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Altered reaction ability as a Function of Enhancement in Cortical Activation

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Abstract

The present study aims at understanding relationships between different psychological parameters in explaining soccer performance outcome. Attempts have been made to realize the relative significance of perceptual-motor skills influencing relevant psychological, physiological factors required for achievement of performance excellence. One-hundred seventy-six young soccer players living in Kelantan province of Malaysia participated in this study. Regression analyses were done to identify in-depth relationship between the psychological and psychomotor processes with psychobiological autonomic arousal modulation capacity of the players, which would determine higher-order cortical activation in the soccer players. These analyses were associated with performance analyses pertaining to skilful soccer performance. Psychomotor and autonomic processes involved in differential levels of soccer participation and performance were verified in accordance with the level of cortical activation. Generalised lack in motor coordination, delayed movement timing as well as faster reaction ability along with adequate autonomic response habituation were viewed as the most significant intervening variables explaining cortical activation observed in the soccer players.

Keywords: Soccer, reaction ability, cortical activation.

Introduction

Success in soccer performance mostly depends up on achievement of mastery over bodily movements characterized by agile reactions, which refer to the ability of the players to perform abrupt body fainting movements. Talent identification in soccer hence would focus mostly on bodily characteristics of the talented players in ensuring agile most performance. Researchers concentrating on predictors of performance excellence in soccer, instead hinted up on the significance of combined input of physical, physiological, sociological and psychological factors which interacting in between to bring forth talented soccer performance[2]. The present study thus intended to focus on only the psychological aspects predicting changes in soccer performance. As it was proposed by Williams and Reilly in their pioneering work (2000)[1] , apart from personality variables perceptual-cognitive skills such as – attention, anticipation and motor skills were better predictors of performance excellence in soccer. Here we need to acknowledge that, in sports particularly in soccer, attentional aspects are specifically related to perceptual-motor skills, such as reaction ability, anticipatory reaction time, movement coordination etc. At par with that notion, our previous attempts concerned with revealing impacts of perceptual motor and other associated factors on the cognitive-emotional make-up of the players of Indian Sub-continent as well as of ASEAN clarified a vicious cycle of psycho-regulatory problem in the players of ASEAN region.

Cognitive-emotional make up of players of ASEAN countries: i. Cognitive constrictions inhibits normal sensory-motor information processing[3], ii. Perceptual- cognitive inability in adopting faster and accurate level of anticipations[4-5], iii. Retarded level of anticipation, coordination and motor processing hinders faster reaction[6-8], iv. Slower reactions and poor anticipations reduce chances of getting ahead of opponents[9-11], v. Generalized perception of deficient performance reduces internal self-regulation and motivation[12], vi. Dispositional lack in effective stress management[13-15].

The aforementioned analogy however was postulated on the basis of outcomes obtained from investigation on quite large number of ASEAN as well as other neighboring South-Asian athletes and players from different disciplines, which were carried out in past four years[2,7,8,14,15,12]. Based on those previous researches we developed one model explaining predictive relationships between few selective psychomotor, perceptual, cognitive, emotional and performance variables, which are clarified in the Figure 2. This model however was developed on the basis of predictive regression analysis reports, which however depicted that - cortical activation related to perceptual discrimination had significant contributions onto Visual ability of the players in anticipating changes in competitive situations and onto the regulation in autonomic activation. Visual anticipation was also observed as influential in regulation of autonomic activation and in visual perception as well. Thus finally visual reaction ability and movement time performance was directly influenced by visual perception, dynamic interactional contribution of perceptual and autonomic processes

and on autonomic regulation as well. Contribution of cortical activation, visual anticipation and autonomic adaptation were mediated through other interactional processes, while dynamic exchanges between perceptual-autonomic processes, visual perception and autonomic regulation emerged as significant direct predictor of reaction ability in the players[2,7,8,12,14,15]. This phenomenon of associations between autonomic and cortical activation and perceptual motor skills with particular reference to reaction ability was mostly evidenced in soccer players[1,2,6,9,10,13,16] and hence we intended to know about the possibility of corroborative contribution of alterations in psychomotor aspects onto the modifications in cortical activation. We postulate that, any modification in cortical activation would be mediated through alterations in autonomic regulation, since psychomotor activations would lead to modifications in the pre-motor cortex as well as in both ascending and descending reticular tract[2,14,15,17] and if so, then the valid issue would be how far a sustainable change in cortical activation is possible through modifications in perceptual-motor skills.

