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Cadets' performance prediction in a static balance task based on arousal and activation

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Abstract

Aims: Complex physical movements that are often dangerous have increased the importance of balance in military forces. The aim of the present study was to investigate the relationship between cadets' physiological arousal and activation with performance in a static balance task. The task was chosen according to its association with military health and physical fitness.

Methods: This descriptive study with correlation pattern was carried out in 2009 on 30 male cadets with the age range of 19-23. Skin Conductance Level (SCL) as arousal index was recorded continuously during the 30-second performance of a static balance task. Sway index was recorded on an electronic stabilometer as performance measure. Pearson correlation coefficient and stepwise linear regression was used to analyze the data by SPSS 16 software.

Results: Results indicated a negative linear relationship between activation and performance, while arousal did not correlate with performance. Activation also predicted performance with a medium strength.

Conclusion: The quality of the task is affected by activation, but not arousal. Confirmation of these data in future studies will lead to comprehension of the interaction between physiological measures and its behavioral associations in high level military or sport performance, especially in emotional contexts.

Keywords: Arousal, Activation, Skin Conductance Level, Static Balance, Performance

Introduction

Several hypotheses and theories have described the relationship between the performance and the level of arousal; however, the relationship between these two variables is not clear enough. Among the major causes of the ambiguity of the relationship between these two variables is the lack of a unified concept of arousal agreed by researchers. Barry et al. stated that the relative uselessness of the research in this area is due to the confusion caused by the weak definition of the terms "arousal" and "activation", because these two terms are often used as the synonyms [1]. The various terms which are used to describe the attentive conditions in the central nervous system have different bonds and links [2, 3, 4] and it seems that the more they are used, their less the concepts are transferred.

Using the terms of arousal and anxiety interchangeably causes the conceptual confusion in particular. Since the anxiety often leads to increased activity of the central and automatic nervous system, it has been used as a synonym for arousal. Many researchers who had studied the arousal used the anxiety scales and discussed about the findings in the way that they presumably had evaluated the arousal [5, 6, 7]. Recently, the term "excitement" has caused the increased conceptual confusion in the topics of arousal and the state of the relationship between the arousal and performance. Therefore, it is clear that the establishment of the meaning and the application of the term "arousal" is significant from the theoretical and practical perspective [8, 9, 10, 11, 12]. The motor behaviorists used motivation as the theoretical basis of the arousal structure. Especially, Sage defined the arousal as an energetic function which indicates the intensity of the motivation and directs the behavior towards a specific goal [9]. Magill considered the arousal as the synonym of activation. He stated that giving motivation to an individual is actually stimulating or activating that individual in a way that prepares him for the task [10]. Cox referred to "readiness" or the individual's consciousness which is only a function of the physiological state of readiness [11]. Some sport psychology books have operated the arousal in the context of motivation; for example, Landers and Boucher defined the arousal as an "energetic function" which is responsible for the control and implementation of the body's resources for the severe activities [12]. Other researchers believe that arousal only represents the intensity of motivation [13]. Similarly, Brehm and Self had used the term "motivational arousal" to describe the intensity of the motivation that their meaning was primarily the response of the sympathetic nervous system [14]. Generally, If the motivation is considered as the framework of arousal, the arousal will be considered

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as a continuum which changes from very low levels (e.g. sleeping) to very high levels (e.g. excitement) that occurs in the conditions of threatening (e.g. war or escape) or stimulation (e.g. sexual activity). The motivational explanation for the arousal implies that the sympathetic nervous system reflects the motivational arousal [15].

The definition of the arousal as a monolithic structure have been much criticized and strong evidence have supported this belief that first the arousal is a multidimensional physiological structure [16, 17, 18, 19, 20] and second, it has physiological, behavioral, cognitive or emotional dimensions [19, 20, 21, 22, 23, 24, 25]. The first evidence related to the multidimensional nature of the arousal was provided by Lacey who showed that the three types of physiological arousal were distinct from each other including the neural cortical arousal (electro-cortical), automatic arousal (autonomic) and behavioral arousal and concluded that these dimensions of the arousal could change independently [15].

Neiss is one of those who intensively criticized the structure of the arousal and actually suggested that this term would be discarded. In his point of view, the study of arousal has the smallest role in understanding the relationship between the arousal and performance. He noted that the weak anxiety and the optimal level of preparation may contain the similar levels of arousal [26, 27, 28].

