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Aggressiveness Level Assessment using EEG Inter Channel Correlation Coefficients

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Abstract

Aggressiveness is one of the most important human characteristics that enable humans to achieve and reach to a higher level in their day to day activities. Conventionally, the aggressiveness of a subject is normally measured using Buss Perry aggressiveness questionnaire method. The validity of the aggressiveness score of a subject measured using this questionnaire method highly depends on the honesty of the subject while giving feedback for the questionnaire. Further, the aggressive level of a subject will change with respect to time and other environmental factors. Considering the variability of aggressive level, two simple methods, namely, task based mean of inter channel correlation coefficient method and inter trial task based channel correlation coefficient method have been proposed to estimate the aggressiveness of a subject while playing a smart phone game. A simple protocol to measure the EEG signals from the subjects while playing a smart phone game is proposed and EEG signals from 10 different subjects are obtained. Using the developed methods, the Buss Perry Aggressive Index, BPAI values were computed and analyzed together with the conventional Buss Perry Questionnaire based aggressive level index values. From the results it has been observed that subjects with higher BPAI value will get into higher aggressiveness state quickly and recover back to relaxing state quickly compare to subjects with lower BPAI value. For subject with BPAI level near to the group classifying limit might possess both group characteristic of Net Aggressiveness Index, NAI development when expose to induction of aggressiveness. Therefore the proposed task based mean of inter channel correlation coefficient method and inter trial task based channel correlation coefficient method can be used to measure the aggressive index values.

Keywords: Aggressiveness Level Index, Channel Correlation, Correlation Coefficient, EEG, Smart Phone Game

1. Introduction

In the literature, the term aggression is defined to represent both violent and hostility behavior[1]. The term aggressiveness which is derived from aggression does not limit to violent and hostility[9] instead it has been used to measure the optimistic behavioural responses from a subject's emotion[4]. Conventional methods use questionnaires to measure the aggressiveness of a subject. Research based on questionnaire faces frequent critic since the test subject might give false or socially more acceptable answers. This subsequently may yield a negative trait in assessing the aggression due to perception. The development of questionnaire[17,18] for assessing aggression has been continuously improved ever since 1957[1] to the current Buss Perry Questionnaire, (BPQ)[10]. Some researchers argue that the validity of self-report measures of aggression, arguing that social desirability and self-presentational concerns produce inaccuracy[19]. This means that when dealing with a socially unacceptable behaviour such as aggression, respondents may be hesitant to admit the extent of such behaviour[6]. It may be assumed that respondents are concerned with the opinions of others, which they fear that they will be judged negatively if they admit to engage in aggressive action. Consequently, the researcher design procedures and instructions to suggest that such behavior might be acceptable or justified and to hide the respondent's identity. Besides, one additional issue with the questionnaires based method is that this is a passive measurement method suitable to measure the aggressiveness evaluated through a set of questionnaires.

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These questionaries' methods cannot actively measure the aggressiveness level of an individual while performing an active task. As the source of aggressiveness can be measured from the brain[3,8], further experimental based investigation on aggressiveness will provide clear understanding on the various levels of aggressiveness[2]. Measuring the aggressiveness level of an individual gives valuable information regarding how aggressive the individual is during a task. As example based on the aggressive level induced to a children on an aggressive video game, studies can be performed to analyse the effect of that particular game to the brain before and after playing the game.

Brain waves is nothing but electrical activities generated by brain cell when the brain is performing a task. The small electrical potential[27] on the scalp is mainly caused by synaptic excitation of dendrite, where neurons are firing rapidly in certain patterns of frequencies. Brain signal that are measured on the scalp by metal electrodes and conductive media[26] and then massively amplified[16,29] and this measurement method is known as Electroencephalogram (EEG). This method can be used to measure the activity of the brain cells only when a large quantity of brain cell in a region[12] are activated at the same time. As the amplitude of the brain signals are of very small (in the range of micro volts), the effect of noise can alter the result of signal analysis, a higher order elliptic band pass filter was used to remove the low frequency and high frequency noise. It has been reported that when a person is focusing on a specific task, then the neurons in the neighborhood of a specific region is also activated[31]. Therefore brain wave pattern of the individual are very unique[30]. This also implies that the subjects participating in the research cannot consciously hide their feelings to affect the EEG signal during the game experiment[33]. The EEG signals emanated from a subject provide the level of aggressiveness made by them while performing a task[15]. In order to measure the aggressive level index of a subject based on the EEG signals emanated, the main objective of this paper is focused on to develop suitable protocols for recording the EEG signals along with suitable methods to infer the aggressiveness values from the recorded EEG signals.