With such a background the present study purports: i. To know about the differential contribution of reaction performances on the cortical regulation in the soccer players. ii. To compare the nature of relationships between cortical activation and simple as well as complex reaction ability of the players. iii. To realize the influence of autonomic regulation evaluated by the skin conductance activity on the level of cortical activation observed in the soccer players.

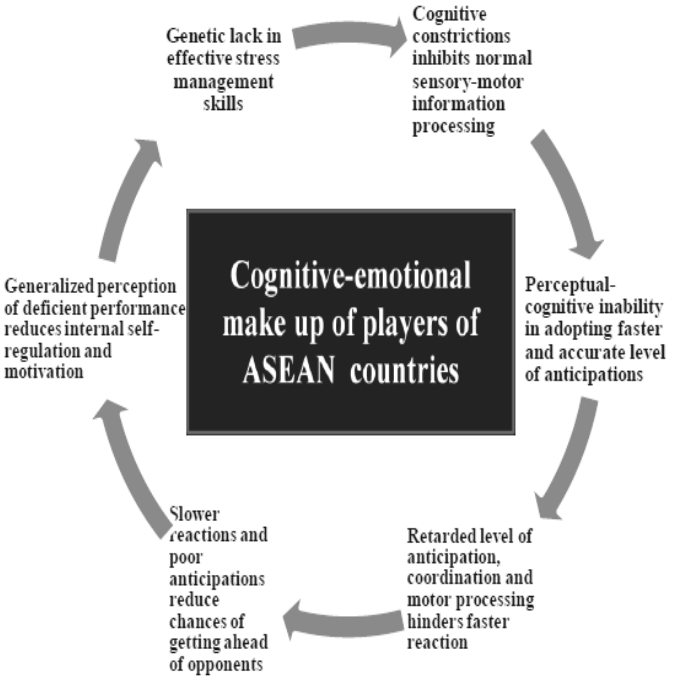

Figure-1
Cognitive-emotional make up of players of ASEAN countries

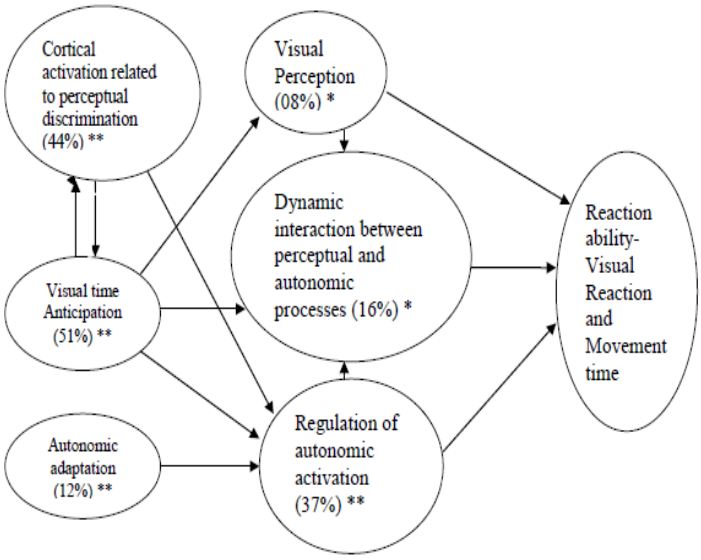

Figure-2
Percentage of shared contributions of the variables influencing the reaction performance in the players.