Neiss argued that the study of the psychobiological states and their independent relationship with the physical performance help more in further researches. He concluded that the best thing is that the arousal would be discarded and the study of psychobiological states including the psychological, cognitive and emotional dimensions would be expanded.

In the operationalizing process of the arousal concept, there were much confusion and challenges and the arousal had been criticized for several years, whereas anyway the central core of the foundation of different aspects of arousal is a concept of the usefulness. Discarding the arousal was the proof of the fact that the problem itself would be excluded instead of solving the problem [29]. Barry stated that the prevalent concept of the integrated arousal is simply idiotic. He proposed that tonic indexes should be considered for the studies of the arousal. Instead of discarding this field, attempts should be done towards the evolution and development of concepts of tonic physiological measurements and it should be integrated with the notified processing stage indexes in order to achieve more abilities in the explanation and definition of the concepts. In Barry's point of view, the findings of Lacey showed that both the heart rate and the skin conductivity levels could not be the indexes of arousal. Therefore, these two indexes should be examined separately in order to conceptually match the data relating to the valid theory of the separation [29].

Barry et al. proposed the activation as an effective agent in the state of the implementation of the action in their recent studies based on conceptualizing of arousal and activation [1, 30, 31]. In these studies, the activation was applied to the changes of the arousal level from the basic resting condition to the task condition. They stated it is likely that the activation could be more effective on the process of performance compared to the arousal. By the review of these studies, it can be concluded that the arousal is not effective on performance and can only set back the physiological responses. In these studies, the arousal referred to the energetic state of the body at a particular moment which can be measured by Skin Electrical Conductance Level (SECL).

Barry et al. used this separation for the study of children performance in continuous performance task (CPT) [1]. They concluded that the mean amount of "orienting reflex" was related to the arousal but not the performance. The measurements of the performance (mean of the reaction time and the number of errors) were improved with the increase of activation but had shown no response to the increase of the arousal. They concluded that more studies using the arousal and activation as the different energetic aspects and the tests of their effects on the physiological and behavioral responding would be significant. Vaez Mousavi et al. found similar results by repeating the same study on the adults [32, 33]. Considering that the presented theory about the differentiation of the concepts of arousal and activation was only studied on the non-motor tasks, Barry et al. [1] and Vaez Mousavi et al. [32, 33] proposed that the study of the motor-base skills would be important based on the differentiation of the concepts of arousal and activation. The importance of studying the presented theories about the differentiation of the concepts of arousal and activation in the motor skills is related to both the nature of the skill and the application of obtained findings. Therefore, the fundamental importance of the research is debatable regarding its application importance.

In this study, the differentiation of the concepts of arousal and activation in the cadets and their relationship with performance in laboratory balance task was studied. The static balance which was considered as the criterion variable in the present study was the basis of the most job skills [34]. This task was selected due to its importance in the health and fitness of the military forces. Complex physical movements which are often dangerous have increased the importance of the balance in military forces. In the present study, the assumption was that the performance of the balance task was dependent to the activation and not to the arousal. The hypothesis of this study predicted that the level of arousal had no effect on the behavior during the performance of the balance task. In contrast, the activation related to the task as a change in the level of the arousal from the resting state would determine the behavior which led to more precise performance.

The aim of this study was to investigate the relationship between cadets' physiological arousal and activation with performance in a static balance task.

Methods

This descriptive study with correlation design was done in 2009. The population of this study was 120 first semester students of Imam Hussein University with the age range of 19-23. 30 students voluntarily participated in this study. Regarding the used statistical method, this number was sufficient to obtain the statistical square of 0.8 [35]. None of the subjects had already participated in the task of this study and did not have the history of epileptic attacks, serious skull injuries and hearing or vision impairments and were not under the treatment of cardiac, circulatory or nervous problems.

First, the volunteers were registered and were justified about the process and objectives of this study and a written consent was obtained from all of them. Considering that the present study was conducted without any invasive or noninvasive intervention, a written consent from the subjects to participate in the study seemed enough.