2. Methodology

2.1 Subjects Selection

The BPQ is a well-developed aggressiveness rating questionnaire[21,22] system normally used by psychologist. For our experimental study, the questionnaire was prepared in two languages, namely, in English and Mandarin. BPQ was given to participants with a request to answer the questionnaire. The questions were explained to the subject, in case, if the subject didn't get the meaning of the question even after reading the translated version. Comparing participants' self-report data with the data obtained from a peer reviewer, a more accurate Buss Perry Aggressive Index, (BPAI) with minimal self-protective bias is computed[24,25]. After computing the BPAI score, participants with the same level of base aggressiveness are grouped together and are randomly selected from each group. As patterns of aggressive behaviour are dependent on both culture and sex[6], healthy male Chinese subjects with three different base aggressiveness levels such as those with low, medium and high BPAI scores were recruited in this experiment. As previous researchers have reported that female subjects will show differences in physical, verbal and indirect aggression level[5,7], we consider only male subjects in our experimental analysis. All the male participants should have no prior experience in any of the EEG experiments. Further, all the subjects considered in the experimental study are not addicted to video or smart phone games[23]. Individuals who have less than 6 hours of sleep before the experiment or those who fall sick were excluded. During the initial trial run, the EEG signal was initially recorded from the subjects with their eyes closed for 60 seconds followed by another 60 seconds of EEG signal recordings with their eyes opened in order to ensure that subject's appropriate data has been recorded.

2.2 Experimental Data Acquisition Protocol

Before starting the data acquisition protocol, the subjects were informed in detail about the purpose and the objective of the research work and using a consent form their acceptance to participate in the experimental study were obtained. Then the subjects were requested to fill the BPQ and their aggressive index values (BPAI) were computed and categorized into three different base aggressive classes. A subject with BPAI score less than 50 is considered to be in the lower class. A subject whose BPAI score lie in the range of [50-69] is considered to be in middle class. Any BPAI score greater than or equal 70 is considered as a high class. The subjects were then required to play a popular non-violence smart phone game named Temple Run II which is available free in android play store. Using this game it is able to attract the attention of the subject and simultaneously inducing aggressiveness[13]. To measure the aggressive level of the subject, the subject was asked to play[14] the Temple Run II game and at the same time, the EEG signals emanated from the brain were measured at the brain scalp. The experimental setup includes a Mindset-24 EEG amplifier and an electrode cap. The 19 channel electrodes (FP1, FP2, F7, F3, FZ, F4, F8, T3, T5, C3, CZ, C4, T4, T6, P3, PZ, P4, O1 and O2) were placed on the scalp using 10-20 electrode positioning system (Standard Positioning Nomenclature, American Encephalographic Association)[32] and the reference electrodes were placed on the left and right mastoids[34]. The subjects were asked to play the game for 60 seconds with and without sound mode as per the experimental protocol explained in the subsequent paragraph. While the subjects were playing the game, EEG signal was recorded using the19-channel EEG amplifier at a sampling frequency of 256 Hz. To meet the sampling criterion, the sampling frequency of 256 Hz has been selected, since the frequencies of interest lies below 40 Hz[28]. A higher order (5th) elliptic band pass filter with cutoff frequency 0.5 Hz and 40 Hz was selected to remove the low and high frequency noise.

In the experimental protocol, the subject was asked to perform four different tasks in a sequential manner. If the subject has failed while performing Task 2 or Task 3 then the subject has to restart from the first task. The first task is the relaxation stage. During this task, the subjects were asked to remain seated ideally in a relaxed state without making any movement. The EEG signals were then recorded for 60 seconds. From the recorded signals, the initial and the final 25 seconds signals were removed and only the middle 10 second signals were extracted and used as the base reference signal. Once after completing the first task, the subjects were asked to play the Temple run II game in the mute mode continuously for 60 seconds and the signals recorded during the last 10 seconds of the game play was extracted and used for analysis. The subject should survive during the entire play period of 60 seconds and collect as many gold coins as possible. Thus by setting a goal, we induce the subject and made him to be aggressive during the game play[20]. EEG signal was recorded during the entire 60 seconds and only the last 10 seconds is considered for analysis; this is due to the fact that the subject will have the highest aggressiveness when the time is running out and the goal stated has not yet been reached. Furthermore during the play period the subject were requested to play the game without making any sudden movement. If the subject was able to complete the second task successfully by surviving the entire game play period of 60 seconds, then the subject was asked to take rest for 30 seconds and proceed to the third task else the signals recorded during this trial session was not considered and the subject was asked to start from the first task. After completing the first and second tasks completely in sequence, the subjects were asked to take a rest for 30 seconds and asked to perform the third task. The third task is also similar to the second task except that the subject has to play the Temple Run II game for 60 seconds in the maximum sound mode as the visual and auditory stimuli will increase the aggressiveness during the game play[11]. During this game play period, EEG signals were recorded. If the subject completes the third task also successfully then the subject was asked to remain seated in a relaxed manner without making movement for 10 seconds and the corresponding EEG signals were recorded. As the subject has completed all the four tasks successfully, the recording made during this trial session was considered for further analysis. The experimental protocol was repeated till the subject successfully complete three such trial sessions. Ten different subjects participated in the experimental study by following the above set of experimental protocols. EEG signals were then recorded and a database was formulated and analyzed to determine the aggressive level of the various subjects.

