Arousal and activation in a pistol shooting task

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Abstract

Aims: Precise pistol shooting is influenced by arousal, which has been recently defined as an individual's energetic state at a particular time and is measured by skin conductance level. On the other hand, task related activation has been defined as the change in arousal, from a resting baseline to the task situation. Present study was performed in order to investigate whether previous theories on functional differentiation between arousal and activation could be generalized from laboratory tasks to military skills.

Methods: This quasi experimental study was performed on 21 military elite shooters including 4 women and 17 men with mean age of 34 years who voluntarily took part in the study, in year 2009. Skin conductance level was recorded as an index of arousal. Several performance measures including scores, inter-shot intervals, and the total shooting time were also electronically recorded. Data was analyzed using inferential statistical methods including repeated measures analysis of variance and stepwise linear regression analysis by SPSS 16 software.

Results: There was a linear negative correlation between activation and all three performance measures. Arousal didn't have correlation with any of performance measures.

Conclusion: Findings of present field study support previous laboratory results and shows that quality of task performance, regardless of its type, is affected by activation and not by arousal.

Keywords: Arousal, Activation, Electro-Dermal Activity, Pistol Shooting Task, Skin Conductance Level

Introduction

Arousal is the level of central nervous system wakefulness which ranges from deep sleep to hysteria mode, and often is measured by extensive physiological measurements such as Electroencephalography (EEG), electrocardiography, electromyography, Catecholamines' assay, the intensity of respiration, blood pressure, heart rate and sweating etc. [1]. Among these, skin measurements, specifically Skin Conductance Level (SCL), has been used most frequently. SCL reflects the activity of sympathetic cholinergic neurons in the surface of secreted glands of skin sweat during emotional, cognitive and physical behaviors.[2] This scale is so sensitive to the arousal variations resulting from the sympathetic nerves that Barry and Sokolov have considered it as "arousal gold standard". SCL contains information that is probably related to the hidden aspects of central nervous system during the information processing [4].

Arousal-performance relationship is one of the most contentious issues in sport psychology which has been focused since about 100 years ago by scientists in this field. At high levels in many sports, there is little difference between participants' skill levels. Thus, it is often the ability to control arousal that separates the winners from losers [1]. Optimal level of arousal depends on many factors such as the complexity of skill, skill level, and individual differences and physical fitness of people. So far, many research works have been conducted in order to explore the relationship between arousal and performance, and various theories have been presented, among which drive theory, inverted-U hypothesis, catastrophe model, the optimum range of individualized zone of optimal functioning (IZOF), return theory, etc. can be noted that each considers a part of the relationship between arousal and performance and has theoretical value, but ultimately does not lead to a clear conclusion.

Research results are inconsistent and sometimes even in contradiction with these theories. For example, in confirming the inverted-U hypothesis, Martens and Landers reported the best performance at moderate arousal levels [5]. Arnet and Landers observed the optimal performance in simple assignments in the range of 60 to 70% of maximum arousal [6]. On the other hand, Bargh and Cohen obtained the inverted-U relationship only in difficult and strenuous assignments [7]. Sontroem and Bernardo found that the inverted-U relationship is more dominant for athletes with higher competitive state anxiety; while it is not the same in different people [8]. Gould et al. noticed the inverted-U only between arousal and performance and not between cognitive anxiety and

performance [9]. Unlike the findings of Bargh and Cohen, Collet et al. expressed that the relationship between arousal and performance exists just in simple assignments [10]. Perkins et al. concluded that in situations where the exercise performance requires the maximum power in a short time, high arousal can improve performance [11]. Having studied the relationship between arousal and performance on the Italian national archery team's members, Robazza et al, reported a link between high arousal and poor performance [12]. Noteboom et al. also reached a similar conclusion [13]. Tremayne and Barry also observed further decrease in arousal before the good performance in comparison with bad performance [14], while Shepperd et al. and Demoja et al. reported the improvement in performance with increased arousal [15, 16].