Then, the data collection began in a laboratory equipped with air-conditioning. The SECL electrodes (silver/silver chloride with the diameter of 7.5mm) were attached to the standard location (the first joint of the middle and index finger) of the subjects' non-dominant hand. First, the attached position was cleaned with alcohol dipped cotton. After drying the alcohol, the electrodes were attached to the position while their middle hole was filled by 0.5M NaCl. Then, the subjects rested for 20 minutes in sitting position, so that their base SECL would be measured.

The subjects participated in an experimental task for 3 minutes. This task was done by the purpose of getting familiar with the properties of the electronic stabilometer, the possible range of movements and the visual feedback accuracy. They stood on the screen of the electronic stabilometer (Tavan Azma, Tehran, Iran) which was attached to a specific computer for 30 seconds. The screen of the electronic stabilometer transferred the displacement of the power caused by weight and muscular contractions to maintain the center of mass center at the reliance level to the computer on the axis of front-back and inside-outside with a frequency of 100Hz for registration. The visual feedback was spontaneously presented to the subjects from a 38-cm screen that was placed in front of the participants in the distance of 150cm. The test instructions included using the visual guidance to the lowest movement in the center of mass. The task was begun when the experimenter became sure of the full understanding of the instructions by the subjects. The computer attached to the electronic stabilometer was recorded the data resulting from the balance of the individual. The computer attached to the skin conductivity level was recorded the relevant data with a frequency of 10Hz. Two computers started to work with the chronometer connected to the software and the participants also started the task simultaneously. After the end of performance of the task, the experiment was completed.

Skin Electrical Conductance Level (SECL) was recorded to the Microsiemens unit continuously during 30 seconds performance of the task as an index of arousal and established the independent variable of the first hypothesis (predictor). 30 seconds of the lowest base level of arousal which was recorded in 20 minutes was used as the base arousal. 30 seconds were considered for being equal with the time of the performance of the task. Considering that 10 numbers were stored per second, 300 numbers were obtained as the arousal index for each subject. These numbers were subtracted from 300 numbers related to the base level so that 300 numbers obtained from the subtraction which showed the activation as the second independent variable (predictor) would be obtained [1, 30, 31, 32, 33]. SPSS 16 software was used for data analysis.

Using a single group test of Kolmogorov-Smirnov, the normality of the scores' distribution of the subjects' performance was accomplished. The mean of the activation level and the sway index were calculated for all participants. The figure of the performance's variance towards arousal was plotted using the data of each subject.

Then, the figure of the similar dispersion which showed the performance towards the activation was plotted. Each group of data was equipped to an oblique line and the determination coefficient was obtained for each. Then by ANOVA with the repeated measures, the increase of skin conductance level was observed from the basal level to the activated level which indicated the "activation".

Afterwards, the arousal and activation were studied by multiple stepwise linear regression and their effects on the criterion variable (balance performance) were studied.