3. Aggressive Level Index

3.1 Single Trial Correlation Vector

EEG signals were recorded from 19 channels, at a sampling frequency of 256 Hz for 10 seconds. Ten subjects have participated in the experimental study. The experimental study consists of four different tasks and each task has three trials. Since the data was recorded for 10 s at a sampling frequency of 256 Hz, the total number of samples in one channel, N is 2560.

The EEG signal recorded from the i^{th} channel for the r^{th} trail, t^{th} task of the s^{th} subject, $\boldsymbol{X}_i^{rts}$ is written as

$\boldsymbol{X}_i^{rts} = \left\{ x_{i,1}^{rts}, x_{i,2}^{rts}, x_{i,3}^{rts}, \ldots, x_{i,N}^{rts} \right\}$, , i = 1, 2, 3, …, 19; r = 1, 2, 3; t = 1, 2, 3, 4 and s = 1, 2, 3, …, 10.

The correlation between the j^{th} and k^{th} channel signals, $\boldsymbol{X}_j^{rts}$ and $\boldsymbol{X}_k^{rts}$ can be written as

$$C_{jk}^{rts} = \frac{\sum x_{ji} x_{ki} - N \overline{X_j^{rts} X_k^{rts}}}{(N-1)\sigma_j^{rts} \sigma_k^{rts}} \tag{1}$$

where, $\overline{X_j^{rts}}$, $\overline{X_k^{rts}}$ are the mean values of the j^{th} and k^{th} channel signals obtained for the r^{th} trail, t^{th} task of the s^{th} subject, Similarly, σ_j^{rts} and σ_k^{rts} are the standard deviations of the signals X_j^{rts} and X_k^{rts} respectively. Using Equation 1, corresponding to a specific task performed by a subject in a single trial, a correlation coefficient matrix C^{rts} consisting of the correlation coefficient values, $C_{jk}^{rts}\left(j,k = 1,2,3,\ldots 19\right)$ between all the 19 channels can be formulated.

Since the correlation coefficient matrix C^{rts} is symmetrical about the diagonal, all the elements above the principal diagonal (171 elements) can be arranged in a row order to represent a single trail correlation vector W^{rts} corresponding to a specific task of subject. The elements of the single trial correlation vector can be thus formulated as

$$\begin{aligned} W^{rts} = [& C_{1,2}^{rts}, C_{1,3}^{rts}, C_{1,4}^{rts}, \ldots, C_{1,19}^{rts}, \\ & C_{2,3}^{rts}, C_{2,4}^{rts}, C_{2,5}^{rts}, \ldots, C_{2,19}^{rts}, \\ & C_{3,4}^{rts}, C_{3,5}^{rts}, C_{3,6}^{rts}, \ldots, C_{3,19}^{rts}, \ldots, \\ & C_{j,j+1}^{rts}, C_{j,j+2}^{rts}, C_{j,j+3}^{rts}, \ldots, C_{j,19}^{rts} \ldots, C_{18,19}^{rts} \end{aligned} \tag{2}$$

Thus, using Equations 1 and 2, the Single Trial correlation vectors W^{rts} (r = 1, 2, 3; t = 1, 2, 3, 4 and s = 1, 2, 3,…, 10) of all the three trials corresponding to each of the four tasks made by all the 10 subjects can be computed. Using the single trail correlation vector, two analyses namely, task group based channel correlation coefficient analysis and inter trail-task channel correlation coefficient analysis have been formulated and discussed in the subsequent sub sections.

