IMPACT OF DECOMPOSITION OF AUTONOMIC TONIC AND PHASIC RESPONSES ON PREDICTORS OF REACTION PERFORMANCE IN ELITE MALAYSIAN SWIMMERS

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ABSTRACT

Psychobiological predictors of emotionality were evaluated in relations to complex reaction and movement performances have been considered as the significant aspect of research interest. Considerable research base confirms that the expert players employ more pertinent search strategies, eliminate irrelevant cues which enable them to effectively anticipate action requirements and they have superior ability to use cue-related information to reliably anticipate occurrence of relevant events. 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 skin conductance responses isolated from the tonic measures. Altogether two-hundred and twenty-five individuals having high athletic calibre, and holding top-positions in recently held (within the period March 2011 up to the June 2011) 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 skin conductance) 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 – June 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 however suggested direct, inverse and supportive relationships between decomposition of skin conductance tonic and phasic autonomic components 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.

Keywords: Autonomic decomposition, reaction ability, swimming

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INTRODUCTION

Elite level performance in sports has long been considered as the combination of some salient physical, physiological, social and psychological factors, which interplay between them to culminate in performance excellence. Sports requiring faster reactions to visual stimulation require faster sensory processing and precise cognitive judgements ensuing in accurate and appropriate-most reactions.

Empirical supports here have alternatively postulated the use of anticipation by the elite players to circumvent the reaction time delays inherent in every aspect of sport activity (McLeod, 1987) and to optimize their visual search strategies to make best use of early information (Land & McLeod, 2000). There exist reasonable amount of evidence to indicate
that early pick-up of information from the opponent's movement pattern is integral to skilled performance (Abernethy & Russell, 1984; Penrose & Roach, 1995; McRobert & Tayler, 2005; Renshaw & Fairweather, 2000). But these researches have number of limitations (Müller et al., 2006). First, the majority of studies have typically included skilled players who did not have adequate international exposure, and more over these players were compared with the novices.

Another aspect of significant importance is that the expert players always pay detailed attention to the relevant cues, and only the field-relevant information matched with cognitive schema (already structured temporal and spatial cues) gets immediately processed with the introduction of optimum cortical arousal initiated by ascending reticular activating system (ARAS) which is mostly essential for cognitive processing (Eysenck, 1982). Optimum excitatory ARAS would facilitate in faster reactions, since it keeps up a sports performer ready to react to any incoming stimulus. The RAS also has descending tract, which influences motor functions. There is good reason to believe in that the descending tract of the RAS may be in part responsible for the improvement in the speed and coordination of reactions under higher levels of arousal (Franken, 1998). Thus apart from anticipation, it seems important to identify the role of the sensory – perceptual discrimination ability of the players in augmenting faster reactions.

The highly skilled players have the ability to read and interpret complex situations quickly and to initiate decisive action. The faster the simple muscular reaction and movement time of the individual, the quickly will be responses to complex situations (Saha et al 2003; Saha et al 2005a). In cricket, apart from reaction and movement time, accurate anticipation of relevant visual cues and the consequent whole body reaction seems absolutely essential to conceptualise different facets of expert performance (Togari & Takahashi, 1977 and Suzuki et al. 1988).

Here the matter of concern for the sport psychology researchers in the fields of athletic events appear with the question of the relative contribution of the intricate psychological and psychobiological processes in ensuring excellent reaction performance. Numerous studies pointed out the importance of ARAS only in controlling excellent reaction performance (Franken, 1998), while a lot others pointed out the need for consideration into movement related motor coordination (Heyman 1982 and Tenenbaum et al 1992) and others considered role of involvement of cortical and autonomic activation as cognitive-emotional mediator component as more important factor for concern (Saha et al 2003; Saha et al 2005a and Saha et al 2005b).

Authors of the present study on the contrary, are trying to point out to their concern over the methodological issues related to the assessment and analyses of the reaction performances in athletics. Apart from that, of vital importance is the question of whole-body reaction performance along with the simultaneous assessment of other correlated and influencing psychobiological mediators are also considered as the significant aspect of research interest. Introduction of few relevant psychobiological measures such as measures of tonic electrodermal activity as index of emotionality substantiated by the autonomic arousal modulation and the orienting activity in experimental models to fit in correlation analyses would provide the researchers with relevant information related to faster reaction performance toward achievement of performance excellence. To date, laboratory-based analytical researches incorporating objective and direct measures of performance that could be served as predictors of excellent reaction and movement performance, is scarce, 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 orienting amplitude can predict changes in whole-body reaction ability in the swimmers;
2. Whether autonomic regulation indexed by the tonic skin conductance can predict changes in whole-body reaction ability in the swimmers;
3. Whether orienting reflex indexed by the phasic skin conductance amplitude can predict changes in whole-body reaction ability in the swimmers.