Methodology

Participants: This study was concerned with predictive relationships, and hence on the basis of the sample size calculation in this study, 176 high-skilled soccer players of Kelantan province of Malaysia, age ranged between 20 – 23 years were recruited as participants. The sample size was calculated using G power 3.1.7 in which the power of the study is set at 95% with 95% confident interval and the effect size F at 0.10[18]. They were mostly state selection–level soccer players and they were selected by three expert soccer coaches, while they were preparing for their forthcoming soccer season in 2014.

Materials Used: For assessment of psychophysiological parameters: i. Heart Rate Monitor (Polar Team System HR Monitoring System – Polar, Norway, 2012). ii. Critical Flicker Fusion Threshold (CFF Apparatus - Lafayette, USA, 2010) (Refer to Figure-3). iii. Electrical Muscle Potentiality (EMG Apparatus) (ME6000, Finland, 2008). (Refer to Figure-4). iv. Skin Conductance Biofeedback Apparatus (ProComp5 Infinity, USA 2014) figure-5.

Performance Test and Reaction ability test: – Ball, cons, stop watch, marker, PVC Box, electronic reaction timer.

Procedure: All of the participants were subjected to assessment of psychobiological parameters such as skin conductance analyses (ProComp5 Infinity, USA 2014), evaluation of electrical muscle potentiality (ME6000 EMG Apparatus, Finland, 2008), assessment of cardiovascular efficiency (Polar Team System HR Monitoring System – Polar, Norway, 2012) and analyses of cortical competence based on Critical Flicker Fusion Threshold (Lafayette, USA, 2010). Apart from that

psychomotor parameter such as simple muscular reaction time measures were analyzed employing electronic reaction timer (Udyog, 2001).

Figure-3
CFF apparatus

Figure-4
EMG apparatus

Figure-5
Sc apparatus

The afore-mentioned measures were taken in the laboratory of Department of Exercise and Sports Science, in the Univ. Sains Malaysia and for the field –specific whole-body reaction type with the soccer ball agility test, participants were taken to the indoor facility of the sports complex within the university campus. There the players were subjected to perform slalom soccer zigzag run test (figure-6 Serdarevic, 2011), in which the soccer players were supposed to run with the ball avoiding the cones. The task was made complicated, since they were allowed to pass the ball through the cones wherever two cones are lined, but were not allowed to do so, while they had to pass by the three-cone pathway. Thus they were supposed to run with the ball from one end of the path up to the other end and returning back to complete the run altogether for three times. Total time taken to perform this task and the numbers of errors committed (if they hit the cones either by foot or by the ball and if they pass the ball through the three-cone pathway where they were not supposed to pass) by the players were recorded as data for the complex reaction time performance. Thereafter the obtained data were analyzed using SPSS version 21.0. Descriptive statistics were done only to evaluate the normality index, and wherever Obtained scores were evident either as skewed or kurtotic, those were filtered and transformed following standardized methods of corrections. Thereafter the normality treated data were treated for standard score (Z-score) conversion. Thereafter the extents of predictive contributions of differential aspects of reaction ability on the measures of cortical competence were evaluated on the multiple-linear regression analyses.