3.2 Task Group based Mean of Inter Channel Corerlation Coeffient Analysis

In this analysis we consider the mean effect of the inter-channel correlation coefficient of each task. As each subject has performed three trials for each task, we can group the single trail correlation vectors of a subject based on each task. Thus, for each subject, we have four groups and for each group we have three trail correlation vectors. It should be noted that each task group consists of three rows and 171 elements in each of these rows.

From the task group based correlation vectors, the mean of the correlation coefficient vector between the various channels of the s^{th} subject for the t^{th} task M^{ts} can be obtained by considering the average values of the correlation coefficients obtained during the three trials of the t^{th} task for the s^{th} subject.

It should be noted that the task correlation coefficient vector M^{ts} contains one row and 171 inter–channel correlation coefficient values. For each subject, the relaxation task is considered as a base line task. The task based inter-channel correlation coefficients of the tasks 2 to 4 can be compared with the reference relaxation task and the aggressive index level of the tasks 2 to 4 can be formulated. This can be accomplished by computing the total distance between the inter-channel correlation coefficient values of the various tasks and the respective inter-channel correlation coefficient values of the reference relaxation task. The net aggressive level A^{ts} of various tasks performed by the s^{th} subject can be computed using equation (3).

$$A^{ts} = \sqrt{\sum_{q=1}^{171}\left(M_q^{1s} - M_q^{ts}\right)^2}, t = 2,3,4. \tag{3}$$

3.3 Inter Trail-Task Channel Correlation Coefficient Analysis

Using Equations 1 and 2, for the s^{th} subject, we first formulate the inter-channel correlation coefficient values for all the three trials pertaining to a specific task. Similarly for the same subject, we then formulate the inter-channel correlation coefficient values for all the three trials pertaining to the remaining three tasks. Thus, we can formulate task group based inter-channel correlation coefficient matrix as:

$$T^s = \left[T^{1s}\ T^{2s}\ T^{3s}\ T^{4s}\right]^{Tr}, s = 1,2,3,\ldots,10 \tag{4}$$

where, $$T^{1s} = \left[W^{11s}\ W^{21s}\ W^{31s}\right]^{Tr} \tag{5}$$

$$T^{2s} = \left[W^{12s}\ W^{22s}\ W^{32s}\right]^{Tr} \tag{6}$$

$$T^{3s} = \left[W^{13s}\ W^{23s}\ W^{33s}\right]^{Tr} \tag{7}$$

$$T^{4s} = \left[W^{14s}\ W^{24s}\ W^{34s}\right]^{Tr} \tag{8}$$

The relative aggressive correlation level among the three inter trial-task-channel correlated trial signals of the relaxation task A_{11}^{s} with reference to itself can be computed by correlating T^{1s} with T^{1s} and written as a matrix form as

$$A_{11}^{s} = \begin{pmatrix} W^{11s} \circ W^{11s} & W^{11s} \circ W^{21s} & W^{11s} \circ W^{31s} \\ W^{21s} \circ W^{11s} & W^{21s} \circ W^{21s} & W^{21s} \circ W^{31s} \\ W^{31s} \circ W^{11s} & W^{31s} \circ W^{21s} & W^{31s} \circ W^{31s} \end{pmatrix} \quad (9)$$

where, the correlation operator is denoted by the symbol '∘'. The relative aggressive correlation level of the inter-trial-task-channel correlated trail signals of the reference relaxation task with respect to the inter channel correlated trial signals of the second task A_{12}^{s}, can be computed by correlating all the inter channel correlated signals of the reference task T^{1s} to the inter channel correlated trial signals of the second task T^{2s}.

$$A_{12}^{s} = \begin{pmatrix} W^{11s} \circ W^{12s} & W^{11s} \circ W^{22s} & W^{11s} \circ W^{32s} \\ W^{21s} \circ W^{12s} & W^{21s} \circ W^{22s} & W^{21s} \circ W^{32s} \\ W^{31s} \circ W^{12s} & W^{31s} \circ W^{22s} & W^{31s} \circ W^{32s} \end{pmatrix} \quad (10)$$

Similarly, the relative aggressive correlation levels of the inter-trail-task channel correlated trail signals of the reference relaxation task with respect to the inter channel correlated trial signals of the third and fourth tasks, namely A_{13}^{s} and A_{14}^{s} can be computed using Equations (11) and (12) respectively.

