Environmental Predictors of Cognitive-Emotional Competence Facilitating High Performance in Malaysian Elite Swimmers

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ABSTRACT: The purpose of this study was to examine the extent of confounding contributions of various socio-economic and cultural determinants in the upbringing of Malaysian high performing swimmers (National – level swimmers of Malaysia). A total of 225 swimmers having high athletic calibre, and holding top-positions in recently held National and International meets (Mostly ASEAN level), 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. 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 suggesting direct 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 excellent competitive performance outcomes.

Keywords: Environment, cognitive-emotion, swimming, predictor, motivation

Introduction

Swimming at the competitive level has gone through different transitions from a recreational or amateur-competitive atmosphere to an ultra-professional set-up wherein success is being ensured by all means in the laboratories and championships in International meets such as in Olympics or World athletic meets are only the appreciated outcomes. Multiple close interactions between salient physical, physiological, social and psychological factors contribute to produce excellence in sports behaviour; particularly those requiring faster reactions, stemming out of faster processing of relevant neural impulses and precise cognitive judgements that culminate in accurate and appropriate-most reactions.

Research initiations by McLeod (1987) and Abernethy and Russell (1984) explained the neuropsychological pathways, which inspired future researchers (Penrose and Roach, 1995; Land and McLeod, 2000) to explore further the intricate cognitive-emotional interactions, revealing the significance of accurate anticipation. This is used by the elite players to minimize the reaction time delays inherent in every aspect of sport activity (Renshaw and Fairweather, 2000; McRobert and Tayler, 2005). However, these researches have a number of limitations (Müller *et al*., 2006) particularly most of those included

competent players with minimal international exposure, who were compared with the novices.

Elite-level performers instead read and interpret complex situations instantly and initiate decisive action (Saha *et al*., 2003; Saha *et al*., 2005a). Previous researches conducted by the authors of the present study on a range of novice, intermediate as well as competitive adolescent athletes (Saha *et al.*,2012a and 2012b) on one hand and on World-class Cricketers (performed in the ICC world-Cup One-Day International Cricket Tournament 2011) on the other, revealed the significance of socio-psychological and environmental contributors (Saha *et al.*, 2012c) in determining optimal level of cognitive flexibility earnestly required to gain the competitive edge.

Numerous studies so far pointed out the importance of assending reticular activation system (ARAS) only in controlling excellent reaction performance (Franken, 1998). Other studies pointed out the need for consideration into movement related motor coordination (Tenenbaum *et al.*, 1992). Several other studies that considered role of involvement of cortical and autonomic activation as a cognitive-emotional mediator component as a more important factor for concern (Saha *et al.*, 2003; Saha *et al*., 2005a).

There is a need to pay in-depth attention to the socio-economic (SES) and socio-cultural (SCS) aspects related to upbringing and grooming of the adolescent performers. Top-class as well as competent athletes (from Indian sub-continent) representing from diverse SES (across urban-rural and across lower middle-class and upper-class) and SCS (across various clans, ethnic and racial origins) were observed as having differential nature of cognitive competence (Saha *et al.*, 2005b; Saha and Saha, 2006) which ensures accurate anticipation and mediate in faster reactions. To carry out explorative analyses onto the confounding pathways involved in behavioural manifestation of faster reaction ability in swimming, laboratory-based analytical researches incorporating objective and direct measures of performance are scarce.

With such a background, the present study was done to identify differential impacts of socioeconomic status of the swimmers on the nature of orienting amplitude in predicting consistency in performance and justify the role of orienting reflex indexed by the phasic skin conductance amplitude in predicting adaptability and consistency in performance.

Materials and Method

Participants

225 consistently high performing swimmers (aged between 19.9 and 21.9 years, mean age = 21.4 and SD = 1.54), selected as the National cadets by the respective selectors volunteered as the participants in this study. These athletes mostly reside and train in Malaysia, and they were representing their provincial teams and were selected by their respective National selectors (Senior National and the Selected Development Squad listed as potentially top-level athletes training for the ASEAN athletic events and with an ultimate goal of being selected for the 2012 London Olympics Games). They were matched according to their socioeconomic (higher SES) and sociocultural (privileged) background, having sound academic and training facilities; comfortable social environment with ample opportunities to carry on sports career (both parents were having sound academic background; working in higher position, were ex-players and supportive for sports training, and hence provide their offspring with enough resources to pursue their sports career).

