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FIT2012-0273

Impact of Accuracy in Anticipation on Decomposition of Autonomic Tonic and Phasic Responses as Predictor of Performance Excellence in Malaysian Swimmers

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URL Conference Papers Series: www.atiner.gr/papers.htm

Printed in Athens, Greece by the Athens Institute for Education and Research.

ISSN **2241-2891**
15/11/2012

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This paper should be cited as follows:

Saha, S., Saha, S., Krasilshchikov, O. and Ismail, Mohd. S. (2012) **"Impact of Accuracy in Anticipation on Decomposition of Autonomic Tonic and Phasic Responses as Predictor of Performance Excellence in Malaysian Swimmers"** Athens: ATINER'S Conference Paper Series, No: FIT2012-0273.

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Abstract

Present study was aimed at identification of intricate relationship between the ability of the high performing swimmers (National – level swimmers of Malaysia) in anticipatory cue-utilization and corresponding autonomic phasic responses isolated from the tonic measures. Altogether two-hundred and twenty-five individuals having high athletic calibre, and holding top-positions in recently held National and International (Mostly ASEAN level) meets volunteered as the participants in this study. Simultaneous evaluation of autonomic arousal modulation (habituation paradigm tonic and phasic measures of Sc) was done when the swimmers were engaged in cue-related anticipatory task, associated with complex reaction performance. For this purpose, participants were evaluated intermittently (twice within the calendar

year August 2010 – July 2011) with the identical research paradigm. Perceived sense of competence as well as the subjective feelings of apprehension of loosing was explored, and attempts were made to identify the obscure subjective expression of cognitive-emotional make-up, in explaining differential performance outcomes evident in the participants. Findings of multiple linear and polynomial regression analyses and predictive structural analyses however suggested direct, inverse and supportive relationships between measures of physiological arousal and psychological phenomena related to cognitive-affective and affective-motivational aspects of sports behaviour explaining pathways to both excellent and debilitative performance outcomes during practice sessions as well as in actual competitive situations.

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INTRODUCTION

Effective utilization of time and a feeling of passing of time are often considered as quite important aspect of successful performance in sports. The ability to anticipate occurrence of relevant cues are extremely important in sports because of the severe time constraints placed on the performer (Abernethy, 1987). A considerable research base confirms that the experts or the successful players have superior ability to use such information to reliably anticipate occurrence of relevant event as well as an opponent's actions. Expert players employ more pertinent search strategies, eliminate irrelevant cues and fixate on more informative areas of the display, enabling them to effectively anticipate action requirements (Williams and Davids, 1998).

Skilled performers are better able to make use of expectations or situational probabilities to facilitate anticipation and are less affected by changes in emotional state. The visual search behaviours in them are robust to changes in emotional states such as anxiety, whilst players having difficulties in temporal occlusion (Williams and Burwitz, 1993), typically increase their search rate and fixate on more peripheral display areas as a result peripheral narrowing or increased susceptibility to task irrelevant cues (Williams and Elliott, 1999).

Glencross and Cibich (1977) reported that players, who react to the stimulus as opposed to anticipating its intended occurrence, are unlikely to be successful. Such skilled behaviour requires many years of practice, allied to considerable amount of ability (Erickson et al, 1993). This ability of anticipation – coincidence can be defined as the timing of an own response to coincide with a response triggered by an outside source. It is thus accepted that successful performance in such sports requires skill in perception as well as the efficient and accurate execution of movement patterns (Williams and Burwitz, 1993). Recent studies have shown that pre-stimulation temporal cues are used in number of sports (Abernethy, 1987). Most of these studies have examined expert vs. novice differences in anticipation, while problems of emotional regulation as precursors of poorer anticipation amongst experts, in causing inconsistency in excellent performance, have been largely ignored (Saha et al. 2012).

The neural mechanism identifying the time lapse between stimulus and awareness keeps perceived time sufficiently close to the flow of events in real time, that actions are effective even in the course of exceedingly rapid external flows (Libet, 1994). The highly skilled players if emotionally well-regulated can read and interpret complex situations quickly and initiate decisive action, which enables them to produce faster reactions and movements in complex situations (Saha et al 2005a & 2012).