$$A_{13}^{s} = \begin{pmatrix} W^{11s} \circ W^{13s} & W^{11s} \circ W^{23s} & W^{11s} \circ W^{33s} \\ W^{21s} \circ W^{13s} & W^{21s} \circ W^{23s} & W^{21s} \circ W^{33s} \\ W^{31s} \circ W^{13s} & W^{31s} \circ W^{23s} & W^{31s} \circ W^{33s} \end{pmatrix} \quad (11)$$

$$A_{14}^{s} = \begin{pmatrix} W^{11s} \circ W^{14s} & W^{11s} \circ W^{24s} & W^{11s} \circ W^{34s} \\ W^{21s} \circ W^{14s} & W^{21s} \circ W^{24s} & W^{21s} \circ W^{34s} \\ W^{31s} \circ W^{14s} & W^{31s} \circ W^{24s} & W^{31s} \circ W^{34s} \end{pmatrix} \quad (12)$$

The relative aggressive correlation level of a specific task with reference to Task 1 can be then computed by calculating the mean values of the respective inter-trail-task channel correlated matrices. Further, from the inter-trail-task channel correlated matrices, we can compute the mean and standard deviation values of the relative aggressive correlation level for the various tasks for making further analysis.

4. Results and Discussions

To perform task group based mean coefficient correlation analysis, using Equations 1 and 2, the single trial correlation vectors W^{rts}(r = 1, 2, 3; t = 1, 2, 3, 4 and s = 1, 2, 3, …, 10) of all the three trials corresponding to each of the four tasks made by all the 10 subjects were computed; the computed values for each subject were then arranged based on the four tasks. For each subject, the mean of the task group based correlation vectors were then computed. The subject wise Net Aggressive Index (NAI) values of the various tasks are then computed with reference to the relaxation and the results are tabulated in Table 1. Using Table 1, corresponding to each subject, the mean of net aggressive index values for the tasks 2 to 4 are depicted in Figure 1. From the Figure 1, it can be observed that NAI values during the game play (Task 2 and Task 3) for all the subjects except S5 and S9 are higher than the NAI values

Table 1. Subject wise Net Aggressive Index

Subject No.	Net Aggressive Index			BPAI
	Task 2	Task 3	Task 4	
S1	30.31	28.26	25.86	51.2
S2	21.57	25.71	9.75	67.0
S3	51.58	49.64	11.59	76.1
S4	35.31	50.67	21.71	51.4
S5	27.97	26.52	36.96	34.6
S6	50.41	50.25	10.34	65.9
S7	31.23	31.65	14.66	57.3
S8	56.54	55.10	14.64	84.5
S9	26.37	26.85	39.48	49.0
S10	21.50	17.91	14.75	46.4

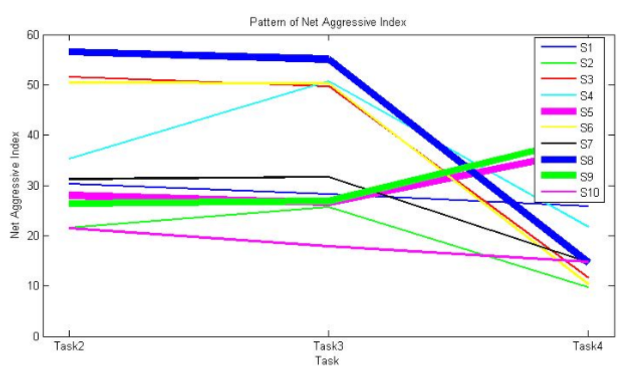

Figure 1. Net Aggressive Index for tasks 2 to 4 (subject wise).

corresponding to final relaxation period (Task 4). This is because during the game play period (Task 2 and Task 3), the subjects were concentrating to achieve their goal and hence their aggressiveness index values were higher. After completing the game (Task 4), the subjects started to feel comfortable and hence their level of aggressiveness has dropped. For the subjects S5 and S9, the increase in NAI during Task 4 (as compared to the NAI during game play) indicates that the impact of playing the two games persistently exists even after they stopped playing the games.