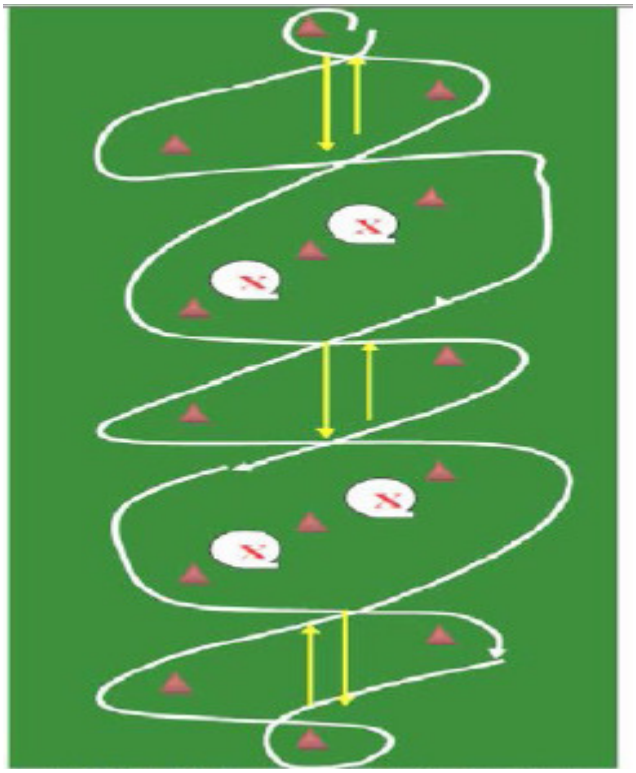

Figure-6
Slalom Soccer agility drills test Serdarevic (2011)

Results and Discussion

Descriptive analyses were done to verify the extent of normality in the data and wherever data were found away from normality, those were treated and were finally prepared for multiple linear

as well as non-linear regression analyses. Table I represented the outcomes of multiple linear regression analyses, in which the model *a* explained that, predictors such as Autonomic Arousal, Simple Reaction time, Movement time and Complex reaction time together could predict 67.2% of extent of changes in cortical activation observed in the players. Model a further revealed that, when inhibitive impact of autonomic arousal is regressed or controlled for the extent of cortical activation, players observed as having faster simple reaction time had higher cortical activity, though delayed movement time as well as complex reaction time were found associated with the higher-order cortical activation.

In Table 2 the model *b* emerged as a significant model which however explained that, independent predictors such as second-order or squared version of complex reaction time, simple reaction time and movement time observed in the soccer players could predict 73.5% of extent of changes in cortical activation. Model b further revealed that, when inhibitive impact of squared version of complex reaction time is regressed or controlled for the extent of cortical activation, players observed as having faster simple reaction time had higher cortical activity, though once again delayed movement time was found associated with the cortical activation, which may reveal that cortical overloading might be relatively more over-whelming for the soccer players to move faster.

Predictive contribution of psychomotor factors especially of the obtained reaction performance outcomes were attempted to verify on the basis of multiple linear as well as polynomial analyses. Prior to concentrating on the predictive relationships, we intended to see the outcomes of perceptual motor competence of the soccer players onto the changes in cortical activation. Figure 7 however clarified that, combined impact of all of the perceptual motor skill variables onto the extent of cortical activation was observed. Measures of reaction ability (SRT), movement time (MT), movement coordination (RP), anticipation (BAT), complex reaction ability (with the ball agility) (CRT) and fine motor control variables, such as - two-arm coordination (TAC), motor skill (MS) and motor learning ability (ML), were observed as having significant contribution onto the extent of changes in cortical competence. Here the path regression analysis explained a combined influence of all of the psychomotor variables onto the cortical activation, which however did not clarify the shared aetiology of those variables onto the changes in cortical activation. Predictive regression analyses were done to emphasize on the relative contribution of psychomotor variables, which are being discussed in the next section.

Table-1
Summary of linear multiple regressions

Variable	B	Standard error	Beta	T	P
Dependent Variable: *Cortical Activation* [a]					
Intercept	-5.782	1.498	-	2.561	.019
Autonomic Arousal	-0.021	0.010	-1.984	-2.220	.048
Simple Reaction time	- 0.059	0.014	-0.428	-4.158	.004
Movement time	7.485	2.102	2.158	3.456	.032
Complex reaction time	0.111	0.044	1.141	2.543	.027

[a] ($F(11, 149) = 3.205$, $p < 0.001$)) model adj. $R^2 = 67.2\%$.

Table 2
Summary of linear multiple regressions

Variable	b	Standard error	Beta	T	p
Dependent Variable: *Cortical Activation* [b]					
Intercept	3.810	0.621		6.135	.000
Complex reaction time (Squared)	-2.335	0.474	-1.141	-4.993	.003
Simple Reaction time	- 0.689	0.174	- 0.428	- 3.984	.004
Movement time	0.485	0.102	2.158	4.759	.008_

[b] ($F(12, 153) = 12.051$, $p < 0.007$)) model adj. $R^2 = 73.5\%$.

