AROUSAL AND ACTIVATION IN A PISTOL SHOOTING TASK

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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], 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 [18-19]. Barry *et al.* considered that another reason was uncertainty arising from poor definition of the terms “arousal” and “activation”, which have often been used interchangeably [20]. 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 [21].

Following the separation proposed by Pribram and McGuiness [22, 23], Barry *et al.* used “arousal” to refer to the current energetic state, and “activation” to refer to task-related mobilization of arousal [21]. 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 ("baseline") or "activated" (during the task), while "activation" always refers to a *change* in SCL from baseline to task. Barry *et al.* then linked the effects of arousal to phasic physiological responses, and related the effects of activation to behaviour/performance measures [21]. They used this conceptual division to study children's performance in a continuous performance task (CPT). VaezMousavi *et al.* in a follow up study [25], and in an across subjects/between trials approach [26] also used this conceptualization to study adults' performance in a CPT. Using SCL as the index of arousal and its mobilization from the baseline as the index of activation, Barry *et al*. found that performance measures (mean RT and number of errors) was predicted by activation, but not with arousal [21]. Similar finding was reported by VaezMousavi Hashemi, and Jalali after examining this idea in a sport shooting task [27]. 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 military pistol shooters. The hypothesis was that the performance on the shooting 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 scores, inter-shots interval, and the total shooting duration.

METHODS

Participants: Twenty-one elite pistol shooters, 12 females and 9 males; mean age 34 years, participated in this study. They were all current or previous members of military pistol shooting team.

Procedure*:* After the study was described and written informed consent was obtained, participants performed part of the Standard Pistol Shooting Protocol, using a Browning pistols. Within the first epoch, they shot 15 shots (3*5) at a target 25 m distant. In the second epoch, which was designed to record the baseline SCL, shooters performed 5 blank shots, obviously without any psychological drive for aiming. The third epoch was the repetition of the first epoch to come up with the total of 30 shots. Electrodermal activity was recorded, using a constant voltage device (UFI Bioderm Model 2701) from 7.5 mm diameter Ag/AgCl electrodes on the medial phalanges of the second and third digits of the participant's non-preferred hand, at a constant voltage of 0.5 V, with an electrolyte of 0.05 M NaCl in an inert viscous ointment base. Electrodermal activity was sampled continuously at 10 Hz, both in the task and in the baseline. Performance measures, including the score for each shot, time interval between shots, and the total duration of shooting were collected during the task, using the electronic device Sius SA931 (Sius-Ascor).

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.

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. Three measures were taken as dependent variables: Total Points, inter-shot interval (S), and the total time spent on shooting 30 shots (S). Each of these was regressed on the independent variables – activated arousal level (μS), and task-related activation (μS) – in separate analyses.

FINDINGS

Task related activation*:* The overall SCL increased from 7.11 μS in the baseline resting condition to 7.89 μS in the activated task condition. This increase in arousal level was statistically significant ($F_{1, 20}$=14.18, P<0.001). As expected, the two within-subject measures of arousal ("baseline" and "activated") were significantly correlated across participants (r=0.97, P<0.001), sharing 94% of their variance. The measure of activation within subjects ranged from .19 μS to 1.75 μS, with a mean of .78 μS.

Performance: The final score for each participant are shown in relation to each of the independent variables in different panels of Figure 1. Each set of data has been fitted with a linear regression line to indicate the relationship with the independent variable, and determination coefficient was written to indicate the strength of this relationship. The effect of arousal was not significant (F < 1, panel A). Panel B shows that shooting scores significantly decrease in higher levels of activation ($F_{1, 17}$ = 6.961, P < .05), an effect explaining some 26% of the variance and .509 correlation in these measures. In panel C and D, the inter-shot interval is drawn in relation to arousal and activation. There is no effect of arousal in panel C (F < 1), while the effect of activation approached significance ($F_{1, 17}$ = 4. 83, P = .072), which explains some of the 16% of variance in these measures. In panel E and F, the total duration for spent to shoot is drawn in relation to arousal and activation. The total time of shooting was not significantly affected by arousal (F < 1), but approached significance as an effect of activation ($F_{1, 17}$ = 5.012, P = .062). An effect explaining 17% variance and -.42 correlation between measures.