From Figures 2, 3 and 4, it can be observed that for subjects S2, S4, and S7, the rate of NAI drop from Task 3 to Task 4 is lower when compared to the rate of NAI drop for subjects S3, S6 and S8; however the drop is relatively higher when compared with the subjects S1 and S10 (drop of NAI 15-35 points). This indicates that the subjects S2, S4 and S7 need some time to reach the relaxation state after stop playing the games. It is also observed that the BPAI values for these subjects are within range of 50 to 70. Another interesting pattern that can be observed within this subject group (S2, S4 and S7) is that the rate of NAI has increased from Task 2 to Task 3 while for all the other subjects, the rate of NAI from Task 2 to Task 3 is not changing abruptly. During Task 3 a subject is playing the Temple Run II Game in Max Sound Mode and this is one of the reasons why the NAI value has increased in this task. Another possible explanation is these subjects are slow in getting into aggressive state. After the game play in Task 2, the aggressiveness level of these subjects continues to build up in Task 3. This group of subjects (BPAI 50-70) took some time to raise their aggressive and took some time to fall back to the relaxing state. Figure 2 display the pattern changes in NAI value for Subject 2, 4 and 7 with BPAI in range of 50-70.

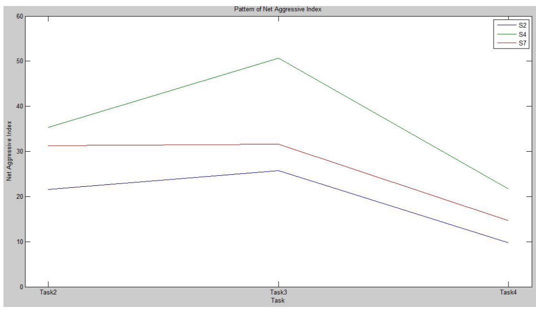

Figure 2. Net Aggressive Index for tasks 2 to 4 (subject BPAI 50-70).

From Figure 3, it can be observed that for subjects S3, S6 and S8, the rate of NAI drop from Task 3 to Task 4 is much higher (drastic drop of NAI at least 35 points) and this indicates that these subjects are able to come to the relaxation state immediately after playing the games. Another interesting pattern that can be observed within this subject group (S3, S6 and S8) is that the BPAI values for these subjects are much higher than 65. Moving from Task 2 to Tak3, it can be observed that there no increase in NAI value as these subjects are quick in getting into their highest level of aggressiveness even during the game play in Task 2. It is also observed that the BPAI values for these subjects are within range of above 65. This group of subjects (BPAI>65) is quick in raising their aggressive level and also quick enough to set back to the relaxing state.

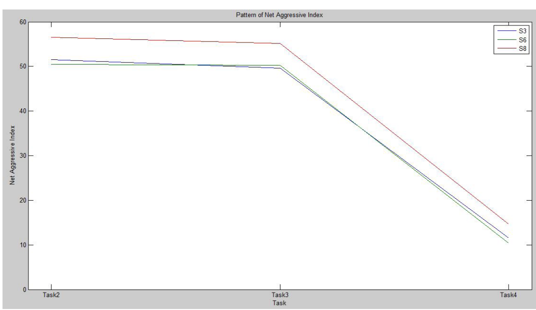

Figure 3. Net Aggressive Index for tasks 2 to 4 (subject BPAI>65).

For subjects S1 and S10, the rate of NAI drop is very less (NAI drop linearly <5). This indicates that these subjects are still remaining in the game playing stage itself and slow in returning to the resting stage. The BPAI values corresponding to these two subjects are 46.4 and 51.2 respectively. The NAI patterns for Subject S1 and S10 with considerable low BPAI (<50) is shown in Figure 4.

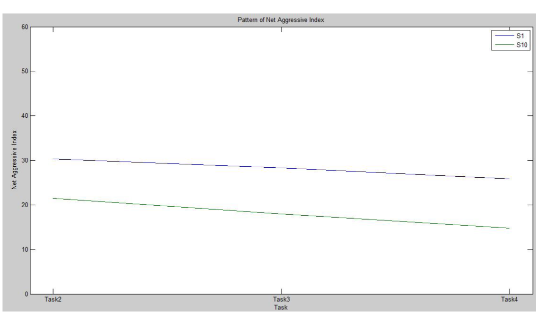

Figure 4. Net Aggressive Index for tasks 2 to 4 (subject 1, 10).

From Figure 5, it can be observed that the pattern changes in NAI value for subject S5 and S9 is increasing even after performing the relaxing task. These subjects tend to remain in the same game play state and not able to transfer to the relaxing state. It is interesting to observe that Subject S5 and S9 have a common similarity which is having a very low BPAI value which is 34.6 and 49 respectively.

