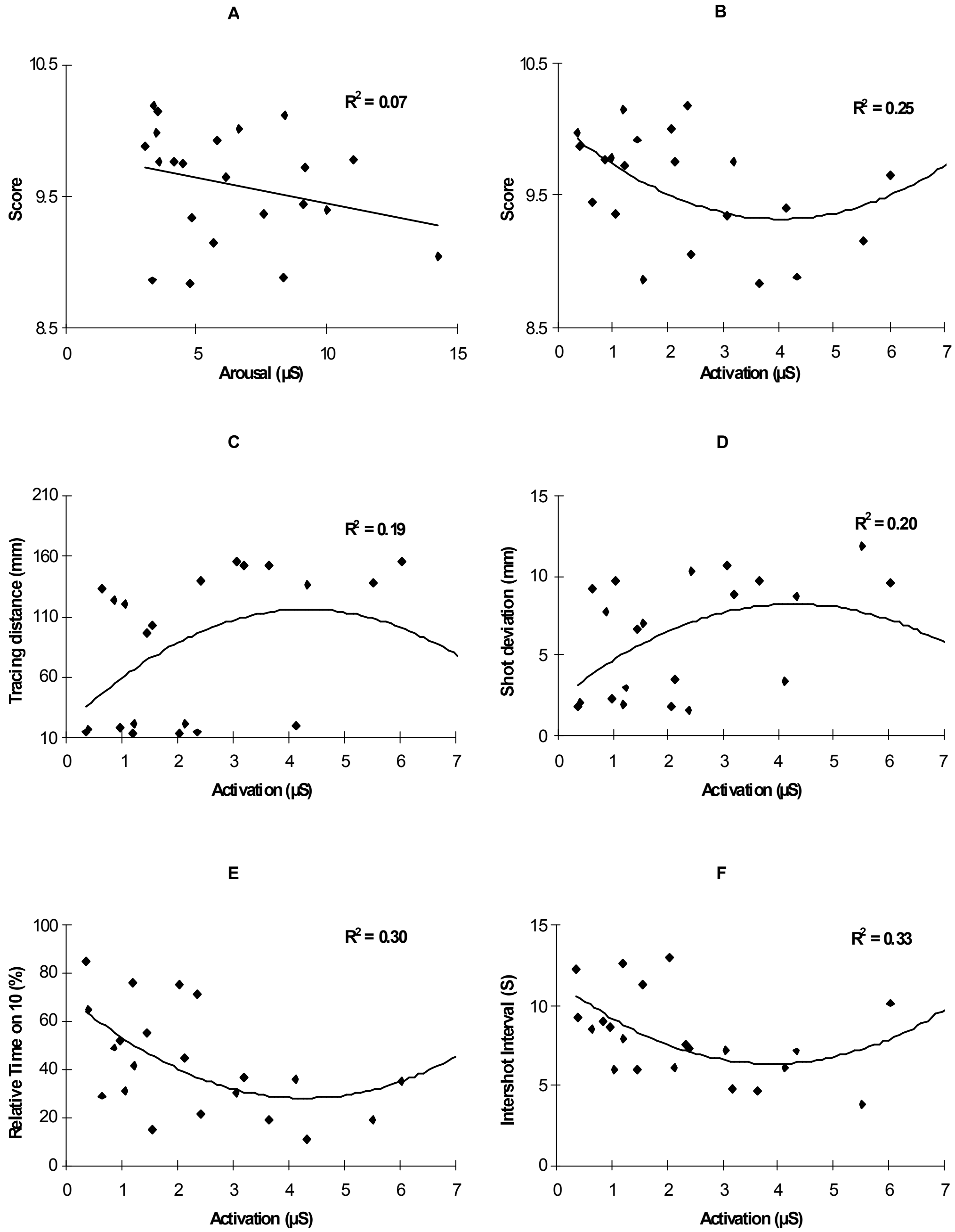

Fig.1: Predicting Performance Measures by Arousal and Activation

Performance: The final score for each participant are shown in relation to each of the independent variables in panel A and B of Fig. 1. Each set of data has been fitted with a linear regression line to indicate the relationship with the independent variable. In the absence of substantial linear relationships between final score and activation, the possibility of non-linear relationships was explored using second degree polynomial regression. There were no significant effects of arousal level (P=0.76) on this variable (panel A). Arousal did not show any other linear or polynomial relationship with any other performance measures in this study. As shown in panel B, there is a significant effect of activation on final score ($F_{1,21}$=6.96, P<0.05), an effect explaining some 25% of the variance in these measures. In panel C, a significant effect of activation on tracing distance ($F_{1,21}$=4.89, P<0.05) is clearly noticeable which explains some 19% of variance in these measures. In pane D, significant effect of activation on shot deviations is apparent ($F_{1,21}$=4.49, P<0.05), which explains the 20% of variance in these measures. Two other measures of performance, relative time on target (panel E) and inter-shot interval (panel F), also showed their dependency on activation, since the effect of activation on them was significant ($F_{1,21}$=8.83 and $F_{1,21}$=9.19; P<0.05 and P<0.05, respectively). These effects explained for 30% and 33% of variance in these measures.

Individual measures of final scores for each participant, displayed as functions of arousal level. Each set of data in this and subsequent panels are fitted with a regression line, linear or second degree polynomial, which best represent the relationship between two variables and the coefficient of determination for this regression is indicated (Fig. 1A). Individual measures of final scores for each participant, displayed as functions of activation. A significant U shaped relationship is apparent (Fig. 1B). Individual measures

Of tracing distance (mm) for each participant, displayed as functions of activation (Fig. 1C).

A significant inverted U shaped relationship is apparent. Since tracing distance is principally negatively correlated to score, the regression line assumed to be consistent with panel B and D. Individual measures of shot deviation from the mean (mm) for each participant, displayed as functions of activation. A significant inverted U shaped relationship is apparent. Since this variable is on the whole negatively correlated to score, the regression line assumed to be consistent with panel B and E. Individual measures of relative time on the target (10) for each participant, displayed as functions of activation. A significant U shaped relationship is apparent. Individual measures of inter-shot interval (S) for each participant, displayed as functions of activation. A significant U shaped relationship is apparent (Fig. 1F).

The overall increase in arousal level from the baseline to the shooting task supports the concept of task related activation and the use of the arousal change as its measure, since the overall increase in arousal level from the baseline to the shooting situation was significant.