Materials Used

1. 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.

2. Bassin Anticipation Timer (Lafayette Instrument Corporation, USA 2000) was used to assess the anticipatory reaction time of the participants.

3. Critical Flicker Fusion Apparatus (Lafayette Instrument Corporation, USA 2000) was used to assess the descending flicker threshold of the participants as index of cortical activation related to perceptual discrimination.

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 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; anticipation- BAT) and psycho physiological analyses of the present study (autonomic regulation using skin conductance activities- Sc and perceptual discrimination related cortical activation- CFF), all the participants were assessed in the laboratory of sport psychology in Universiti Sains Malaysia (USM). Simulated reaction performances (particularly related to the WRT), and assessments were done in the Sport Complex of USM. WRT for the athletes were planned mostly simulating the relevant competitive situations, in which players were required to 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 were considered as the data for the WRT performances. All of these assessments were done following standard procedures (methodology detailed in the Saha *et al.*, 2012a and b; 2005).

The data were treated with PASW 18.0, for identification of the normality index and with present types of data multiple linear regression analyses were done. Path Regression Analyses were done using LISREL 8.85 version to identify how far the different psycho physiological variables (autonomic regulation and orienting reflex information obtained from skin conductance measures) contribute in the shared aetiology of excellence in reaction performance.

Results

Outcomes of the path regression analyses employing structural equations have consistently justified interrelationships between the psychophysiological (both cognitive and autonomic) measures and the created corroborative psychological explanatory behavioural phenomena observed in the swimmers.

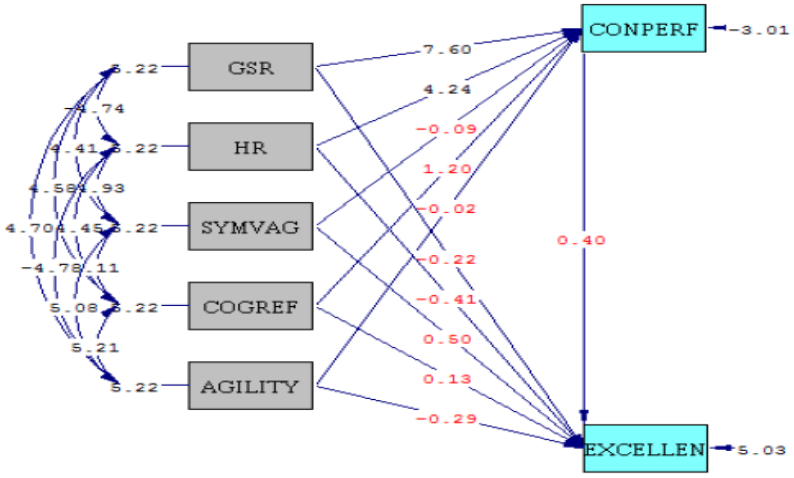

FIGURE 1: Path regression reports showing possibility of direct and additive influence of the psychological variables onto performance measures, while performers from higher SES families with favourable SCS were included in the model.

GSR = Galvanic Skin Resistance indices used as measure of autonomic arousal representing extent of emotional stability; HR = Basal heart rate used both as indices of cardiovascular efficiency and autonomic measure of emotionality as well; SYMVAG = Sympathovagal balance – index of emotional regulation; COGREF = Cognitive reflex or cognitive competence; Agility = Reaction time regressed from the movement timing; CONPERF = Consistency in performance (during practice) and EXCELLENCE = Performance excellence observed in actual competitive situations.

The outcomes of the path regression analyses employing structural equations have consistently justified interrelationship between the the psycophysiological (both congnitive and autonomic) measures and the created corroborative physiological explanatory behavioural phenomena observed in the swimmers. **FIGURE 1** proposes how inter-relationship between the psychobiological (GSR and HR indices) had direct impacts on the question of consistency in performance. Again cognitive reflex (as it is evaluated by critical flicker thresholds) and psychomotor variables (agility conceived from whole-body reaction performances) as well as the measure of sympathovagal balance were found to have no contributory impact at all onto both consistency factor and the question of excellence in performance itself. Both cardiovascular efficiency and GSR were observed as not associated with the EXCELLEN (performance excellence issue), which was supposed to be mediated through the consistency factor (though no significant relationship was established).