MATERIALS AND METHODS

Participants

Two-hundred and twenty-five consistently high performing swimmers (aging between 19.6 and 22.3 years, mean age = 21.2 and SD = 1.24), selected as the National cadets by the respective selectors, volunteered as the participants in this study. These swimmers were representing nine provincial teams and were selected by the respective National selectors of Malaysia (Senior National and the Selected Development Squad listed as Malaysia Probable for the Malaysia Games 2011 & eventually for the 2012 Olympics).

Data were collected on the afore-mentioned swimmers during various National and International Competitions (since March 2011 up to the June 2011), mostly on the basis of their reaction ability - by employing the Precision Reaction and Movement Timer; Bassin Anticipation Timer and Whole-body Movement Timer(Lafayette Instrument Corporation, Illinois, USA 2001). Thus on the basis of the long-term records of psychological measures and on the basis of their pre-inclusion 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. Photocell Whole-Body Reaction and Movement Timer Apparatus (Lafayette Instrument Corporation, USA 2001) were used to assess both the visual and auditory whole -body reaction time of the participants.
3. Bassin Anticipation Timer (Lafayette Instrument Corporation, USA 2000) was used to assess the anticipatory reaction time of the participants.
4. Skin Conductance Apparatus (Autogenic Corporation, USA 2000) was used to assess the extent of autonomic regulation as index of emotionality in the participants.

Procedure

Previous records of the reaction performances of majority of the participants were available in the data bank with the researchers of the present study, and for all of the psychomotor (such as reaction and movement time- RT & MT and anticipation - BAT) and psychophysiological analyses of the present study (autonomic regulation and orienting amplitude; recovery time etc.) employing measures of skin conductance activities- Sc), all the participants were assessed during the competitive tournaments in the make-shift laboratory conditions in the competitions venues. Special care were taken to nullify any contamination from any subject-relevant; sequence-relevant and stimulus-relevant interference, which could have significant manipulative effect on the psychological make-up of the participants. All of these assessments were done following standard procedures (methodology detailed in Saha et al (2005a & 2012a), and are comprehensively detailed in the next section.

Reaction ability of the participants were evaluated with the help of Lafayette Reaction & Movement timer, which consisted of two touch key-pads attached with the main processor unit, and the participants were required to react to specified auditory or visual stimulus signals either by depressing or by releasing key of the initiator touch-pad (which denotes reaction time - RT) by employing the index finger of their dominant hand and were required to move the hand and the upper body as well (while the lower body remains stationary) towards the other touch key-pad to press the key to denote the movement time (MT). The processor unit assesses the initiation of response (RT) and accomplishment of the task with the MT response in the second touch key-pad.

Since reaction ability depends on faster and accurate anticipation of occurrence of the stimulation (Abernethy & Russell1984; Saha et al., 2005a & 2012a; Suzuki et al., 1988) (which is extremely essential attribute of the swimmers & athletes, who react to starting signals) we intended to assess the anticipatory cue-utilization ability of the swimmers. Bassin Anticipation timer (which consists of a track along which a sequence of LEDs & one target LED), in which swimmers were instructed to watch the LEDs as those go get on and off as the following LED lights up, and it seem that lights travel down with variable speed through the runway track. Swimmers had to anticipate the light reaching the target and were required to press a pushbutton, to coincide with the arrival of the light at the target.

Here a question may be raised as even if someone can anticipate well can perform finger-dependent RT and upper-body MT, does it match with the requirements of swimming anticipation and RT-

MT? That's why the Photocell analyser was used to evaluate RT and MT of the swimmers, while they intended to jump from the starting block in reaction to a starting signal. The Photocell whole-body RT and MT analyser actually enables the researchers to evaluate RT and MT as the photocell sensors detect light from the other source and as a movement in any body-part obstructs light, the photocell detects RT and the next pair of photocell detects the MT. Thus the evaluation of RT-MT was substantiated by employing assessment of anticipation and whole-body reaction ability, which could ensure that evaluation of RT-MT revealed the perceived sense of competence evident in the swimmers, while they attempted to react to the stimulus signals, they intended to perform up to the best of their reaction potentiality (Saha et al. 2012a).

