Relationship Between Arousal and Choice Reaction Time

Samaneh Damanpak[1]*, Puneh Mokhtari[2] and S. Mohammad Vaez Mousavi[3]

[1]Department of Physical Education, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[2]Department of Physical Education, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
[3]Department of Psychology, Exercise Physiology Research Center, Baqiyatallah University of Medical Sciences and University of Imam Hossein, Tehran, Iran.

doi: http://dx.doi.org/10.13005/bbra/1341

(Received: 16 June 2014; accepted: 20 July 2014)

Traditional Inverted-U hypothesis had been the primary model used by sport psychologists to describe the arousal-performance relationship. However, many sport psychology researchers have challenged this relationship. The aim of the present study was to determine the relationship between arousal and Choice Reaction Time (RT) performance .28 non-athlete female undergraduate students (mean age: 20 years and 6 months) voluntary participated in this study. They were asked to produce responses by depressing buttons with two fingers of one hand in choice RT task. Skin Conductance Level (SCL) as arousal index was recorded continuously during performance. Results indicated that arousal did not correlate with performance. This finding provides no support for the Inverted-U hypothesis in relation to choice RT performance.

Key words: Arousal, skin conductance level, choice reaction time, inverted- U hypothesis.

In many situations, one should take the best decision at least possible time. The importance of this issue is more obvious in the world of sports, as taking the correct decisions at least possible time considered an important part of skilled performance[1]. In such cases, the reaction time is very important. Reaction time (RT) also called response latency is defined as time from the onset of a stimulus to the occurrence of a response (S-R interval)[2,3]. It is a reliable index related to processing speed of sensory stimuli made by central nervous system and its execution as motor response[4,5].

There are many factors, such as type of stimulus and stimulus intensity[6-8], which affect reaction time. Moreover, some studies show that characteristics of the subjects such as age, gender and level of arousal may also change the RT[9-13].

Reviewing the literature shows that arousal improves some aspects of performance. Preliminary studies[14,15] proved a relation between performance and arousal level. There are several hypotheses such as drive theory, catastrophe model, Individualized Zone of Optimal Functioning (IZOF), inverted- U hypothesis and etc tried to describe the relationship between arousal and performance. In this context, inverted- U hypothesis have been the primary model used by sport psychologists to describe the arousal-performance relationship[16]. According to this, the relationship between performance and arousal is curvilinear, meaning that performance increases up to a certain level of moderate arousal, but as the arousal increases further performance deteriorates[17]. Stennett[18] examined this issue in human participants in auditory tasks and realized that these tasks will be performed better in the average levels of arousal. Studies of Sjoberg[19], Levitt and Gutin[20], Martens

* To whom all correspondence should be addressed.
E-mail: sdamanpak@gmail.com

and Landers[21], Lansing *et al.,*[22] and some other studies[2,9, 23-25] supported inverted- U hypothesis, but some others have failed to show this[26-28]. Some researchers also have reported no relationship between arousal and cognitive functions such as RT[29-34]. Gould and Krane[35] pointed out that most conflicting results may be due to controversies over the concept of arousal and its related states. One of the reasons is application of different measures of arousal measurement, such as heart rate (HR) and skin conductance level (SCL) and inconsistency reported between these measures[36-38].

Difficulties in finding appropriate measure for arousal measurement in the literature of psychophysiology continued until Tremayne and Barry[39] suggested SCL as an index of arousal. SCL is a sensitive measure of the tonic modulation of sympathetic activity[40] and the "gold standard" in the measurement of arousal[41]. It shows the electrical changes related to the activities of sweat glands (which are mostly concentrated in the palm of the hands and feet).

This study was designed to examine the relationship between arousal and performance in the choice RT. SCl was considered as index of arousal and its relationship with the performance of choice RT was evaluated.

METHOD

Participants

28 non-athlete, right- handed female undergraduate students, aged between 18 and 22 (mean age 20 years and 6 months), participated in this study. None of the participants had previous experience in RT tasks; none of them ever suffered from an epileptic seizure, serious head injuries, or periods of unconsciousness and none had hearing or vision problems, or received treatment for nerve or sensory problems.

Procedure

After describing the study to the participants, data were collected separately from each participant in an air-conditioned laboratory; electrodermal activity was recorded using a constant voltage device (UFI Bioderm Model 2701). Two 7.5 mm diameter Ag/AgCl electrodes were attached on the distal phalanges of the second and third digits of the participant's non-preferred hand, with an electrolyte of 0.05 M NaCl in an inert viscous ointment base.

Participants sat facing the screen with their fingers resting comfortably on the response buttons. They were presented with two-choice RT task. The test included two series of stimulus, each series consist of 20 separate stimuli. Participants had to respond quickly and accurately by depressing one of two vertically arranged buttons (gray & black) on a response box. They worked with two fingers of one hand (each finger on a button). The visual stimuli consisted of "dot" and "cross" were used in this test. Depends on presented stimulus, one had to respond to that specific stimulus. For example, if the "cross" displayed on screen, she would respond by depressing gray button. If it didn't, she'd respond by depressing black button. Each stimulus was preceded by a warning signal (a blue exclamation mark). This signal appeared 1.5 seconds ahead of the stimulus and remained visible until the stimulus was presented. After a response given by participant (by depressing a button) nothing was displayed on the screen for 2 seconds. Then the warning signal appeared again to indicate that the next stimulus is going to be presented. After a practice session, the task commenced when understanding of the instructions was evident. SCL was sampled continuously at 10 Hz.