Authors of the present study are trying to point out to their concern over the methodological issues related to the assessment and analyses of the reaction performances in sport. Of vital importance is the question of complex reaction and movement performance along with the simultaneous assessment of other correlated and influencing psychological (emotional) and substantiated psychobiological mediators are also considered as the significant aspect of research interest. Introduction of few relevant psychobiological measures such as measures of tonic and phasic electrodermal activity as indices of

emotionality substantiated by the projective evaluation of inner emotional make-up, and the orienting activity in experimental models to fit in correlation analyses would provide the researchers with relevant information related to faster reaction and movement performance toward achievement of performance excellence. To date, laboratory-based analytical researches incorporating both subjective and psychobiological measures of performance that could be served as predictors of excellent reaction and movement performance, are not frequent, and available researches are either not dealt with direct and objective measures, or done with variables which are detected as having source of multicolinearity, and hence are not capable of predicting process-related shared aetiology behind excellent reaction ability related to successful athletic performance.
With such a background, the present study would focus on identifying-

1. Whether accuracy in anticipation can predict interrelationship between psychological and psychobiological measures of emotionality;
2. Whether accuracy in anticipation can predict changes in complex reaction ability in the swimmers;
3. Whether psychological measures of emotionality can predict changes in complex reaction ability in the swimmers;
4. Whether decomposition of tonic Sc responses can predict changes in complex reaction ability in the swimmers;
5. Whether decomposition of phasic Sc responses into measures of orienting responses activity can predict changes in whole-body reaction ability in the athletes.

MATERIALS AND METHODS

PARTICIPANTS

Two-hundred twenty-five consistently high performing male athletes (aging between 16.3 and 20.1 years, mean age = 18.2 and SD = 2.84), selected as the National cadets by the respective selectors, volunteered as the participants in this study. Athletes representing nine provincial teams were selected by the respective National selectors of the Malaysia (as Senior Nationals and Malaysia Probable for the Malaysia Games 2011). On the basis of the previous records (data collected in between February 2011 and April 2011), of psychological measures and on the basis of their pre-inclusion high level of reaction performances, the inclusion criterion for the purpose of present study was set.

MATERIALS AND MEASURES

1. Reaction Movement Timer Apparatus (Lafayette Instrument Corporation, USA 2001) was used to assess both the visual and auditory reaction and movement time of the participants.
2. Bassin Anticipation Timer (Lafayette Instrument Corporation, USA 2000) was used to assess the anticipatory reaction time of the participants.

3. Sc Apparatus (Autogenic Corporation, USA 2000) was used to assess the extent of autonomic regulation as index of emotionality in the participants.
4. Rorschach Ink-Blot (RIB) test was used to assess inner emotional make-up of the participants.

PROCEDURE

Previous records of the reaction performances were available in the data bank with the researchers of the present study, and for all of the psychomotor (such as visual complex reaction and movement time- CRT & MT) and psychophysiological analyses of the present study (tonic and phasic autonomic regulation and orienting responses – latency; amplitude and recovery time etc. employing measures of Sc activities- Sc), participants were assessed in the laboratory of sport psychology in the Universiti Sains Malaysia. MT for the athletes were planned mostly simulating the relevant competitive situations, in which players were required display agile responses to some visual signal cues presented randomly, by diving laterally either to the left or right to strike a touch pad. Consistency in the agile-most reactions was considered as the data for the MT performances. All of these assessments were done following standard procedures (methodology detailed in the Saha et al 2005a).
On the basis of the performance outcomes of the temporal anticipation test records, those who were observed a having difficulties in anticipation tasks were identified. On the basis of the scores obtained from the projective analyses of emotionality (employing RIB), emotional measures of Resilience; Excitability and Constriction were derived. Tonic and phasic Sc (Sc) activity data were decomposed as – basal or tonic Sc; SF or NS-SCR (non-specific Sc response, which is also termed as spontaneous fluctuation or SF) and tonic consistency measures; and, phasic Sc, and stimulus-specific orienting response measures (viz. latency; amplitude and recovery time).
The data were treated with PASW 18.0. Multiple linear and polynomial regression analyses were done to identify whether accuracy in anticipation has any differential impact onto different psychological (emotional measures derived on that basis of projective analyses) and psychophysiological variables (autonomic regulation and orienting reflex information obtained from Sc measures) in producing contributor effects in the shared aetiology of excellence in reaction and movement performance.