Since the outcomes of any unprecedented performance leads to subjective feelings of apprehensions pertaining to the issue of either success or failure, we intended to analyze this feeling of competitive performance related apprehensiveness (Andreassi1966; Saha et al. 2012a). on the basis of autonomic indices of emotionality (which are aptly revealed through tonic and phasic skin conductance (Sc) indices along with the evaluation of startling response (SF) and autonomic response latency; amplitude and recovery time, which adequately reveal the autonomic adaptation associated with the feelings of apprehension (Beauchaine, 2001; Chattopadhyay et. al. 1975; Chattopadhyay & Biswas, 1983 and Dawson et al., 2007). Sc was evaluated using the tonic sweat gland activity, which refers to evaluation of basal Sc, and the habituation paradigm response-specific or event-related responses were measured employing phasic modalities (latency; amplitude & recovery from stress) (Dawson et al., 2007 and Saha et al., 2012a).

Thus incorporating rigorous methodological control and with applications of several psychomotor and psychobiological indices, the data pertaining to RT and MT were taken).

Thereafter the data were treated with SPSS 18.0 (now known as PASW 18.0) statistical software for identification of the normality index. In accordance with the extent of skewness, wherever required, normality transformations were done with squared and log conversions. Thereafter reports on correlation analyses, prompted the authors to look into prediction analyses, and with present types of data both multiple linear and non-linear (Polynomial Regression analysis) by employing both squared and cubic transformations of the centralised version of predictor variables, wherever needed could be of the best statistical model to fit in. Polynomial Regression Analysis was done to identify how far the different psychophysiological variables (autonomic regulation and orienting reflex information obtained from skin conductance measures) contribute in the shared aetiology of excellence in reaction performance.

RESULTS

Measures of both tonic and phasic Sc activity and reaction ability are summarised hereafter in the Table -I, which depicted the Means and SDs of Tonic and phasic Sc levels; orienting response measures of latency, amplitude and recovery time; measure of spontaneous fluctuation (NS-SCR – non-specific Sc response); 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

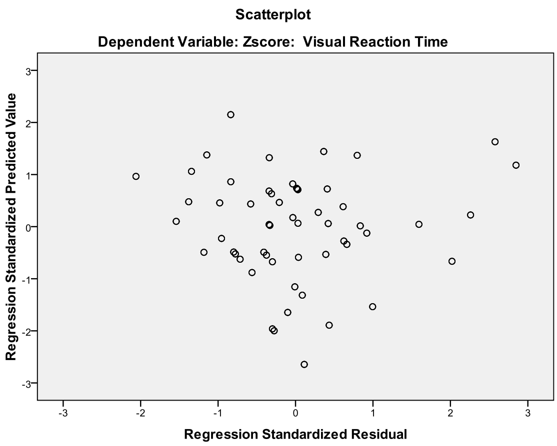
Statistics	Tonic Sc level (log microsiemens)	Phasic Sc level (log microsiemens)	Orienting Latency (sec.s)	Orienting Amplitude (log microsiemens)	Orienting Recovery (sec.s)	Spontaneous Fluctuation (scores)	Visual Choice Reaction Time (sec.s)	Movement Time (sec.s)
Mean	4.8330	7.0877	2.37	.721	11.65	8.12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

Tables II to III 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).

Table II -Model ***a*** - Summary of multiple linear regression analysis.

Model a Dependent Variable – Excellence in Visual Reaction Time	**Unstandardized Coefficients**		**Standardized Coefficients**		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	-.467	.115		-4.071	.000
Level of SFs in GSR	.197	.058	.268	3.401	**.001*****
Amplitude in reference to Initial Sc	-.215	.055	-.332	-3.909	**.000*****
Amplitude in reference to final Sc	-1.429	.358	-1.858	-3.990	**.000*****
Amplitude in reference to average Sc	.719	.323	.898	2.228	**.027***
Amplitude in reference to Sc adaptation score	-.323	.070	-.484	-4.628	**.000*****
Tonic Skin Conductance (GSR)	-.190	.054	-.270	-3.527	**.001*****
Recovery time	.724	.120	.563	6.062	**.000*****
Amplitude	.451	.245	.682	1.846	.067
Orienting reflex	.190	.283	.203	.672	.503
(F (9, 215) = 6.61, P <0.000)) Model Adj.R^2 = 23.5%.					