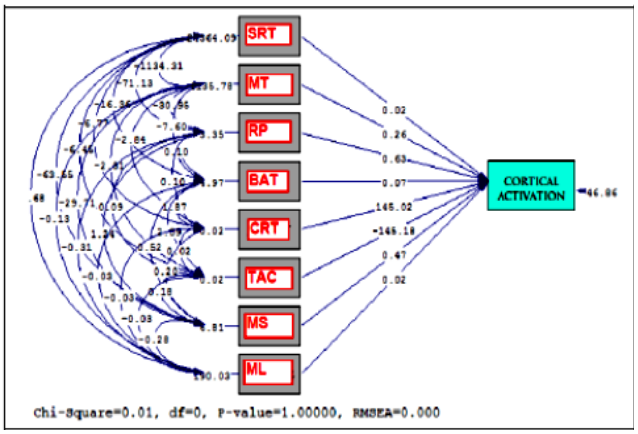

Figure-7
Diagram of Structural Equation Revealing Predictive Relationship Between Psychomotor Parameters and Cortical Activation

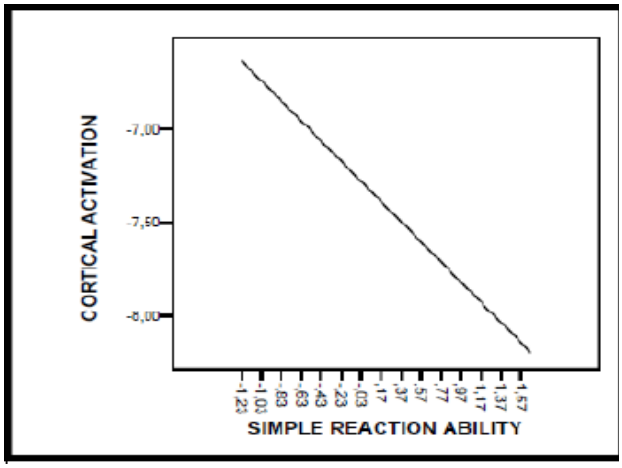

Figure-8
Graphic Representation of Linear Relationship Between Simple Reaction Ability and Cortical Activation

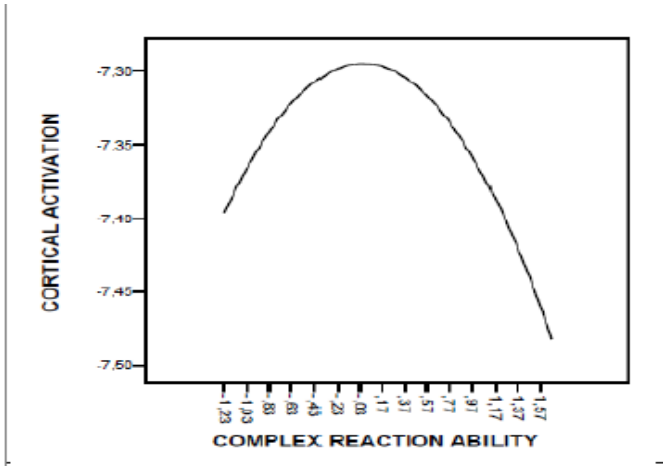

Figure-9
Graphic Representation of Non-Linear Relationship Between Complex Reaction Ability and Cortical Activation

Two different models were conceived for explanations onto differential impacts of psychomotor variables mediated by autonomic activation and without the influence of autonomic activation. Model *a* implied that, when autonomic arousal was adjusted for cortical activation, it was observed that, players having higher extent of autonomic arousal had lower extent of cortical activation. When heightened autonomic arousal was regressed for, outcomes of those who had relatively lower extent of autonomic arousal were evident, which however revealed that, faster simple reaction time was found associated with higher extent of cortical activation. The model *a* further revealed that, those who were observed to have relatively delayed movement time as well as delayed complex reaction time performance were found as having higher extent of cortical activation. Thus outcomes of model *a* however clarified that, if players have lower extent of autonomic arousal, they are supposed to have faster reaction ability, yet may have relatively slower movement time and delayed agility performance. Further to that, role of autonomic mediation in alteration in cortical activation was confirmed[2,15,17] and apart from that relationships between psychomotor parameters and cortical competence without autonomic influence was also verified.