It seems that the disability of above studies in clear description of the arousal-performance relationship is partly due to the lack of comprehensive definition of arousal [17]. Arousal is often used as a synonym of words like "activation". However, there is some evidence concerning the difference between these two. [17]. Pribram and McGuiness made distinction between arousal and activation. These researchers proposed different physiological bases for arousal and activation [18, 19].

Recent efforts to distinct the concept of "arousal" from "activation", has made it possible to review the relationship between arousal and performance more carefully. Recent research methodologies emphasize on using a base line measurement in order to separate arousal from activation. Arousal is defined with the body energetic status in a particular moment measured by SCL while activation is the change in arousal rate from base line to task implementation situation which is obtained by deducting the basic line from the arousal rate during the task implementation [17, 20, 21]. This clear and precised definition helps researchers to describe the probable relationship between each of these two variables with performance. Barry et al. clearly expressed their expectations for finding a relationship between activation and performance and they predicted that there will be no relationship between arousal and performance. They added that arousal is associated with physiological responses, not behavioral responses [17]. Subsequent researches confirmed this prediction.

Conceptualization of arousal and activation has been shown in Figure 1 [20]. Barry et al. and Va'ezmousavi et al. investigated the relationship between arousal and activation with the performance of children and adults in the ongoing laboratory task and concluded that the

performance scales (mean reaction time and number of errors) are associated with the activation range but arousal level has no significant relationship with this scale. Since the differentiation of arousal and activation is only tested in the laboratory exercises, Barry et al., and Va'ezmousavi et al. mentioned that testing the differentiation of arousal from activation will be of value in the field assignments.
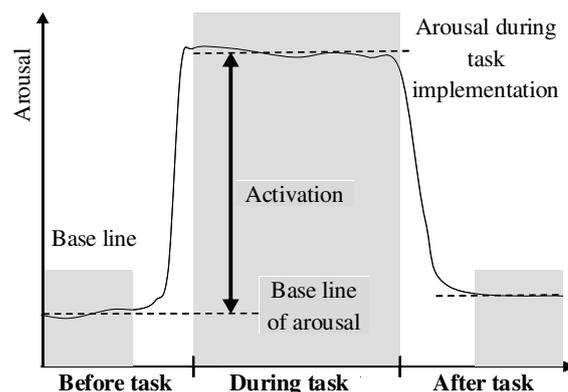

Figure 1- Conceptualization recommended by Barry et al. and Va'ezmousavi et al. that separates arousal from activation. Based on this conceptualization, increase (or sometimes decrease) of arousal from the base level to task implementation level is called activation which is linked to performance.

In the present study, pistol shooting task was selected since the operating role of arousal has been repeatedly reported in its exercises. Also, lack of transitional movements in implementing the task of shooting makes it easier to record physiological variables. Therefore, hypotheses of this study were regulated in such a way that arousal is not performance predictor in shooting task, but activation predicts performance in the given assignment in score scale, intervals between shots, and total shooting time.

The purpose of this study was to test whether the previous comments regarding the functional differentiation of arousal and activation of laboratory tasks could be generalized to the military skills (shooting with a pistol).

Methods

In this quasi experimental research in 2009, the participants were 21 military elite male and female shooters aged from 20 to 40 years old with an average age of 34 years old who had voluntarily participated in this research. They were chosen through available sampling method. Considering the research methodology, to achieve statistical power of 0.8, this number of participants was sufficient [22].

For shooting, the standard organizational browning pistol was used. First, the position for connecting the electrodes in the middle and index fingers of pointed subject were cleaned by alcohol for better connection [23]. Then the electrodes of U.F.A bioderm device (model SC2701; United States) installed on personal computer by SC41 Software, was connected to the position. This device measured SCL through silver/chloride silver electrodes with a diameter of 7.5 mm. The amount of 0.5mg of sodium chloride electrolyte was used as skin ointment for better guidance of electrical current.