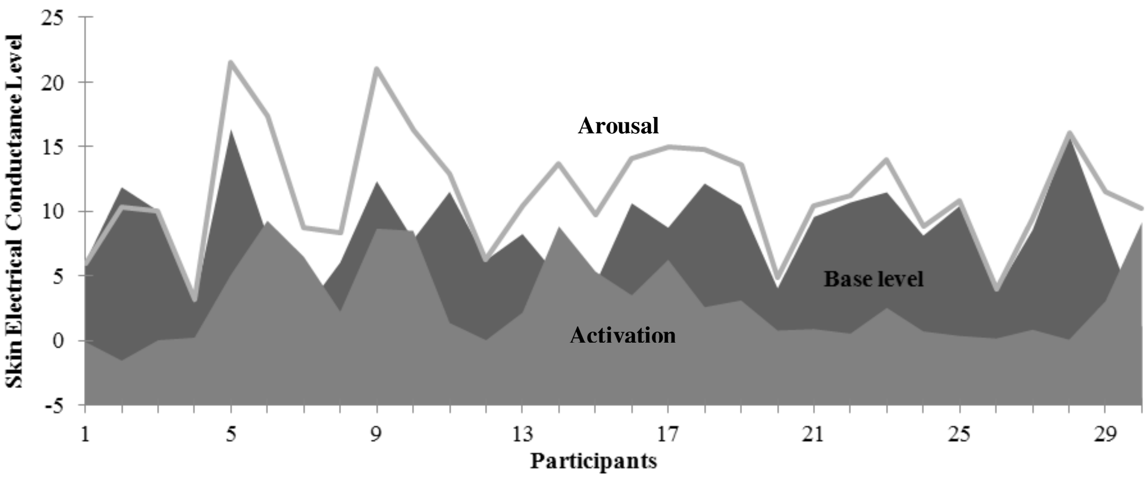

Diagram 1- The horizontal axis shows the subjects of the study and the vertical axis shows Skin Electrical Conductance Level (SECL) with Microsiemens unit. It seemed that arousal level had changed parallel to the base Skin Electrical Conductance Level (SECL). The level created from the difference between the base Skin Electrical Conductance Level (SECL) and arousal is activation. The rate of activation was seemed different in the subjects of this study.

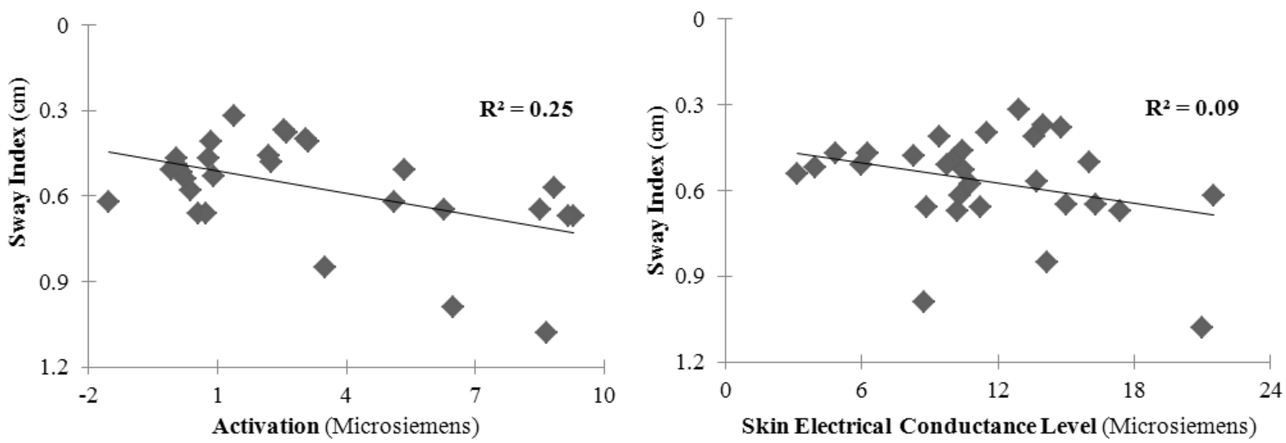

Diagram 2- The above part of the figure shows the distribution of the sway index towards the arousal. A regression line was added to each group of data so that the image would indicate the relationship and the determination coefficient was written above it in order to show the strength of this correlation. Each point in the image represents one participant. In the below part, the dispersion of the sway index towards the activation is plotted. The higher determination coefficient shows the higher power of the relation. Each point in the image had also represents one participant. The drawn line among the data shows the strength of relationship between the two variables.

Results

Base Skin Electrical Conductance Level (SECL): the SECL had many changes among the subjects. Its minimum rate was 1.05 and its maximum rate was 16.36 Microsiemens. These changes in SECL were observed during the task performance and ultimately led to the changes of the activation among the subjects. Diagram 1 shows the rate SECL, the rate of arousal and the rate of activation among 30 subjects. The minimum arousal index was 3.17 and the maximum arousal index was 21.48 among the subjects and the mean was 11.49±4.84 Microsiemens.

Activation: the minimum activation was -1.53 and the maximum activation was 9.28 and the mean was 3.05±3.42 Microsiemens. The total increase of SECL from 8.44 in the basal state to 11.49 in the task state caused the activation. This increase in the SECL level was statistically significant ($F_{1, 29}$=7.17; p<0.05).

Performance: The minimum sway index was 0.32 and the maximum sway index was 1.08 among the subjects and the mean was 0.57±0.17cm. The balance sways were rapid and successive. The peak of the sway was observed at the seconds of 15 and 30 that its rate was about 0.7cm respectively. The distribution of the sway index towards the arousal and activation is shown in Diagram 2. Performance towards arousal has shown a very weak linear relationship. Correlation of the arousal with the sway index was 0.290 and the determination coefficient was 0.09 which was not statistically significant (p=0.12). Correlation of activation with the sway index was 0.501 and the determination coefficient was 0.25. This relationship was statistically significant (p<0.005).