To perform Inter Trail-Task-Channel Correlation of Coefficient Correlation Analysis, for each subject, the relative aggressive level matrices of all the tasks with reference to the Task 1, namely, $\boldsymbol{A}^s_{11}, \boldsymbol{A}^s_{12}, \boldsymbol{A}^s_{13}$ *and* $\boldsymbol{A}^s_{14}$ were formulated using Equations 9-12. Using the elements of the formulated matrices, the mean and the standard deviation of the relative aggressive level of the inter-trial-task-channel were computed and shown in Table 2 and 3 respectively. Further, for three typical subjects S8 (rate of NAI drop -high), S1 (rate of NAI drop-slow) and S5 (rate of raise) the box plot corresponding to the elements of the relative aggressive correlation level matrices of all the tasks with reference to the first task, namely, $\boldsymbol{A}^s_{11}, \boldsymbol{A}^s_{12}, \boldsymbol{A}^s_{13}$ *and* $\boldsymbol{A}^s_{14}$ are shown in Figures 6 to 8.

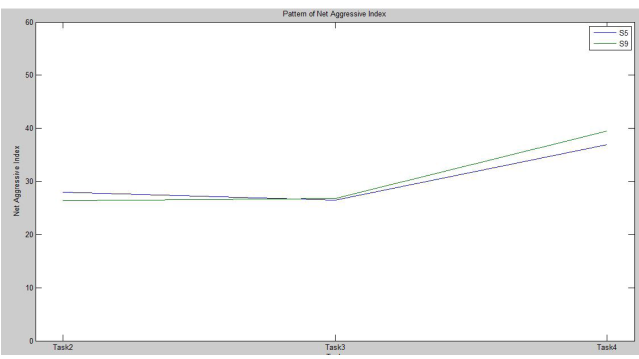

Figure 5. Net Aggressive Index for tasks 2 to 4 (subject 5, 9).

Table 2. Subject wise mean of relative inter-trial-task-channel aggressive level

Subject No.	Mean of Relative Aggressive Correlation				BPAI
	Task1	Task2	Task3	Task4	
S1	0.96	0.66	0.60	0.94	51.2
S2	0.99	0.83	0.84	0.93	67.0
S3	0.99	0.72	0.72	0.97	76.1
S4	0.97	0.89	0.83	0.89	51.4
S5	0.99	0.80	0.78	0.91	34.6
S6	0.97	0.77	0.75	0.94	65.9
S7	0.97	0.74	0.82	0.97	57.3
S8	0.99	0.40	0.44	0.99	84.5
S9	0.96	0.80	0.80	0.92	49.0
S10	0.98	0.93	0.93	0.95	46.4

From Table 2, it can be inferred that the mean relative aggressive correlation values corresponding to Task 1 and Task 4 (relaxation tasks) are higher which indicates these tasks are more similar. Further, the mean relative aggressive correlation values corresponding to Task 2 and Task 3 are lying away from the mean relative aggressive correlation values corresponding to Task 1 and Task 4. This indicates that the tasks 2 and 3 are more different in nature and the formulated relative aggressive correlation values can be used as an aggressive level indicator.

From Table 3 and Figure 6, we can very easily observe that, the standard deviation of the relative aggressive correlation values for tasks 1 and 4 are very small indicating the subjects are making very less variation in the relative aggressive levels while performing the relaxation tasks. Further, referring to tasks 2 and 3, the standard deviations of the relative aggressive correlation values are very higher as compared to the standard deviation of the relative aggressive correlation values for tasks 1

Table 3. Subject wise standard deviation of correlation

Subject No.	Std. Dev. of Relative Aggressive Correlation			
	Task1	Task2	Task3	Task4
S1	0.035	0.062	0.149	0.025
S2	0.014	0.029	0.029	0.016
S3	0.010	0.049	0.022	0.017
S4	0.021	0.013	0.047	0.032
S5	0.009	0.032	0.027	0.012
S6	0.024	0.041	0.072	0.025
S7	0.029	0.091	0.074	0.015
S8	0.005	0.029	0.010	0.005
S9	0.043	0.054	0.078	0.022
S10	0.014	0.012	0.006	0.016

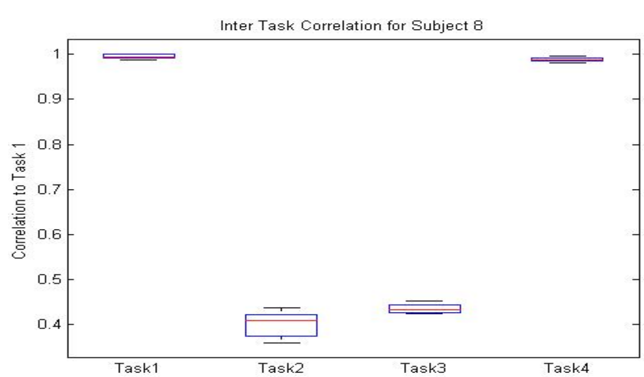

Figure 6. Box plot of relative aggressive level of subject S8.

and 4. This indicates that the aggressiveness made by the subjects while performing the game play tasks has higher variation. The inter task correlation value for subject S8 (BPAI>65 Group) with the highest BPAI value of 84.5 is shown in Figure 6. From Figure 6, it can be easily observed that the mean values between Task 1 to Task 2 as well as between Task 3 and Task 4 have a very high deviation. This high deviation in the mean of relative aggressive correlation values represents the presence of high aggressiveness of the subject S8 while performing the tasks.