GSR = Galvanic Skin Resistance indices used as measure of autonomic arousal representing extent of emotional stability; SF = Spontaneous Fluctuation scores are indices of startle autonomic changes in response to suddenly evoked emotional crises; Recovery time = Recovery time required to stabilize and to retain the autonomic homeostasis; Amplitude = Combination of orienting amplitude changes with respect to the other autonomic indices; Orienting reflex = The reflex-like ratio between the sharp increment in orienting autonomic amplitude and consequent faster recovery.



In Table II & III, summary of linear multiple regressions are presented. Significant models emerged for the models ***a*** and ***b*** (impacts of different measures of emotionality on attentive behaviour was evaluated). In the Table II the **model *a*** however, was found to explain 23.5% of variance in changes in the extent of improvement in attentive performance. The scatterplot however signified that the obtained data had somewhat predictive relationship onto the visual reaction ability of the swimmers, and the equation specifically explained the presence of main effects of differential component measures of skin conductance measure in the habituation paradigm (viz. SF; amplitude; recovery time; orienting reflex etc.) on the attentive performances done by the swimmers (assessed by the visual reaction time measures). Overall, improvement in attentive performance was found directly contributed by the SF scores, amplitude and recovery time and the Orienting reflex ratio, while both tonic measure of GSR, and phasic measures of amplitude were found to have negative impact onto changes in reaction ability.

Table – III -Model ***b*** **-** Summary of multiple linear regression analysis.

Model b Dependent Variable – Excellence in Movement Time	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.282	.082		-3.442	.001
Level of SFs in GSR	.207	.056	.282	3.665	**.000*** **
Amplitude in reference to final GSR	-.495	.117	-.643	-4.233	**.000*** **
Amplitude in reference to GSR adaptation score	-.159	.064	-.239	-2.492	**.014** **
Tonic Skin Conductance	-.164	.051	-.234	-3.222	**.002*** **
Amplitude	-.683	.239	-1.032	-2.862	**.005*** **
Orienting Amplitude	.903	.198	1.385	4.570	**.000*** **
Orienting Recovery Time	.548	.083	.599	6.604	**.000*** **
(F (7, 217) = 9.87, P <0.000)) Model Adj.R^2 = 27.5%.					

GSR = Galvanic Skin Resistance indices used as measure of autonomic arousal representing extent of emotional stability; SF = Spontaneous Fluctuation scores are indices of startle autonomic changes in response to suddenly evoked emotional crises; Recovery time = Recovery time required to stabilize and to retain the autonomic homeostasis; Amplitude = Combination of orienting amplitude changes with respect to the other autonomic indices; Orienting reflex = The reflex-like ratio between the sharp increment in orienting autonomic amplitude and consequent faster recovery.

Table III depicts that **model *b*** emerged as a significant model, which was found to explain 27.5% of variance in changes in the extent of improvement in attentive performance. The equation specifically explained the presence of main effects of differential component measures of skin conductance measure in the habituation paradigm (viz. SF; amplitude; recovery time; orienting reflex etc.) on the attentive performances done by the swimmers (assessed by the visual reaction time measures). Overall, improvement in attentive performance was found to be directly contributed by the SF scores, amplitude and recovery time and the Orienting reflex ratio, while both tonic measure of GSR, and phasic measures of amplitude were found to have negative impact onto changes in reaction ability.