To verify extent of contribution of perceptual motor skill parameters on cortical activation with particular reference to reaction ability independent of autonomic influence, model *b* was conceived, which however revealed that if the non-linear relationship revealed between complex reaction performance and cortical activation is adjusted for, faster simple reaction but relatively delayed movement timing were observed to contribute in higher extent of cortical activation evident in the players. Here we need to pay attention to the nature of observed contribution of complex reaction performance, since the polynomial relationship revealed that delayed reactions, which were observed as outcomes of with the ball agility performance, had been associated with cortical activation. Interestingly a considerable extent of improvement in agility had huge impact on cortical activation. In fact players who had relatively faster with the ball agility had been observed as having highest level of cortical activation. Finally fastest agility performance was evidentially associated with moderate extent of cortical activation, which however seemed to match with the inverted- U hypothesis, in which instead of arousal, agility was observed as having differential contributions onto cortical competence of the soccer players. Thus if the observed inhibitive contribution of soccer players' ability to display agile reactions was regressed or controlled for cortical activation, simple reaction ability and movement timing significantly contributed in changes in the extent of cortical activation. Finally outcomes explained complicated relationships between the psychomotor behavioural outcomes and cortical activation indices, in which, players who had slower agility also evidentially had slower reaction ability but relatively faster movement timing, and that resulted in very low extent of cortical activation. The observed relationships were evidentially on line with those reported by Williams and Reilly[1] and Saha and Saha[4]. The quadratic relationship between

agility performance and cortical activation however explained that, players having moderately faster agility were able to have very fast reaction ability but delayed movement timing, which however facilitated in maximal extent of cortical activation. This finding however gets supported by our previous researches[2,6,16]. Contrary to these findings, our previous findings[3,5,7,12], were observed to report association between moderate level of cortical activation and faster reaction and agility performance outcomes in male young-adult players. Here, we need to highlight that, the observed contradiction could be attributed to the experimental sample, since Saha and her co-researchers in both of the studies[3,5] included Malaysian superior level competitive swimmers (both Mala and Female participants), and in other studies Saha and his colleagues[7,12] reportedly observed the contradictory findings, while working on World-class as well as developmental level of young male cricketers, who were supposed to have differential extent of cortical competence and agility component were also altogether different for them. Finally a differential phenomenon was observed when players having fastest agility were observed to have moderately fast reaction ability as well as faster movement timing too, and those were found to result in moderate level of cortical activation in the players. Outcomes of previously done methodologically sound researches of Saha and his co researchers[9] and that of Togari and his colleagues[16], confirmed similar findings, while in their universally acclaimed research Suzuki and his colleagues[10] reported to observe a differential nature of relationship between cortical efficiency and agility behaviour. In-depth scrutiny however revealed that, observations of Suzuki and his colleagues were based on the findings obtained from the soccer goal-keepers only, while the present data were obtained mostly from soccer defenders and mid-field players (none of the participants were custodians).

Thus the outcomes of this present study could be summated as, simple reaction ability and cortical activation were found to have predictive relationship which was not similar to that obtained on the basis of prediction analysis between with-the-ball agility performance and cortical competence of the players. Differential natures of shared aetiology behind alteration in cortical activation have been confirmed.

Conclusion

i. Two flash threshold measures in way of critical flicker fusion threshold served as indices of cortical activation was found associated with reaction ability of the high performer soccer players. ii. Skin Conductance activity was observed closely associated to reaction ability of the players, which however evidentially facilitated in optimal cortical activation required for high soccer performance. iii. Both simple and complex reaction abilities were found negatively associated with optimal cortical activation, though differential natures of relationships were explained. iv. Simple reaction ability was found linearly associated, while a quadratic relationship between complex reaction ability and cortical activation have been observed.

Acknowledgement

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