RESULTS

Measures of Sc activity, projective analyses of emotionality and reaction ability are summarised hereafter in the Table -I, which depicted the Means and SDs of Tonic and phasic Sc (Sc) levels; orienting response measures of latency, amplitude and recovery time; measure of spontaneous fluctuation (NS-SCR – non-specific Sc response); derived measures of emotionality such as- Resilience, Constriction and Excitability, and Visual Complex Reaction (CRT) as well as Movement time response scores. Normality indices of all of the afore-mentioned measures were done and as per requirement data were centred to ensure normality.

Table -I – Table of Descriptive Statistics

Statistics	Tonic Sc level (log microsiemens)	Phasic Sc level (log microsiemens)	Orienting Latency (sec.s)	Orienting Amplitude (log microsiemens)	Orienting Recovery (sec.s)	RESILIENCE (scores)	CONSTRICTION (scores)	EXCITABILITY (scores)	Spontaneous Fluctuation (scores)	Visual Choice Reaction Time (sec.s)	Movement Time (sec.s)
Mean	4.8330	7.0877	2.37	.721	11.65	12.3	9.81	11.94	8.12	.382	.794
SD	1.3150	2.8286	0.32	.263	2.451	2.31	2.16	3.82	3.51	.115	.322
N	225	225	225	225	225	225	225	225	225	225	225

Tables II to VI represented the summary of multiple regression analyses between different dependent measures related to reaction performances and independent measures of autonomic indices of emotionality (different aspects of Sc activity) and projective evaluation of emotionality.

In the Table -II, summary of linear multiple regression is presented. Significant model emerged for the models ***a*** (participants identified as having fairly lower level of accuracy in anticipations). The model ***a*** however, was found to explain 24.4% of variance in changes in the extent of CRT performance.

Table – II – Summary of Multiple Linear regression analyses (participants with inaccurate anticipations)

Model ***a***	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
Intercept	.338	.006		54.442	.000					
Spontaneous Fluctuation	.039	.008	.477	4.809	.000	.469	.485	.477	.999	1.001
Consistency in Sc activity	-.012	.006	-.208	-2.093	.040	-.190	-.235	-.207	.999	1.001

a. Dependent Variable: Visual Choice Reaction Time

(F (3, 75) = 13.407, P <0.000)) Model Adj.R^2 = 24.4%.

The Table II further revealed that, there existed positive relationships between the Sc spontaneous fluctuation and CRT performance, which explained that, those who were observed to have lesser extent of SFs, had relatively faster CRT performances. Similarly negative relationship explained that, relatively higher level of consistency in Sc activity was associated with faster CRT performances.

Table -III summarised the model ***b*** which revealed that, when participants having higher accuracy in anticipations were included, the model ***b*** however was found to explain 35.3% of variance in changes in the extent of CRT performance.

Table – III – Summary of Multiple Linear regression analyses (participants with accuracy in anticipations, when both tonic and phasic Sc activities were considered as predictors)

Model ***b***	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
Intercept	.121	.021		5.707	.000					
Tonic Sc level	-.069	.008	-.723	-9.161	.000	-.449	-.557	-.530	.538	1.860
Phasic Sc level	.057	.010	.495	5.689	.000	.018	.384	.329	.443	2.256
Orienting Recovery	-.023	.005	-.383	-5.061	.000	-.061	-.347	-.293	.586	1.707
Orienting Amplitude	.016	.005	.242	3.141	.002	.133	.224	.182	.564	1.772
Orienting Latency	.012	.003	.304	3.436	.001	.066	.244	.199	.429	2.330
Resilience	.000	.000	.199	2.715	.007	-.178	.195	.157	.625	1.601

b. Dependent Variable: Visual Choice Reaction Time
(F (5, 187) = 18.588, P <0.000)) Model Adj.R^2 = 35.3%.

Detailed reports however revealed positive relationships between the phasic Sc responses and orienting amplitude and latency. Emotional resilience was also observed to have positive relations with CRT performance. Contrarily tonic Sc responses and orienting recovery time were observed to have negative relations with the CRT, which explained that, swimmers having higher extent of tonic Sc responses displayed relatively faster CRT. Negative relation between orienting recovery time and CRT however clarified that participants having delayed recovery performed faster CRT. Positive relations explained that, relatively lower level of phasic Sc activity; orienting amplitude and latency and emotional resilience scores were associated with faster CRT.