DISCUSSION AND CONCLUSIONS

Results of regression analyses have consistently justified interrelationships between the psychophysiological measures, decomposed as the tonic and phasic components of skin conductance and the explanatory reaction behavioural phenomena observed in the participants. Findings of corroborative relationships between the psychophysiological measures seemed on line with the previous researches done by the researchers from same research institute (Saha & Saha 2001; and Saha et al. 2005a). Strikingly enough, while previous researches engaging elite Malaysian swimmers of similar calibre reported contributory impact of only orienting amplitude in relation to initial and final skin conductance scores on the visual whole body reaction performance scores, findings of regression analyses (refer to Model a – table II) revealed that effective decomposition of skin conductance components could aptly explain changes in reaction behaviour. To clarify this position, it could be revealed that in previous researches structural equations were done to identify intricate relationships between several psychobiological, especially skin conductance (Sc) components and reaction measures (Saha et al., 2012a, b & c), which revealed that changes only in the tonic orienting response, alike the spontaneous fluctuations, consistently predicted superior vigilance –like reaction performance (Andreassi, 1966; Crider, 1972). To overcome that problem of lack in coherence, outcomes of Sc responses in this experiment have been decomposed into - amplitude in reference to initial Sc; amplitude in reference to final Sc; amplitude in reference to average Sc and amplitude in reference to Sc adaptation score. Results of this differential decomposition finally indicated that, while usual components of amplitude and orienting reflex were not found associated with reaction behaviour, decomposition of amplitude in relation to other Sc components could yield explanatory relationships between reaction ability and psychobiological correlates of emotionality. Findings however revealed that, the swimmers having higher extent of orienting amplitude, mostly had lower level of tonic Sc, and thus the decomposed ratios were appeared as negatively related to the faster reaction ability of the elite level swimmers. Findings also revealed that, the higher extent of orienting amplitude, which is a manifestation of sudden and startle-like non-specific autonomic response, mostly had lower level of tonic Sc since they were assessed right after their swimming performance, which were mostly characterised by pseudo motor responses rather than only psychobiological concomitants of emotionality (Dawson et al. 2007).

Contrary to that, participants who had lower capacity to adapt and lower autonomic arousal modulation ability faced more coping-strategy related difficulties. Similarly higher cortical and autonomic arousal (Sc) were observed to put deleterious effects onto their level of alertness, and the higher orienting amplitude made them more vulnerable to have high prevalence of impulsive behaviour (Fowles 1988; and Beauchaine, 2001). Further to add, strong relationships between relatively interdependent physiological factors like autonomic arousal, orienting amplitude strengthened their contributory effects on feelings of restlessness (Chattopadhyay et. al. 1975; and Chattopadhyay & Biswas, 1983), which was most interestingly observed to facilitate in attentive activities revealed through the complex reaction ability in response to visual stimuli. Questions may be raised as to how restlessness can facilitate in this kind of psychomotor evaluation of attentive behaviour? In sports behaviour restlessness has preferable dimensions in active living orientations. It also urges for social engagement and curious explorations for more and more relevant information into the field of competitive commitments (Saha et al. 2003). Table - III also explained how adaptive behaviour (revealed through the evaluation of autonomic Sc indices) in participants got directly influenced by physiological inputs from enhanced autonomic adaptations, stability measures, Sc and arousal, which helped in reductions in impulsive behaviour and restlessness. The motivational components involved in coping and in attentive engagements were aroused with increment in arousal, while cautious alertness perhaps facilitated the goal-directed narrowing of attention. This narrowing could be aptly task-focussed if adequately supported by the perceptual-discrimination ability and cortical arousal as well as by adequate levels of emotional regulations (Nideffer, 1989).

The summated analyses however suggested that, the combined aspects of physiological measures could be employed as predictors for corresponding corroborative psychological parameters. Attentiveness, alertness, effective adaptive ability and emotional stability are considered amongst the most widely recognized and essential psychological attributes required for successful sports performances. The regression relationships in this case adequately explained that, these variables were found adequately associated and were found to have adequate structural relationships in between them and as well as with the corroborative physiological predictors too. To conclude it could be stated that, exploratory and novelty-seeking (since majority of the participant swimmers were observed as having higher autonomic amplitude) tendencies in participants (which could be considered as extroverted behavioural patterns) if uninhibited, can result in high and uncontrollable arousal, which in turn may disrupt in alertness and attentive performances. It could be further added that, dispositional emotionality could be helpful in facilitating coping behaviour, which may be helpful in more social –engagements and field-relevant searching for attentional cues. This could result in high attentional control, alertness and adequately effective coping skills, which could ensure performance excellence and high-orientations to achievement of successes. We expect that, this methodological attempt would encourage further research in this field of study and would stimulate replication studies following similar types of structural analyses, and eventually would be able to explain corroborative psychological attributes for several other physiological parameters related to successful sports performance.

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