Evaluation of arousal and activation as the independent variables showed that the sway index was not affected by arousal (F<1), while it decreased with higher activation ($F_{1, 28}$=9.478; p<0.01) which justified the amount of 25% of variance in this scale (Table 1).

Table 1- Variance analysis related to the stepwise regression. The predictor variable is activation and the dependent variable is performance. Activation predicts the performance.

Model	Sum of squares	Degree of freedom	Mean square	F	Level of significance
Regression	0.215	1	0.215	9.478	0.005
Remaining	0.636	28	0.023		
Total	0.851	29			

Table 2- Correlations related to the stepwise regression.

Model	Non-standardized coefficients		Standardized coefficients	t	Level of significance
	B	Standard error	Beta		
Fix	0.488	0.038	0.503	12.920	0.0001
Activation	0.026	0.008		3.079	0.005

Table 2 represents the standard and non-standard correlation coefficients related to the regression. The beta standard coefficient showed that by each unit of standard deviation change in the predictor variable of the activation, 0.503 standard deviation change is made in the performance variable.

Table 3- The variable excluded from calculation. This table shows that the SECL could not predict performance.

Model	Beta	t	Level of significance	Partial correlation	Statistics of linear/ tolerance
Regression/ SECL	0.024	0.119	0.906	0.023	0.676

Table 3 shows the statistics of the excluded variable which could not predict the dependent variable, and Table 4 also represents the statistics related to the remained values.

Table 4- Statistic related to the remained values (n=30).

Statistics	Minimum	Maximum	Mean	SD
Predicted Value	0.4481	0.7310	0.5680	0.08616
Remaining	-0.2043	0.3649	0.0001	0.14809
Standard predicted value	-1.391	1.891	0.0001	1.0001
Standard remaining	-1.356	2.421	0.0001	0.983

Discussion

The arousal mean of the whole participants could not predict their scores. The inability of arousal in predicting the performance was probably due to the considerable variability of this variable during the performance. It was likely that the lack of acquisition of tonic arousal as a basal level led to decrease in the correlation between the two variables similar to what happened in the evaluation of activation. Using the basal level introduced in previous studies [1, 32, 33, 36] caused the appearance of a considerable level of activation in the present study which represented the features introduced by Barry et al. [1]. In the present study, activation was a predictor of performance from the obtained scores' perspective. This finding was consistent with previous findings which suggested that activation is the predictor of behavior, but not arousal [1, 32, 33]. The mentioned suggestion which was supported by the findings of this study was consistent with the theoretical basis presented by Pribram and McGuiness who defined the different nervous sub-layers for these two concepts [37, 38].

From the neurological studies related to this phenomenon, it can be concluded that arousal is caused by amygdale activity and the Ascending Reticular Activating System and only affects the physiological responses, but the factor affecting the motor fitness processes is activation which is the outcome of the activity of the basal ganglia. In addition, Pribram and McGuiness stated that arousal controls the stage physiological responses especially the orientating response. According to them, the arousal can be considered as a factor to strengthen the response [37, 38]. From these researchers' point of view, activation is related to a kind of fitness for the related behavior. This finding is consistent with what already reported in laboratory tasks [1, 32, 33, 36]. However, it was necessary to investigate the scope range of the different effects of arousal and activation on performance in balance tasks that is closer to daily life performance.

Balance in the elderly medicine is applied for the rehabilitation of the amputation patients and under movement therapy, patients who lost some degrees of the internal ear function and also in the fields of sport and the championship [34]. Balance as a motor skill is affected by cognitive factors and mental status. Recent studies have shown that many attention demands are required to control the balance [39]. The researches which manipulate mental status (such as pre-test anxiety) and measure the static balance have shown that the increase of anxiety leads to more instability. Benedict et al. measured the relationship between the stress levels and balance acquisition and their findings showed that the group with moderate stress had learned balance tasks better, whereas low and high levels of stress deteriorated the performance [40]. Considering the available differences in the form and objectives of the daily motor tasks compared to the laboratory tasks that probably have more cognition/perception load, findings which refer to the opposite effects of arousal and activation in this task would more acceptably approve the theory of conceptual and functional differentiation of arousal and activation; thus, previous researchers had stressed the necessity of this action [1, 32, 33, 36]. Therefore, the consistence of this research's findings which was done in daily motor tasks for the first time with the findings of the previous researches which evaluated the differentiation of arousal and activation in laboratory tasks shows that the quality of task performance is effected by activation, but not arousal. The common variance was 25% which shows the medium strength of this effect. Knowing that whether the rate of this effect in within-subject manipulations compared to the current inter-subject study would be higher or not, has a considerable attraction which will be paid to in further research.