Studied group rested in sitting position for 10 minutes to obtain the required relaxation for shooting and getting used to electrodes. Meanwhile, they replied to related questionnaires.

The data collection process was in the way that at the first stage, each shooter adjusted his shooting by firing 5 shots. In the second stage, the assignment of shooting with war pistol was done by shooting with 3 cylinders of 15 shots at the standard distance of 25 meter. In the third stage, to determine the base level of arousal, each shooter without having gunshot and naturally with no incentive for accurate shot, fired at the target 5 times dryly. The fourth step was to repeat the second step to obtain a total of 30 shots.

During this assignment, performance measures, including scores for each firing, intervals between shots and total shooting time was recorded by Sius SA931 electronic apparatus (Sius-Ascor; Germany). Over the task performance, SCL was recorded with a frequency of 10 Hz. Shooters' mean SCL, equal to 500 milliseconds before each shooting was considered as the level of arousal for that shot. Also for determining the activation rate, the lowest level of arousal of any shooter during the fourth step(as the base line) was specified and reduced from his arousal rate for each shooting [17, 20, 21].

For statistical analysis, repeated measures ANOVA was used to show any significant change in SCL from base line to activated level for assignment performance. After that, performance measures (including scores, inter-shot intervals and total shooting time) were inserted as the criterion variables respectively, and arousal and activation, both as predictor variables in linear regression analysis were entered to test the given relations in the research hypotheses.

Results

Mean SCL was increased from 7.11 micro siemens in base line to 7.89 micro siemens in task situation, which reflects the overall increase of the level of arousal $(F(1, 20)=14.18; p<0.001)$. This increase has been shown in Figure 2, called as "activation". The correlation between arousal in base line and task situation was high. $((r=0.97; p<0.001))$, which showed 94% of shared variance. The lowest amount of activation was 0.19, the maximum rate was 1.75 and the average was 0.78micro siemens.
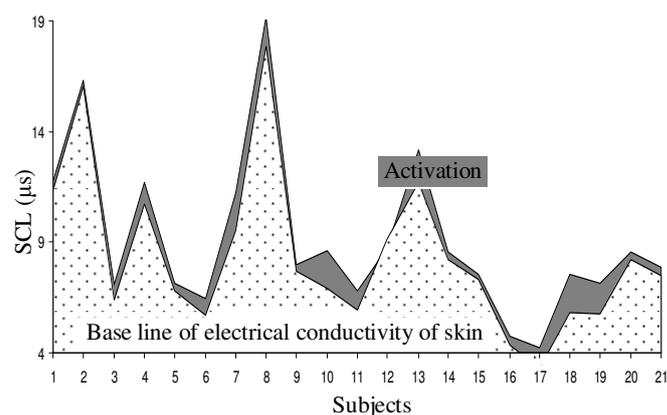

Figure 2- Skin conductance level (vertical axis) is shown versus the participants (Horizontal axis). Pointed area indicates arousal and dark area indicates activation.

The effect of arousal level on the shooting score was not significant $(F<1$; Diagram 3A), but in the higher levels of activation the shooting scores significantly decreased. $(F(1, 17)=6.961$ and $p<0.05$; Diagram 3B). This effect explains 26% of common variance and a correlation of 0.509 between these two measures.

Also, the inter-shot intervals were not influenced by arousal $(F<1$; Diagram 3C), while at higher levels of activation, this variable was nearly meaningful $(F (1, 17)=4.833$ and $p=0.072$ Diagram 3D). This effect indicates 16% of common variance and correlation of -0.403 between two variables.

Total shooting time were not influenced by arousal $(F<1$; Diagram 3E), while the effect of activation on it was almost meaningful $(F (1, 17)=5.012$ and $p=0.062$ Diagram 3F). This effect also indicates 17% of common variance and correlation of -0.416 between two variables.

P was reported by bilinear probability, although considering the relatively clear theoretical background, the unidirectional possibility seems to be acceptable as well; in this case both p values had been less than 0.05.