Table – IV – Summary of Multiple Linear regression analyses (participants with accuracy in anticipations when only tonic Sc activity was considered as predictors)

Model ***c***	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
Intercept	.149	.021		7.134	.000					
Tonic Sc level	-.064	.007	-.667	-9.451	.000	-.449	-.568	-.561	.706	1.416
Second-order EXCITABILITY	5.631E-6	.000	.157	2.333	.021	.017	.168	.138	.776	1.288
Orienting Amplitude	-.013	.004	-.214	-3.060	.003	-.061	-.218	-.182	.721	1.387
Orienting Latency	.009	.003	.243	2.723	.007	.066	.195	.162	.442	2.265

c. Dependent Variable: Visual Choice Reaction Time
(F (5, 188) = 19.222, P <0.000)) Model Adj.R^2 = 32.1%.

Table -IV represented the summary of model ***c*** which explained 32.1% of variance in changes in the extent of Visual CRT performance when tonic Sc performance was regressed. The model however revealed the fact that participants having higher levels of tonic Sc levels as well as higher orienting amplitude had faster CRT. Positive relations such as, quadratic or second order of emotional excitability and orienting latency revealed that, participants having faster latency and both lower as well as higher extent of excitability were observed to have faster CRT.

Table –V – Summary of Multiple Linear regression analyses (participants with accuracy in anticipations, when only phasic Sc activity was considered as predictors)

Model ***d***	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
Intercept	.044	.004		11.208	.000					
Phasic Sc level	7.604E-5	.000	.395	6.933	.000	.276	.377	.350	.784	1.276
Second-order RESILIENCE	-1.407E-6	.000	-.220	-3.707	.000	-.226	-.212	-.187	.721	1.387
Second-order EXCITABILITY	-8.531E-6	.000	-.373	-5.544	.000	-.242	-.309	-.280	.562	1.779
Second-order CONSTRICTION	1.231E-5	.000	.348	5.204	.000	-.025	.292	.263	.570	1.754
ORIENTINGAMP	.001	.000	.337	4.601	.000	.018	.260	.232	.474	2.109
Orienting Latency	-.001	.000	-.209	-2.829	.005	-.058	-.164	-.143	.468	2.136

d. Dependent Variable: Visual Choice Reaction Time
(F (6, 191) = 16.926, P <0.000)) Model Adj.R^2 = 24.3%.

Table – V summarised the model ***d*** which could explain 24.3% of variance in changes in the extent of Visual CRT performance when phasic Sc performance was regressed. The model revealed the fact that participants having higher levels of phasic Sc levels as well as higher orienting amplitude had faster CRT. Positive relations such as, quadratic or second order of emotional constriction clarified that, participants having moderately higher extent of emotional constriction were observed to have faster CRT. Negative relations on the other hand were observed between CRT performance and second order of emotional resilience as well as of excitability and orienting latency too. Findings however implied that, participants who had relatively delayed orienting latency were observed to have faster CRT, while negative impact of second –order measures of emotionality on CRT clarified that, participants who had moderate levels of emotional resilience as well as excitability, were better capable of producing faster CRT.

Table – VI – Summary of Multiple Linear regression analyses (participants with accuracy in anticipations)

Model ***e***	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
Intercept	.209	.019		10.863	.000					
Resilience	-.001	.000	-.404	-6.414	.000	-.313	-.424	-.309	.584	1.713
Constriction	.005	.000	.815	13.710	.000	.345	.707	.660	.656	1.524
Excitability	-.003	.000	-.617	-9.593	.000	-.271	-.573	-.462	.561	1.783
Orienting Amplitude	.021	.006	.187	3.624	.000	.127	.256	.175	.875	1.143
Tonic Sc level	.036	.011	.216	3.450	.001	-.160	.244	.166	.593	1.687

e. Dependent Variable: Movement Time
(F (5, 188) = 48.585, P <0.000)) Model Adj.R^2 = 55.2%.

Table -VI summarised the model ***e*** which revealed that, model ***e*** was found to explain 55.2% of variance in changes in the extent of Movement Time performance. The equation specifically explained the presence of main effects of measures of emotionality and tonic Sc responses as well as orienting amplitude responses, in which positive relations explained that participants having lower extent of constriction; orienting amplitude as well as lower tonic Sc level, was observed to produce faster MT responses. Negative relations implied that, higher extents of emotional resilience and excitability were beneficial for faster MT performance.