TABLE 1: LISREL Estimates (Maximum Likelihood)

Structural equations	**Variance change**	**Goodness of fit statistics**
CONPERF = 0.23*GSR + 0.21*HR + 0.09*SYMVAG + 0.41*COGREF - 0.13*AGILITY,	36%	Degrees of Freedom = 0 Minimum Fit Function Chi-Square = 0.0 (P = 1.00)
EXCELLENCE = - 0.24*CONPERF + 0.32*GSR + 0.24*HR + 0.44*SYMVAG + 0.61*COGREF + 0.11*AGILITY,	14%	Normal Theory Weighted Least Squares Chi-Square = 0.00 (P = 1.00) The Model is saturated, the Fit is perfect!

TABLE 1 shows that 36% of the variance in the extent of CONPERF (consistency in performance), and only 14% of the variance in the extent of performance excellence in swimming, have been contributed by the – autonomic influence revealed by the GSR or Sc measures and cardiovascular efficiency. This finding has implied that, those who had optimal level of emotional regulation (derived by both the various habituation paradigm and orienting reflex GSR indices), and had optimal level of cardiovascular efficiency, could maintain consistency in their performance.

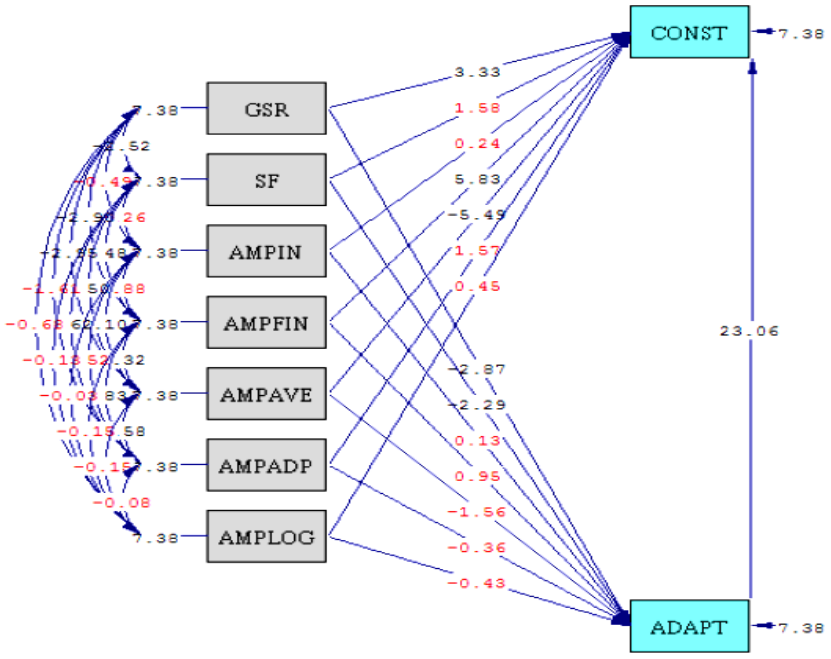

FIGURE 2: Path regression reports showing possibility of direct influence of the psychobiological measures on performance consistency influence of the psychological variables onto performance measures, while in-depth analyses on the cognitive-emotional make-up of the performers were included in the model.

GSR = Galvanic Skin Resistance indices used as measure of autonomic arousal representing extent of emotional regulation; SF = Spontaneous fluctuation; ADAPT = Autonomic adaptability as index of emotional stability; AMPIN = Startle responses observed in accordance with initial autonomic changes; AMPFIN = Sudden change in emotionality based on final changes in autonomic index; AMPAVE = Ratio of orienting amplitude with the average autonomic arousal; AMPADP = Startle reactions observed in accordance with emotional adaptability; AMPLOG = Orienting amplitude in relation with normality adjusted autonomic responses; CONST = Relative consistency in high performance.