Discussion

In the present study, arousal scale was correlated with

none of the performance measurements and did not predict performance. Instead, activation predicted most of performance measurements. These findings are consistent with what had been reported before in laboratory exercises. However, the effect scope of arousal and activation on performance should have

been tested in the field tasks. Due to the differences in the forms and objectives of field tasks and objectives with laboratory tasks, findings showing the opposite effects of arousal and activation in field task can more acceptably confirm the conceptual and functional differentiation theory of these two variables.
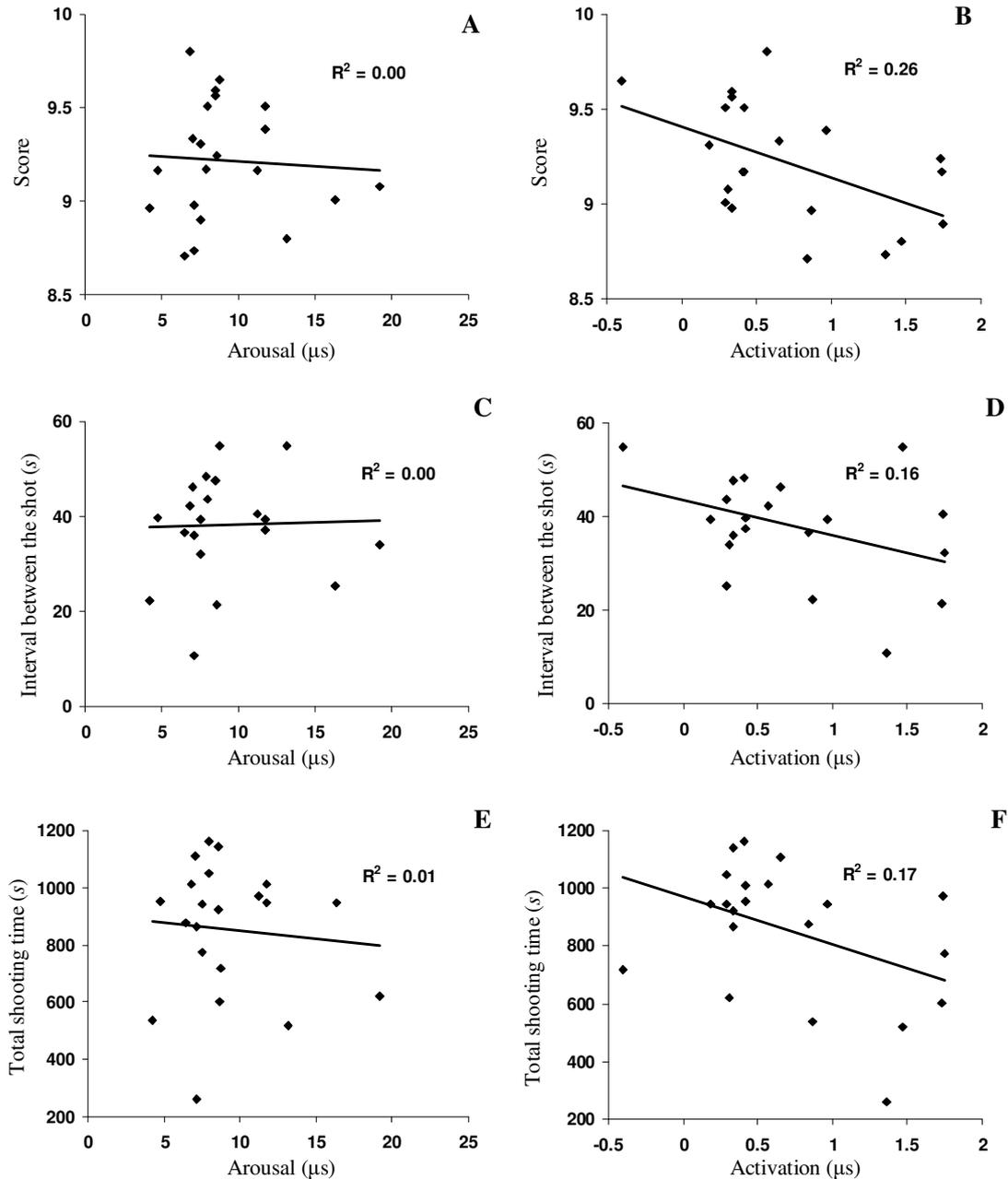