DISCUSSION

Results of regression analyses have consistently justified interrelationships between the psychophysiological measures and the created corroborative emotional measures observed in the participants. Table –II depicted the relationships observed in the model ***a***, which was conceived to discuss the impacts of inaccuracy in anticipations observed in some of the participants. This model however pointed out that lesser extent of Sc spontaneous fluctuation (SF) had unique contribution as predictor of faster choice reaction performance. This has particular significance since SF actually is NS-SCR (non-specific Sc response), that occurs spontaneously in response to sudden startle-like autonomic changes. The partial correlation results also indicated (refer to the table – II) the extent of correlation between SF and CRT, independent of and excluding the effect of the other predictor variable – consistency in Sc activity. Colinearity statistics report from the Table – II, evidentially suggest that, the SF as the independent variable has unique independent variance to predict changes in CRT, excluding the contribution of the variable of consistency in Sc. Here the observed lower frequency of SF responses in the swimmers who had difficulty in accurate anticipation goes contrary to that of the previous research findings reported from the same laboratory following similar methodology (Saha et al. 2005b). Observed failure to anticipate occurrence of response-specific stimuli, might have been linked with transient deficiency in task-specific perceptual discrimination ability, which resulted in observed lack in coherence between the autonomic-perceptual processes (Saha et al. 2005a; Saha and Saha 2009).

Interrelationships between the psychophysiological measures such as – measures of both tonic and phasic Sc responses; orienting responses (viz. Sc latency, amplitude and recovery time) and the contribution of psychological phenomenon of emotional resilience explained changes in the CRT. Significant contribution of tonic Sc response, independent of and excluding the effect of the all other predictor variables, clarified the ability of participants (who were actually top-level swimmers), to maintain autonomic arousal modulation, which was found significant enough to put contributory impact on CRT performance in the participants. Higher tolerance observed in colinearity statistics (Table – III) suggested that – high extent of (53.8%) variance in tonic Sc was not predicted by all other psychobiological and psychological independent measures of emotionality. The model ***b*** also suggested the significance of orienting response measures in influencing the complex reaction ability observed in the participants. Apart from that the model explained the positive impact of the inner psychological aspect of emotional resilience (tolerance was 62.5%) on CRT performance. This corroborative relationships between the psychophysiological and inner psychological phenomena and between the psychobiological measures seemed on line with the previous researches done from same research institute (Saha et al. 2005a & Saha et al. 2012).

Model ***c*** was conceived to realize the unique contribution of tonic Sc, irrespective of the additive influence of phasic measure of Sc, which revealed that correlation between tonic Sc and CRT – independent of other predictors such as the orienting measures as well as the quadratic measure of excitability, was significant enough to produce high negative impact on the measure of CRT. This finding implied that, higher control over basal or tonic autonomic response to emotionality by itself can contribute to produce faster complex reaction performance. This model further revealed additive influences of orienting response measures of Sc, which explained that the swimmers having faster orienting latency performed faster CRT. Negative relation between orienting recovery and CRT however pointed out to the question of necessity for adequate autonomic recovery from stimulus induced emotional overloading. This finding got support from our previous findings (Saha et al. 2005a). Quadratic or second-order influence of emotional measure of excitability on CRT performance implied that, both lower and higher extent of excitability were not suitable to produce high CRT performance, while swimmers only with moderate level of excitability could produce faster CRT. This finding got support from the Yerkes-Dodson's Law of Inverted–U hypothesis (Yerkes and Dodson, 1908).

Model ***d*** was taken into considerations to realize the exclusive contribution of phasic Sc, irrespective of the additive influence of tonic measure of Sc, which revealed that phasic Sc– independent of other predictors such as the orienting measures as well as the quadratic measures of emotionality could generate vital positive impact to produce faster CRT responses in the swimmers. This finding implied that, the unique independent variance associated with phasic Sc, devoid of additive contribution of other factors, were high enough (78.4%) in facilitating faster CRT. Apart from the roles of orienting response activities, both the negative and positive influences of emotional measures were worthy to be discussed. Second-order positive influence of emotional constriction on CRT performance implied that, both low and high level of emotional constriction were not conducive to produce high CRT performance, while moderate level of emotional constriction were observed as capable of producing faster CRT. Observed negative influence of quadratic order resilience and excitability however revealed that, both lower and higher extent of resilience and as well as excitability appeared favourable in producing faster CRT, while moderate emotionality were evidentially associated with poorer CRT performance. This finding of negative relationship between emotionality and CRT however contradicts with the Inverted–U hypothesis (Yerkes and Dodson, 1908).