FIGURE 2 clarifies the significance of direct influences of several autonomic indices on emotional adaptability as well as direct and additive (mediated by autonomic adaptability) onto the question of consistency in high performance in swimming. Autonomic measures such as basal measure of GSR, AMPFIN and AMPAVE were significantly related to consistency in performance, while only GSR and SF were found negatively associated with the factor of adaptability. This diagramme further depicts that the additive influence of adaptability has a contributory effect on the consistency in performance in the swimmers representing families with higher economic resources and with better socio-cultural atmosphere. **TABLE 2** shows that 19% of the variance in the extent of adaptability, and 86% of the variance in the extent of consistency in performance of swimming have been contributed by the autonomic influence revealed by the GSR or Sc measures. This finding implies that those who had optimal level of emotional regulation (derived by both the various habituation paradigm and orienting reflex GSR indices), could maintain consistency in their performance.

TABLE 2: LISREL Estimates (Maximum Likelihood)

Structural equations	**Variance change**	**Goodness of fit statistics**
ADAPT = - 0.11*GSR - 7.57*SF + 0.33*AMPIN + 198.66*AMPFIN - 345.80*AMPAVE - 0.92*AMPADP - 0.17*AMPLOG	19%	Minimum Fit Function Chi-Square = 0.0 (P = 1.00) Normal Theory Weighted Least Squares Chi-Square = 0.00 (P = 1.00) The Model is saturated, the Fit is perfect!
CONST = 0.26*ADAPT + 0.015*GSR + 0.63*SF + 0.071*AMPIN + 145.02*AMPFIN - 145.18*AMPAVE + 0.47*AMPADP + 0.022*AMPLOG	86%	

Discussion

Reports from the structural equations (**FIGURE 1**) however depicted that, swimmers with better cardiovascular and autonomic efficiency (index of stable emotionality) had more consistency in performance. This result had no significant impact on the question of performance excellence. These findings of direct relationship, however implied that, those who had relatively higher HR and displayed higher GSR scores (revealing relatively lower control over autonomic arousal), maintained consistency in high performance. This finding also implied that, psychological variables such as cognitive reflex, agility and sympathovagal balance were relevant for neither the consistency in performance nor the question of performance excellence in swimming. Predictive relationship between cardiovascular efficiency and autonomic basal arousal modulation with consistency in performance seems obvious but a very lower resting HR though define

cardiovascular efficiency, but that excellent resting HR alone may not be sufficient to produce consistent high performance. Similarly a relatively higher basal arousal may appear as lack in emotional regulation, but also reveals serious and attentive engagement in competitive performance (Saha *et al.*, 2005; 2012c).

An observation of no relationship between other psychobiological and psychomotor variables may raise the question as to how far sympathovagal balance, cognitive reflex and agility can contribute to efficient performance in swimming. HR as the index of cardiovascular efficiency may have its implication with cognitive motivational aspect - BAS (Behaviour Activation, i.e., the approaching tendencies), and basal GSR measures on the other hand reflects indices of fear-eliciting tendencies (Behaviour Inhibition i.e., passive avoidance tendencies) (Beauchaine, 2001). Sympathovagal balance being the index of cognitive-motivational explanation behind competitive behaviour, optimal emotional regulation can merely explain consistency in performance, (36 % of changes in the variance was explained) while that was found insufficient to ensure performance excellence (only 14% of variance changes in the extent of performance excellence was explained).

Both cardiovascular efficiency and GSR were observed as not associated with the EXCELLEN (performance excellence issue), which was supposed to be mediated through the consistency factor (though no significant relationship was established). These findings revealed that swimmers representing from apparently wealthy families, with favourable SCS backgrounds, might characteristically have excellent (markedly lower) resting HR, and higher control over autonomic arousal, which might not be adequate to maintain consistency in performance. Hence those who apparently had relatively higher HR and higher score in autonomic regulation (relatively higher GSR basal scores); had active attentive engagement and had the exact kind of psychobiological make-up conducive to produce consistency in performance of competitive swimming.