Data Processing

The mean of SCLs which were recorded during the test was used as arousal index. Mean choice RT for correct responses were taken as the measure of performance.

Statistical Analysis

We used r Pearson to determine the relationship between arousal and choice RT task. The significant level for the tests was set at ≤ 0.05. All analyses were executed using the statistical package SPSS 16.

RESULTS

The mean choice RT for each participant is shown in relation to arousal in the Fig.1. As shown in the Figure, Choice RT versus arousal showed a weak negative linear relationship. Correlation of arousal with choice RT was -0.25 and the coefficient of determination was 0.06. This relationship was not statistically significant ($P > 0.05$).

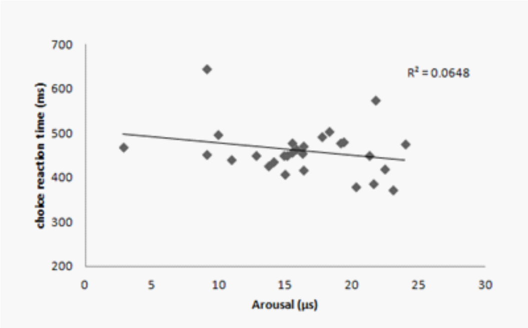

Fig.1. Mean RT of each subject as a function of arousal level. Set of data in this figure is fitted with a linear regression line and the coefficient of determination for this regression is indicated

DISCUSSION

The aim of this study was to evaluate the relationship between arousal and choice RT. Although several studies have shown that the relationship between choice RT and arousal follows an inverted U pattern[9- 10, 19- 20, 22-25], some studies have also failed to provide support for this hypothesis[26-28]. In this study, we found a weak linear relationship between arousal and performance which was not statistically significant. Our study provides no support for inverted- U hypothesis which is consisted with some previous studies[26-28]. It would appear that the linear relationship found in the present study can be better explained better by drive theory. According to this theory, increases in arousal will lead to an improvement in performance. According to Hull [40], a linear improvement will only be shown if the task is well learned and habit strength is high. If the task is novel, there will either be no significant effect or a catastrophe effect at some stages. It seems that inexperience participants in RT tasks can explain the observed weak linear relationship in this study.

Several previous studies failed to report inverted- U relationships, this was often because the linear relationship was too dominant[26,41]. However the relationship observed in the current study was not statistically significant; the relationship was linear rather than inverted-U shape. It seems many factors affect the relationship between arousal and performance. Raedeke and Stein[42] stated that to understand more and better of arousal/performance relationship, the interaction between arousal, thoughts and feelings should be considered. Further studies on this issue through considering different factors are necessary to examine arousal/ performance relationship.

REFERENCES

1. Wang, J. Reaction time training for elite athletes: A winning formula for champions. *International journal of coaching science,* 2009; **3**: 67-78.
2. Welford A T. Introduction: a historical background sketch in Reaction times. The ability to respond to a stimulus is a reaction. Academic press, New York 1980; 1-24.
3. Woodsworth R S. Reaction time. History of reaction time. Experimental psychology. Holt, Rinehart and Winston, Inc. Columbia 1938; 298-349.
4. Schmidt, R.A. and T.D. Lee. Motor control and learning: A behavioral emphasis, Human Kinetics Publishers, 2005; 356-388.
5. Menevse, E.A. Examination of the relationship between muscle palmaris longus and reaction time. *World Applied Sciences Journal*, 2011; **12**(1): 114-118.
6. Galton, F. On instruments for (1) testing perception of differences of tint and for (2) determining reaction time. J*ournal of the Anthropological Institute*, 1899; **19**: 27-29.
7. Woodworth, R. S. and H. Schlosberg. Experimental Psychology. Henry Holt, New York, 1954.
8. Shelton J, Kumar GP. Comparison between auditory and visual simple reaction times. *Neurosci Med*; 2010: 30-32.
9. Broadbent, D. Decision and stress. New York: Academic Press, 1971.
10. Welford, A. Motor performance. In J. Birren & K. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold, 1977: 450-496
11. Welford, A. Choice reaction time: Basic concepts. In A. Welford (Ed.), Reaction times. New York: Academic Press, 1980: 73-128
12. Sanders, A. Elements of human performance: Reaction processes and attention in human skill. Mahwah, New Jersey: Lawrence Erlbaum,1998.
13. MacDonald, S., Nyberg, L., Sandblom, J., Fischer, H., & Backman, L. Increased response time variability is associated with reduced inferior parietal activation during episodic recognition in aging. *Journal of Cognitive Neuroscience*, 2008; **20** (5): 779-787.
14. Malmo, R.B. Activation: A neurophysiological dimension. *Psychol. Rev.,* 1959; **66**: 367-386.