It should be considered that the correlation found in this study has been interpreted as causal.

The justification of this issue is dependent on the chronological order of the effects [1]. The assumption of the researcher was that the characteristics of the balance task have caused the increase of Skin Electrical Conductance Level (SECL) from the basal level to the observed level during the task. The researcher has also assumed that the increase of Skin Electrical Conductance Level (SECL) that is the task related activation has increased the sway index.

When the binomial relationship between variables was observed, the shared variance was more than the time that their linear relationship was tested (r^2=0.62).

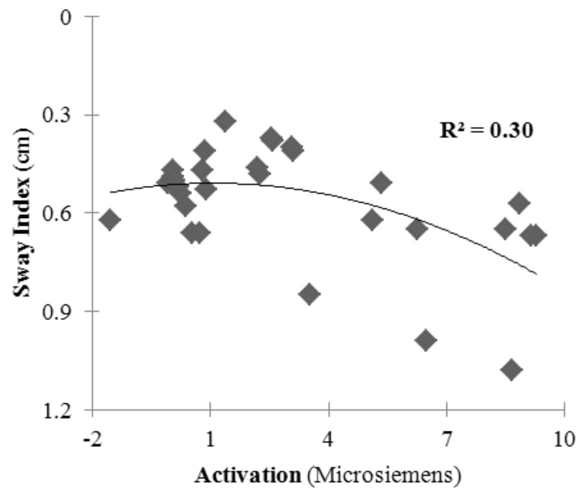

Diagram 3- This figure is actually the lower part of Diagram 2, but the non-linear regression has replaced the linear regression. It could be observed that the shared variance is more than the time that the linear regression was considered. This figure confirms the inverted U relationship between activation and performance.

Diagram 3 shows the binomial relationship between activation and the sway index which was observed in the form of the inverted U. The inverted U relationship was not observed between activation and performance in previous laboratory studies. These studies which measured the effect of activation on the continuous laboratory tasks, only pointed to the significant linear relationship between the two variables [1, 32, 33]. It seems that one of the causes of the previous studies' failure in observing the nonlinear relationship between two variables was the minimal range of changes in the activation in those studies. The continuous laboratory task requires minimal changes in the SECL and consequently in the activation. The maximum range of the activation changes have been reported 2.5 Microsiemens in previous studies [1, 32, 33]. The static balance task in the present study requires severe muscle contractions to keep center of mass center at the reliance level which is reflected in the SECL changes. Evidence recently presented about the change scope of the activation and its relationship with performance in shooting also support this suggestion. The change scope of activation was about 7 Microsiemens in the abovementioned study [41]. Despite observing the inverted U relationship between activation and performance, the findings of this study did not support the hypothesis of the inverted U. Retesting the inverted U relationship requires the experimental manipulation of the activation level or at least the classification of the subjects according to the initial level of arousal. The importance of studying this relationship especially in the static balance task which plays role in the motor development of children, the elderly social welfare and the optimal the sport performance form the further pathway of the present study. Thus, it seems that in further studies, the exact investigation of this relationship is possible using an approach which studies the curve relationship Differentiation of the arousal and activation's effects on the balance performance stresses that continuing the process of the present research will be more valuable in a wide range. The confirmation of present study results by further studies will make researchers able to predict the effects of activation in more complex sport skills. This would encourage us to understand the interaction between the scales which reflect our physiological energetic aspects and their behavioral links at the advanced level of sport skills (particularly the class of the skills with several emotional links).

Conclusion

Activation has a negative linear relationship with performance, while arousal does not correlate with performance. Activation in the balance task also predicts performance with medium strength. The quality of the task is affected by activation, but not arousal.

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