Finally the Model ***e*** was considered to identify the predictive relationships and relative contributions of measures of emotionality and psychobiological variables onto the movement timing performance observed in the swimmers. Interestingly psychobiological measures were evident as having positive contributory associations, while emotional measures had varied relationships, since emotional constriction was observed to have positive relations, while resilience and excitability were observed to have negative associations with the dependent measure of movement timing, which revealed that, higher extents of emotional resilience and excitability were beneficial for faster MT performance, while the unique contribution of lower level of emotional constriction might have significant contribution in producing faster movement timing in the swimmers.

In this section we would like to concentrate on the specific roles of the significant predictors of reaction and movement time performance in the swimmers. Higher regulation of tonic Sc activity was observed to consistently facilitate in visual CRT performance (models ***a, b*** & ***c***) while relatively lower tonic autonomic regulation was found beneficial for faster movement time performance (model ***e***).

The observed disparity could be interpreted as predominantly mediated through ipsilateral influences from hypothalamus and limbic system (Sequeira & Roy, 1993). While higher regulation of tonic Sc responses could be hypothesized as mediated through both inhibitory response of bulbar level of reticular formation (Roy et al. 1993b) and hypothalamic regulation (Boucsein 1992; Dawson et al. 2000), association between relatively lower Sc regulation and MT could be viewed as originating from excitatory influences in the frontal cortex and descending reticular activation (Edleberg 1993 & Dawson et al. 2000). Phasic Sc response characteristics are dependent on response-specific stimulation, hence lower regulation of this autonomic activity (models ***b*** & ***c***) followed differential pathway (prefrontal cortex, as well as amygdala and hippocampus), which resulted in faster CRT response (Venables & Christie 1980 & Dawson et al. 2000).

Orienting Sc responses were found associated to both CRT & MT in diverse ways, as relatively lower orienting amplitude (originally initiated in the prefrontal cortex) was observed to facilitate in both faster CRT (models ***b*** & ***d***), and MT (model ***e***). Similar nature of consistency was also observed in orienting recovery (initiated in the prefrontal cortex, as well as amygdala and hippocampus), as slower recovery time was observed as related to faster CRT performances in swimmers (models ***b*** & ***c***). Shorter orienting latency (prefrontal cortex), on the other hand was evidentially contributed in producing faster CRT (models ***b*** & ***c***), but was also found associated with relatively delayed CRT responses (model ***d***). Orienting Sc responses being largely controlled and elicited by the prefrontal cortex (Boucsein, 1992), facets of latency, amplitude and recovery time might have additional linkages. Orienting reflex activities characterised by shorter latencies, sharp and large amplitude and faster recovery could be associated with excitatory influences from amygdala, while delayed latencies along with smaller amplitude and delayed recovery could be largely affected by inhibitory effects from hippocampus (Dawson et al. 2000 & Saha et al. 2012).

Psychological measures of emotionality derived from projective analyses revealed that, those were differentially associated with both CRT and MT performance outcomes. Lower extent of emotional constriction was observed to facilitate in faster MT, and a non-linear or quadratic relationship with CRT was observed. While lowering of emotional resilience was found associated with CRT, a negative quadratic relationship between CRT and both resilience and excitability was observed, revealing that both lower and higher extents of resilience and excitability contributed in faster CRT, while at moderate levels those were supposed to produce poorer CRT. Summated review on the projective evaluation of emotionality revealed that, higher emotional regulation was found corroborated with the psychobiological indices of emotionality, together which facilitated both in CRT and MT performances. Our previous reports confirmed similar corroborative relationships between subjective and psychobiological indices of emotionality predicting faster reaction (Saha et al. 2005a & 2012).