15. Duffy, E. Activation and Behavior. Wiley, New York, 1962.
16. Haywood, K.M. Psychological aspects of archery In: The Sport Psychologist's Handbook: A Guide for Sport-Specific Performance (Dasil, J., Ed.). John Wiley and Sons Ltd., London, 2006; pp: 549-568.
17. Yerkes, R. M. & Dodson, J. D. The Relation of Strength of Stimulus to Rapidity of Habit-Formation. *Journal of Comparative Neurology and Psychology,* 1908; **18**: 459-482.
18. Stennett, R.G. The relationship of performance level to level of arousal. *Journal of Experimental Psychology*, 1957; **54**: 54-61.
19. Sjoberg, H. Relations between heart rate, reaction speed, and subjective effort at different workloads on a bicycle ergo meter. *Journal of Human Stress*, 1975; **1**: 21-27.
20. Levitt, S. and B. Gutin. Multiple choice reaction time and movement time during physical exertion. *Research Quarterly,* 1971; **42**: 405-410.
21. Martens R, Landers D.M. Motor performance under stress: A test of the inverted U hypothesis. *Journal of Personality and Social Psychology,* 1970; **16** (1): 29-37.
22. Lansing RW, Schwartz E, Lindsley DB. Reaction time and EFG activation. *Am Psychol* 1956; **11**: 433.
23. Freeman, G. L. The facilitative and inhibitory effects of muscular tension upon performance. *American Journal of Psychology,* 1933; **26**: 602-608.
24. Arnet SM, Landers DM. Arousal, anxiety and performance: A reexamination of the inverted-U hypothesis. *Research Quarterly for Exercise and Sport*, 2003; **74** (4):436-44.
25. Kamijo K, Nishihira Y, Higashiura T, Hatta A, Kaneda T, Seung-Ryol K, et al. the interactive effects of exercise intensity and duration on cognitive processing in the Central Nervous System. *Adv Exerc Sports Physiol*, 2006; **12**: 1-7
26. Paller K, Shapiro D. Systolic blood pressure and a simple reaction time task. *Psychophysiology,* 1983; **20**: 585-92.
27. Stern RM. Reaction time between the get set and go of simulated races. *Psychophysiology,* 1976; **13**:149-54.
28. Wankel LM. Competition in motor performance: an experimental analysis of motivational components. *J Exp Soc Psychol,* 1972; **8**: 427-37.
29. Fazey J, Hardy L. The Inverted-U Hypothesis: A Catastrophe for Sport Psychology? *British Association of Sports Sciences,* 1988.
30. Bagherli,J., Vaez Mousavi, S.M., Mokhtari, P. Effects of Arousal and Activation on Simple and Discriminative Reaction Time in a Stimulated Arousal State. *World Applied Sciences Journal,* 2011; **12** (10): 1877-1882.
31. Barry, R.J., A.R. Clarke, R. McCarthy, M. Selikowitz and J.A. Rushby. Arousal and activation in a continuous Performance task. *J. Psychophysiol*, 2005; **19**(2): 91-99.
32. Vaez Mousavi, S.M., R.J. Barry and A.R. Clarke. Individual differences in task-related activation and Performance. *Physiology & Behavior,* 2009; **98**: 326-330.
33. Vaez Mousavi, S.M., R.J. Barry', J.A. Rushby and A.R. Clarke. Evidence for differentiation of arousal and activation in normal adults. *Acta Neurobiol. Exp*., 2007a; **67**: 179-186.
34. Vaez Mousavi, S.M., R.J. Barry, J.A. Rushby and A.R. Clarke. Arousal and Activation effects on Physiological and behavioral responding during a continuous Performance task. *Acta Neurobiol Exp,* 2007b; **67**: 461-470.
35. Gould, D, & Krane, V. The arousal-athletic performance relationship: current status and future directions. In T. S. Horn (Ed.), Advances in sport psychology. Champaign, K: Human Kinetics, 1992; 119-141.
36. Croft, R.J., C.J. Gonsalvez, J. Gander, L. Lechem and R.J. Barry. Differential relations between heart rate and skin conductance and public speaking anxiety. *J. Behav. Therapy Exp. Psychiat., ,* 2004; **35**: 259-271.
37. Lacey, J.I. Somatic response patterning and stress: Some revisions of activation theory In: Psychological Stress Issues in Research (Appley M.H. and R. Trumbull (Eds.)). Appleton-Century Crofts, New York, 1967; 14-44.
38. Lacey, B.C. and J.I. Lacey. Some autonomic central nervous system interrelationships In: Physiological Correlates of Emotion (Black, P., Ed.). Academic Press, New York, 1970; pp: 214-236.
39. Tremayne, P. and R.J. Barry. Elite pistol shooters: physiological patterning of best vs. worst shots. International *J. Psychophysiol,* 2001; **41**: 19-29.
40. Hull CL. Principles of behavior, New York: Appleton; 1943.
41. Cox RH. Consolidation of pursuit rotor learning under conditions of induced arousal. *Res Q Exerc Sport,* 1983; **54**: 223-8.
42. Raedeke, T. Stein, G. Felt arousal, thoughts/ feelings and ski performance. *Sport Psychol,* 1994; **8**: 4.