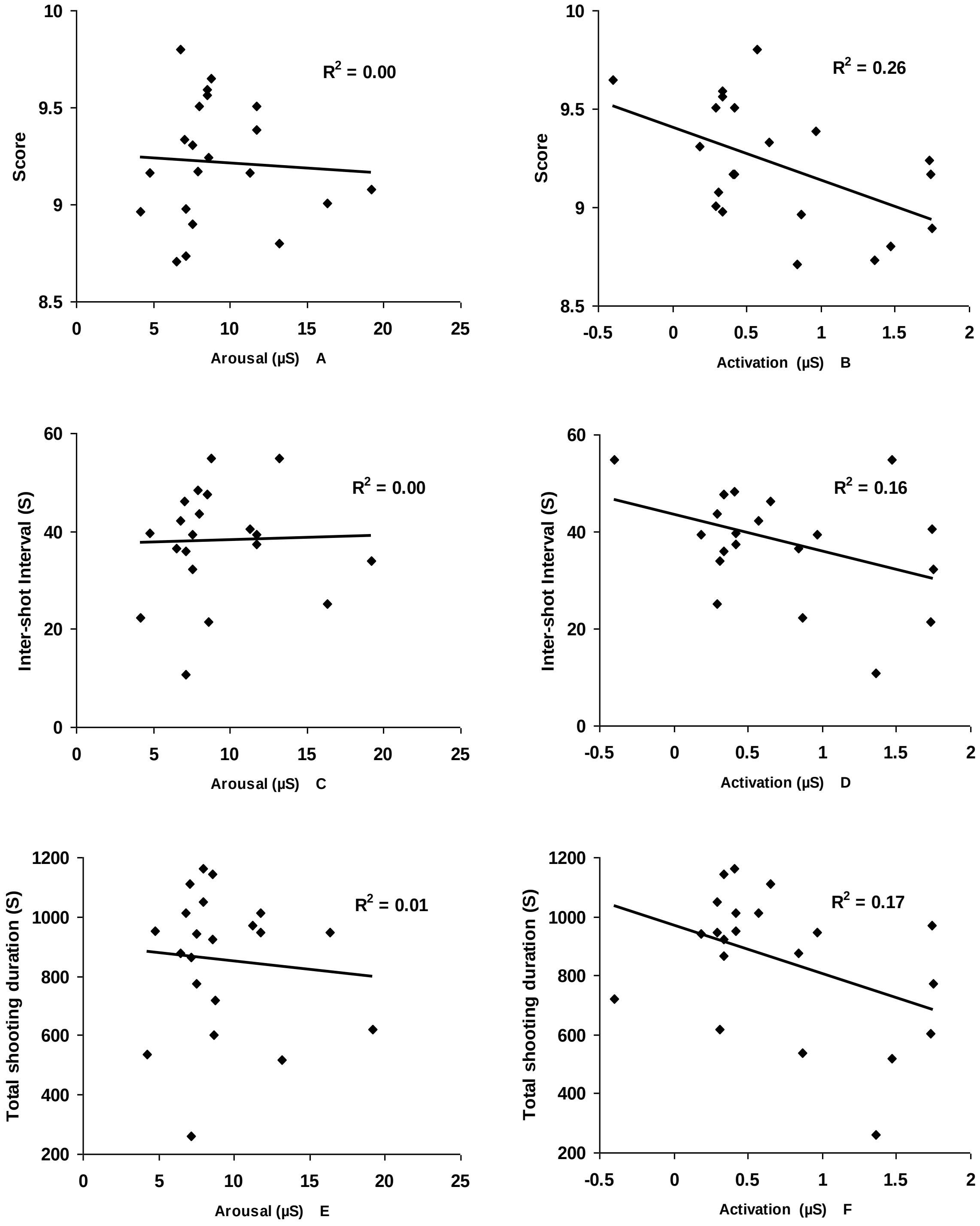

Figure 1. Dependant variables of the study, score, inter-shot interval, and the total shooting duration are drawn in relation to arousal and activation. In each panel, a line of best fit shows the relationship and determination coefficient shows the strength of that relation.

DISCUSSION

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], we didn't find 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 for recording the baseline activity. This is even longer than the periods Del-Ben *et al.* and Moya-Albiol et al. used in their studies [28, 29]. 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. We 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 0.16 to 0.26.

Although previous studies provided evidence for differentiation of arousal and activation in laboratory tasks [21, 28, and 29], the present findings supports the application of these separate concepts in a sport task. Each subject provided one data point in each panel of Figures 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.

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 shooting 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. Pursuing this line of investigation in terms of individual differences in skilled performance, could be fruitful. The present results may gradually find their applications in training sessions, as well as talent identifications for pistol shooting.