Here we paid attention to some other environmental aspects, especially the aspect of favourable socio-cultural situations (most of the parents of the swimmers were ex-players, and some are still continuing to play). This has a lot of impact on to the issue of genetic endowment, but apart from that, swimmers who were raised within an extremely sport-friendly atmosphere, definitely had added advantage compared to their counterparts hailing from less favourable families with larger number of siblings and lower SES. Living in a favourable comfortable environment, majority of the swimmers might have been raised with a sense of abundance, leading toward a sense of assurance, which would carry differential nature of cognitive-motivational tendencies, conducive to exploratory and approaching (BAS dominated) tendencies (Beauchaine, 2001).

These advantageous environmental set-up may lead to the action-regulation techniques inducing a sense of autonomic vigilance (McGaughy *et al*., 1996) (stemming from faster RAS activation mediated by both synergic and competitive actions of cholinergic and adrenergic components to regulate thalamocortical activity and the corresponding behavioural state (Burlet *et al*., 2002). Thus to identify the extent of suppleness in the cognitive make-up of the swimmers and cognitive – emotional pathways facilitating in consistent high performance, certain autonomic measures were conceived out of the habituation paradigm skin conductance data. Those are detailed herewith in this section. ADAPT was developed from the

measures of autonomic adaptability as index of emotional stability; AMPIN was developed as index of startle responses observed in accordance with initial autonomic changes; AMPFIN was conceived out of sudden change in emotionality based on final changes in autonomic index; AMPAVE was formed from the ratio of orienting amplitude with the averaged autonomic arousal level; AMPADP was considered as measure of startle reactions observed in accordance with emotional adaptability, and AMPLOG was considered as the orienting amplitude in relation with normality adjusted autonomic responses.

TABLE 2 however revealed that psychobiological measures could altogether explain about 19% of variance changes in the extent of autonomic adaptability (ADAPT), while additive contribution of ADAPT and all other psychobiological variables explained as high as 86% of variance changes in the extent of consistency in performance. **FIGURE 2** clarified the significance of direct influences of several autonomic indices on emotional adaptability as well as direct and additive (mediated by autonomic adaptability) onto the question of consistency in high performance in swimming. Autonomic measures such as the basal measure of GSR, AMPFIN and AMPAVE were significantly related to consistency in performance, while only GSR and SF were found negatively associated with the factor of adaptability.

This finding revealed that the swimmers having lower level of basal tonic skin conductance and lower extent of autonomic spontaneous response fluctuations (SF) were better able to adapt to suddenly evoked emotional changes, which Beauchaine (2001) opined as cognitively mediated ability to minimize fear-eliciting tendencies, the cognitive-emotional outcome of rationalization of apprehensive thoughts and adequate regulation in negative expectancies. At the psychobiological level it should be processed in the association area of cerebral cortex, from where apprehensive impulses may reach the limbic system via hippocampus, which may then send feedbacks to the fear centres in the central nucleus of brain mediated through the Amygdaloid nucleus. These are the basic framework of TCA pathway, which may explain the possibility of development of fear-eliciting or inhibitive behaviour (as in BIS tendencies), the HPA axis on the other hand conceptually discusses about the role of hypothalamus and then pituitary in releasing ACTH as well as β – endorphins and direct secretion of vasopressin from hypothalamus itself to facilitate in vasodilatation and a sense of well-being and euphoric feeling. These definitely moderate the autonomic effects of somatic arousal, and minimizes emotional overloading.

FIGURE 2 depicted that swimmer having moderate arousal (which is an index of adequate emotional regulation); higher level of autonomic response to sudden changes and adequate autonomic adaptations over orienting response amplitude (which has been termed as orienting reflex) (Kimmel *et al.*, 1979 and Chattopadhyay *et al.*, 1975; 1983) were capable of maintaining consistency in high performance. Previous studies done by the present group of researchers, following similar methodology on other athletes and on internationally famous cricketers yield similar outcomes (Saha *et al.*, 2006 and 2012c).

Conclusion

Favourable environmental set up can ensure upbringing of adolescent swimmers in maintenance of performance excellence, which may be meditated through enhancement in cognitive-emotional competence. Further, autonomic habituation paradigm indices of emotionality and orienting reflex activities

can aptly predict changes in competitive behaviour in the elite-level swimmers. Findings of this study may generate further interest to carry out replicated studies following rigorous methodology on other spectrum of competitive sports.

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