Diagram 3- Mean scores achieved by each participant influenced by arousal and activation. In diagrams A and B, the inter-shot intervals for each shooter is drawn versus arousal and activation in diagrams C and D, and total shooting time versus arousal and activation in diagrams E and F. To show the relationship between dependent and independent variables, a regression line is drawn for data in each diagram and to show the power of this relationship, the coefficient of determination is written above it.

Therefore, previous researchers have emphasized the necessity of this action [17, 20, 21, 24]. The findings of this study, which has been conducted in the field task domain, besides the results of previous studies show that the quality of task (regardless of its type) spending regardless of its type) is under the influence of activation, not arousal.

Considerations in the method implementation indicate the fact that a lot of efforts have been spent on creating the field conditions for data collection. Nevertheless, due to using laboratory tools, the success of researchers to create the perfect conditions was not perfect and this issue is a relative limitation of current study. However, given that the nature of the applied assignment is "field research", the researchers has interpreted the finding of this study as a generalization of laboratory conditions to field conditions in shooting task. Obviously, considering the cognitive and physiological needs of shooting tasks, it is necessary to generalize other field assignments cautiously.

In this study, the differentiation of arousal as a variable which indicates the current energy level of each individual, from activation, as the change in energy level relevant to task demands, has been clearly shown. While arousal had no effect on any of functional variables of shooting skills, activation had significant influence on all three task performance measures. Common variance ranged from 16% to 26% which demonstrates the moderate power of these effects. It should be considered that correlations found in this study have interpreted causally. The justification of this issue is related to the chronological order of effects. [17]. Researchers assumed that shooting task specifications increased the SCL from base line to the observed level before the shooting. Also, Increases in SCL results in a decrease of scores and defect in other performance measures. Alternative hypothesis that only mentions the correlation between activation and performance is not useful in view of researchers.

Shooting is a complex skill that is dependent on precise muscle control and several perceptual/cognitive factors. Therefore, the need for lower arousal in this sport is quite considerable. According to Weinberg and Hunt, high arousal may interfere with emotional control in normal conditions and also with the fine muscle control and decision making, [25]. Tremayne and Barry observed more reduction in S-hap before the good shooting in comparison with bad shootings [14]. Thus, the findings of the present study are consistent with the findings of Tremayne and Barry, as well as many other researches which attribute better performance in the precise skills to lower arousal [14, 17, 20, 21, 24].

In this study, inverted-U hypothesis that is the most famous descriptor of the relationship between arousal and performance [26] was not confirmed. When the linear relationship between variables was observed, the common variance was higher than the time when polynomial relationship between them was examined. Although the existence of a linear relationship between activation and performance is consistent with previous studies, it is inconsistent with the inverted-U relation theory and the mass of literature that confirm this theory [28, 29, 30, 31, 32]. Explaining the linear correlation between activation and performance is related to between-group nature of this study. It is likely that in within group study, each s individual shooter shows the correlation between activation and performance as a U or inverted U which leads to the linear form of mean.   Therefore, it seems that in future research works, the precise investigation of this correlation would be possible by using the method representing individual differences.

The Independence of the effects of arousal and activation on performance measures emphasizes on the importance of continuing the current research in wider range. Confirmation of this research in future studies enables the researchers to predict the effects of arousal and its variations in base line (known as activation in this research) and this will lead them to understand the interaction between energetic functional measures of body (reflecting the energetic aspects of human physiology) and its behavioral links.

Conclusion

Activation has negative linear correlation with performance measures including shooting scores, inter-shot interval and total time of shooting. However, arousal has no correlation with any of performance measures.

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