Unlike several previous reports [21, 25], there is not any negative level of activation in our participants; this means all of our participants showed a task-related increase in arousal from the baseline to the task condition. The negative activation was previously attributed to either subject's preliminary experimental anxiety [21] or to the insufficiency of the baseline recording period [25]. Therefore, previous studies [23] suggested that future attempts to explore the arousal/activation conceptualisation should ensure a longer period of rest before estimating the baseline level.

In the present study we used a long enough period of time (twenty minutes) for recording the baseline activity. This is even longer than the periods Del-Ben *et al*. and Moya-Albiol *et al*. [27-28] used in their studies. Therefore, no cause was present for obtaining negative level of activation. The measure of task-related activation was found to determine behavioural efficiency in terms of score and other performance measures which ultimately lead to a higher performance. Current arousal level did not affect performance. These results provide significant support for our previous findings [25-26] and our hypotheses in the present study.

The overall findings of the present study indicate that arousal and activation can be conceptually separated-the former as the energetic state at a particular time and the latter as the change from a resting baseline to the task situation. It is found that current arousal level did not affect behavioural measures in the task. In contrast, activation in the task affected all five measures of behaviour in the task. These findings support the previous arousal/activation findings [21]. The important effects in this study were of parallel strength, with the significant r^2 values ranging from 0.19 to 0.33.

Although previous studies provided evidence for differentiation of arousal and activation in laboratory tasks [21, 27-28], the present findings supports the application of these separate concepts in a sport task. Each subject provided one data point in each panel of Fig. 1 and hence the study can be thought of as examining individual differences in state measures and the effects of these differences on behavioural performance outcomes. Future studies in this area could usefully explore these relationships on a within-subject basis.

CONCLUSIONS AND FUTURE DIRECTIONS

The overall results of the present study verify previous findings concerning differentiation of the energetics dimension into “arousal” and “activation”.Task-related activation affects behavioural performance in a sport task, while arousal does not. The importance of this separation is that it may be useful in modifying and refining the conventional understanding of the role of the energetics dimension in physiological and behavioural performance. In turn, this may encourage further research aimed at building on this foundation and re-assessing the role of energetics in psychophysiology. Pursuing this line of investigation in terms of individual differences in skilled performance, perhaps in a re-thinking of the inverted-U hypothesis, could be fruitful.

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