From Table 3 and Figure 7, we can very easily observe that the standard deviation of the relative aggressive correlation values for tasks 1 and 4 are relatively smaller thus indicating the subjects are making very less variation in the relative aggressive levels while performing the relaxation tasks. Further, referring to tasks 2 and 3, the standard deviations of the relative aggressive correlation values are very much higher as compared to the standard deviation of the relative aggressive correlation values for tasks 1 and 4. This indicates that the aggressiveness made by the subjects while performing the game play tasks has higher variation. The inter task correlation value for subject S1 (BPAI >65 Group) with the BPAI value of 51.2 is shown in Figure 7. From Figure 7, it can be easily observed that the mean values between Task 1 to Task 2 as well as between Task 3 and Task 4 have high deviation. This high deviation in the mean of relative aggressive correlation values represents the presence of high aggressiveness of the subject S1 while performing the tasks.

From Table 3 and Figure 8, we can very easily observe that the standard deviation of the relative aggressive correlation values for tasks 1 and 4 are relatively smaller indicating the subjects are making very less variation in the relative aggressive levels while performing the relaxation tasks. Further, referring to tasks 2 and 3, the standard deviations of the relative aggressive correlation values are very much higher as compared to the standard deviation of the relative aggressive correlation values for tasks 1 and 4.

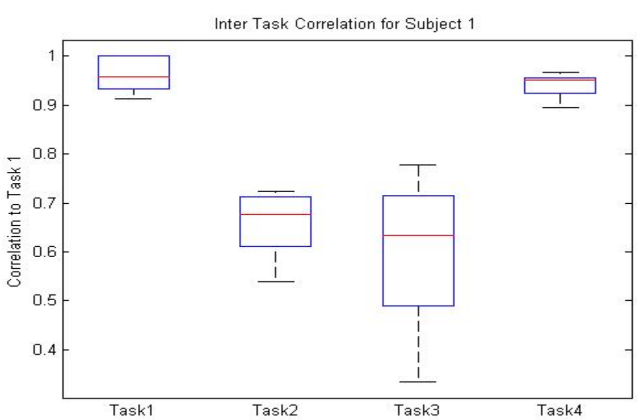

Figure 7. Box plot of relative aggressive level of subject S1.

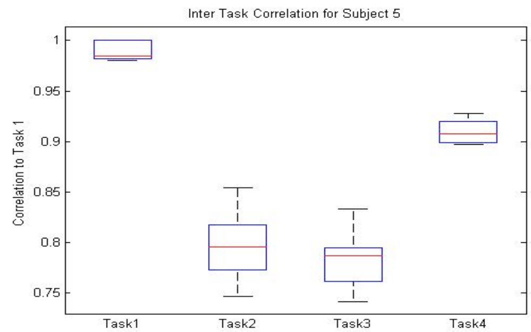

Figure 8. Box plot of relative aggressive level of subject S5.

This indicates that the aggressiveness made by the subjects while performing the game play tasks has higher variation. The inter task correlation value for subject S5 (BPAI <50 Group) with the lowest BPAI value of 34.6 is shown in Figure 8. From Figure 8, it can be easily observed that the mean values between Task 1 to Task 2 as well as between Task 3 and Task 4 have lesser deviation compare to the other subject such as subject S8 and S1.

5. Conclusion

In this paper, subjects based aggressiveness score was measured through BPQ method and the subject's NAI values are computed using the proposed task based mean of inter channel correlation coefficient method. A detailed analysis was also made relating the relationship between the NAI and BPAI. It is inferred that subjects with higher BPAI value get into higher aggressiveness state quickly and recover back to relaxing state quickly when compared to subjects with lower BPAI value. Further, the subject wise relative aggressive correlations values were computed and analyzed using the proposed inter trial task based channel correlation coefficient method. In future, it is proposed to analyze the NAI values with respect to time.

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