REFEREMCES

1. Malmo, R.B., 1959. Activation: A neurophysiological dimension. Psychological Review, 66: 367-386.
2. Barry, R.J., Sokolov E.N., 1993. Habituation of phasic and tonic components of the orienting reflex. Int. J. Psychophysiol., 15: 39-42.
3. Barry, R.J., Clarke, A.R., McCarthy, R., Selikowitz, M., Rushby, J.A., Ploskova, E., 2004. EEG differences in children as a function of resting-state arousal level. Clin. Neurophysiol., 115: 402-408.
4. Cobb, W.A., 1963. The normal adult EEG In: Electroencephalography (Hill D, Parr G, eds.). Macmillan, New York, p. 232-249.
5. Sharpless, S., Jasper, H. 1956. Habituation of the arousal reaction. Brain 79: 655–680.
6. Critchley, H.D., 2002. Electrodermal responses: What happens in the brain? The Neuroscientist, 8: 132–142.
7. Critchley, H.D., Melmed, R.N., Featherstone, E., Mathias, C.J., Dolan, R.J. 2001. Brain activity during biofeedback relaxation. A functional neuroimaging investigation. Brain 124: 1003–1012.
8. Critchley, H.D., Melmed, R.N., Featherstone, E., Mathias, C.J., Dolan, R.J. 2002. Volitional control of autonomic arousal: A functional magnetic resonance study. Neuroimage, 16: 909–912.
9. Asahina, M., Suzuki, A., Mori, M., Kanesaka, T., Hattori, T. 2003. Emotional sweating response in a patient with bilateral amygdala damage. Int. J. Psychophysiol. 47: 87–93.
10. LeDoux , J.E. 1996. The Emotional Brain: The Mysterious Underpinnings of Emotional Life. Simon and Schuster, New York.
11. Phelps, E.A., O'Connor, K.J., Gatenby, J.C., Gore, J.C., Grillon, C., Davis, M. 2001. Activation of the left amygdala to a cognitive representation of fear. Nat. Neurosci. 4: 437–441.
12. Williams, L.M., Phillips, M.L., Brammer, M.J., Skerrett, D., Lagopoulos, J., Rennie, C., Bahramali, H., Olivieri, G., David, A.S., Peduto, A. and Gordon, E., 2001. Arousal dissociates amygdala and hippocampal fear responses: evidence from simultaneous fMRI and skin conductance recording. NeuroImage, 14:1070–1079
13. Cechetto, D.R., Saper, C.B., 1990. Role of the cerebral cortex in autonomic function In: Central Regulation of Autonomic Functions (Loewy AD, Spyer KM, eds.). Oxford Univ. Press, Oxford, UK, p. 208–223.
14. Damasio, A.R., 1994. Descartes' Error: Emotion, Reason, and the Human Brain. Grosset Putnam, New York.
15. Duffy, E., 1962. Activation and Behavior. Wiley, New York.
16. Malmo, R.B., 1959. Activation: A neurophysiological dimension. Psychol. Rev. 66: 367–386.
17. Haywood, K.M., 2006. Psychological aspects of archery In: The Sport Psychologist's Handbook: A Guide for Sport-Specific Performance Enhancement (Dasil J, ed.). John Wiley and Sons Ltd., London, p. 549-568.
18. Croft, R.J., Gonsalvez, C.J., Gander, J., Lechem, L., Barry, R.J., 2004. Differential relations between heart rate and skin conductance, and public speaking anxiety. J. Behav. Therapy Exp. Psychiat. 35: 259–

271.
19. Lacey, J.I., 1967. Somatic response patterning and stress: Some revisions of activation theory In: Psychological Stress Issues in Research (Appley MH, Trumbull R, eds.). Appleton-Century-Crofts, New York, p. 14–44.
20. Lacey, B.C., Lacey, J.I., 1970. Some autonomic-central nervous system interrelationships In: Physiological Correlates of Emotion (Black P, ed.). Academic Press, New York, p. 214-236.
21. Barry, R.J., Clarke, A.R., McCarthy, R., Selikowitz, M., Rushby, J.A. 2005. Arousal and activation in a continuous performance task: An exploration of state effects in normal children. J. Psychophysiol. 19: 91-99.
22. Oken, B.S., Salinsky, M.C., Elsas, S.M., 2006. Vigilance, alertness, or sustained attention: physiological basis and measurement. Clin. Neurophysiol. 117: 1885–1901.
23. Pribram, K.H. & McGuiness. D. 1975. Arousal, activation, and effort in the control of attention. Psychol. Rev. 82: 116–149.
24. Pribram, K.H. & McGuiness. D. 1992 Attention and para-attentional processing. Event-related brain potentials as tests of a model. Ann. N.Y. Acad. Sci. 658: 65–92.
25. VaezMousavi, S.M., Barry, R.J., Rushby, J.A., Clarke, A.R, 2007a Evidence for differentiation of arousal and activation in normal adults. Acta Neurobiol. Exp. 67: 179-186.
26. VaezMousavi, S.M., Barry, R.J., Rushby, J.A., Clarke, A.R, 2007b. Arousal and activation effects on physiological and behavioural responding during a continuous performance task. Acta Neurobiol. Exp. 67: 461-470.
27. VaezMousavi, S.M. Hashemi Masoumi, E. and Jalali, S. (2008). Arousal and activation in a sport shooting task. World Applied Sciences Journal 4 (6): 824-829.
28. Del-Ben, C.M., Vilela, J.A.A, Hetem, L.A.B., Guimaraes, F.S., Graeff, F.G., Zuardi, A.W., 2001. Do Panic patients process unconditioned fear vs. conditioned anxiety differently than normal subjects? Psychiatry Res. 104: 227–237.
29. Moya-Albiol, L., Salvador, A., Costa, R., Martinez-Sanchis, S., Gonzalez-Bono, E., Ricarte, M., Arnedo, M., 2001. Psychophysiological responses to the Stroop Task after a maximal cycle ergometry in elite sportsmen and physically active subjects. Int. J. Psychophysiol. 40: 47–59.