In sum it could be postulated that, the impact of accuracy in anticipation was observed in diverse nature of relationships between the psychological and psychobiological measures in predicting both complex reaction and movement performances. Swimmers, who were better capable of handling temporal uncertainties, could successfully anticipate the occurrence of task-specific stimulation, which enabled them to produce faster CRT and MT responses, compared to their counterpart swimmers who failed to display accurate anticipation. More precisely, swimmers having moderate extent of emotional regulation (substantiated by both projective and psychobiological evaluations) accompanied with accurate anticipations were better capable of maintaining cortical activation required for better signal detections and better perceptual discriminations, which prompted in both faster reactions and movements (Saha et al. 2005a & 2012). Contrarily, swimmers lacked in coherence between the autonomic-perceptual processes (as it was observed in deficient anticipations), coupled with above-average level of autonomic adaptations put deleterious effects on the reaction ability.

CONCLUSION

To conclude it could be stated that, ability to cope with temporal uncertainties helped the swimmers to anticipate accurately, which had helped in producing faster complex reaction and movement performances. Emotional flexibility and higher autonomic regulation along with orienting reflex had helped the swimmers in maintaining higher reaction and movement performances.

ACKNOWLEDGEMENTS

The authors are grateful to the participants for their significant contributions, and are indebted to Ministry of Higher Education, Federal Govt. of Malaysia for the support (Centre of Excellence- Research Grant).

REFERNCE

Abernethy, B. (1987). Anticipation in sports: A review. Physical Education Review, 10, 5-6.

Boucsein, W. (1992). Electrodermal Activity. New York: Plenum.

Dawson, M. E., Schell, A. M., & Filion, D. L. (2000). The Electrodermal System. New York, Cambridge University Press.

Edelberg, R. (1993). Electrodermal mechanisms: A critique of the two-factor hypothesis and a proposed replacement. In Roy et al. (1993a), 7 -29.

Erickson, K. A.; Krampe, R. T. and Tesch Romer, C. 1993. The role of deliberate practice in the acquisition of expert performance. Psychological Review, 100, 360-406.

Glencross, D. and Cibich, B. 1977. A decision analysis of games skills. Australian Journal of Sports Medicine, 9, 72-75.

Libet, B. 1994. Neurophysiology of consciousness: Selected papers and new essay, Boston MA: Birkhauser.

Roy, J. C., Sequeira, H., & Delerm, B. (1993b). Neural control of electrodermal activity: Spinal and reticular mechanisms. In Roy et al. (1993a), 73 -92.

Saha, S., Mukhopadhyay, P., Chattopadhyay, P. K., Biswas, D. and Saha S. (2005a). Arousal modulation as predictor of achievement motivation in high soccer performers, Reading in Sports Psychology, edited by Mohon J. and Sehgal, M. (ed.s) Friends Publications, India, 116-146.

Saha, S., Saha S. and Nushrat, S. (2005b). Psychophysiological approach to reaction ability and high sports performance- An exploratory study. Journal of Sports and Exercise Psychology, 27, 132-133.

Saha, S., and Saha Srilekha (2009). Emerging Psychobiological Factors Predicting Performance Excellence in Soccer. 90 minutes Valerian Soccer Foundation Journal, 1(2), 51 - 68.

Saha, S., Saha Srilekha; Chowdhury, D.; Fahim N. A & Salah Uddin M. (2012c). In search of predictors for reaction ability related to high performance in Cricket. Social Science International, 28 (1), 1 – 18.

Sequeira, H., & Roy, J. C. (1993). Cortical and hypothalamo-limbic control of electrodermal responses. In Roy et al. (1993a), 93 -114.

Venables, P. H., & Christie, m. J. (1980). Electrodermal activity. In I. Martin & P. H. Venables (eds.), Techniques in Psychophysiology, pp. 3 -67. Chichester, U. K.: Wiley.

Williams, A. M.and Burwitz, L. (1993). Advance cue utilization in soccer. In Science and Football II (Ed. T. Reilly, J. Clarys and A. Stibbe), 239-243, London: LE & FN Spon.

Williams, A. M. and Davids, K. (1998). Visual search strategy, selective attention, and expertise in soccer. Research Quarterly for Exercise and Sports, 69, 111-128.

Williams, A. M. and Elliott, D. (1999). Anxiety and visual search strategy in karate. Journal of Sports and Exercise Psychology, 21, 362-375.

Yerkes RM, Dodson JD (1908). The relation of strength of stimulus to rapidity of habit-formation. Journal of Comparative Neurology and Psychology 18: 459–482.