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Methodology to Evaluate the Intensity of Subjective Response to Emotional Pictures

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Abstract - The paper presents the results of a study of human perception of emotional pictures within the valence-arousal theory of emotion. The study involved 2 stages - EEG recording during viewing of images of 2 valences - *happy* and *sad*. After each image, the participant identified the emotion first, and then responded to a Likert scale on the intensity of the emotionality of the picture. The main result revealed a significant difference in the assessment of the emotion intensity by the male and the female participants. Trait-related and gender-related indicators of brain activation - delta and theta waves - are discussed in the context of possible novel approaches to rehabilitation.

I. INTRODUCTION

Cognitive biometrics has long attempted to identify patterns of EEG activations, which underlie experiencing different emotions [1, 2, 3]. A number of models have been proposed to account for the diversity of subjective experiences, associated with given emotions, among which the valence-arousal model has been prevalent [4]. It represents each emotion along a positive-negative dimension, and its intensity as an orthogonal to the former dimension to reflect the underlying level of neural activation. Mapping meaningfully self-reports on the nature and intensity of the experienced emotion when viewing emotional images, however, onto recorded neural activations, has been a difficult and not always definitive process.

The present research aims at identifying possible factors, which may determine the *idiosyncrasy* of the observed neural activations in the EEG frequency maps. One such dimension can be gender. It is possible to observe differing patterns in male and female participants in respect to valence. It is also possible to observe different intensity of the experienced emotion. Another dimension, possibly orthogonal to the first, can be *emotionality* as a trait. The outcome of this study will have an important impact on the rehabilitation approaches that can be undertaken via brain monitoring technology in the future.

II. METHOD

This study was designed with the aim to determine whether, when given emotionally triggering visual stimulus, it is possible to retrieve patterns of emotions from the electrophysiological and verbal responses. A study was designed using pictures validated for *sadness* and *happiness* from the publicly available OASIS[2] database.

Participants. A female (FP) and a male (MP) participant took part in the experiment. FP was 25 years old and MP

[1]The experimental work was performed while the first author was with the Department of Electrical Engineering, Indian Institute of Technology Kanpur, Kanpur, India

[2] https://www.benedekkurdi.com/%23oasis

was 28 years old - a graduate student and a project employee associated with IIT Kanpur, India. They were without any significant physical health issues related to vision (colour blindness) or musculoskeletal problems. The participants were not familiar with the study context until before their arrival.

Ethics. The study was approved by the Institutional Ethics Committee (IEC), IIT Kanpur. All procedures conformed to the IEC guidelines for research involving human subjects. The participants were provided written information about the study and a consent form which they had to sign for their approval to take part in the study.

Hardware. This experiment was done using a gNautilus wearable wireless EEG signal acquisition system[3]. It has 16 active EEG electrodes g.SAHARA (G.Tec), each sampled at 500Hz with flexible electrode positioning option in compliance with the 10-20 electrode placement system. The acquisition system was integrated with the MATLAB Simulink environment and an external TTL circuit to mark the events. The common reference configuration was in place while setting up the electrode arrays.

The eyelink-1000 eye-tracker system was used to capture the gaze pattern and pupil dilation while the participant was attending to the visual stimulus. This data will not be analysed here.

Stimulus. Forty-two pictures depicting four unique emotional states were randomly presented to the participants as visual stimuli. These images were sourced from the OASIS database and were rated on the valence-arousal scale for four emotional states which were *happy*, *sad*, *anger* and *excitement*. In the current study only the *sad* and *happy* cases are presented. Example images of *sad* and *happy* valences are presented in Fig. 1.

Fig. 1. Example images of *sad* (left) and *happy* (right) valences

Procedure. The stimulus began by a resting period of 30 sec, followed by the task in which each trial included a 4 sec display of the image followed by an emotion recognition task and a five-point Likert scale to record user behavioural response, and a 4 sec inter-stimulus interval (ISI). Cases of a sharp discrepancy of the objective emotion, depicted in the picture, and the subjective report (e.g. *sad* pictures perceived as *happy*), were removed from the analysis. A total of 30 such trials were recorded. The EEG recorded the cortical activities during the stimulus presentation. The ISI was selected at 4sec to account for the retraction period after image exposure.

III. RESULTS AND DISCUSSION

Twelve pictures were identified as *sad* by the female participant in contrast to the *male* participant who described eight pictures as *sad*. Fourteen pictures by the female and ten pictures by the male participant were perceived as *happy*.

Fig. 2 illustrates the mean perceived intensity of the observed emotions *sad* and *happy* by both participants. Interestingly, these differed statistically. FM evaluated the intensity of the emotion as reliably

[3]https://www.gtec.at/product/gnautilus-research/

higher for both the *happy* and the *sad* emotion, $F(1,15) = 8{,}27$, $p = 0{,}009$ for the *happy* pictures and $F(1, 21) = 15{,}79$, $p = 0{,}0012$ for the *sad* ones.

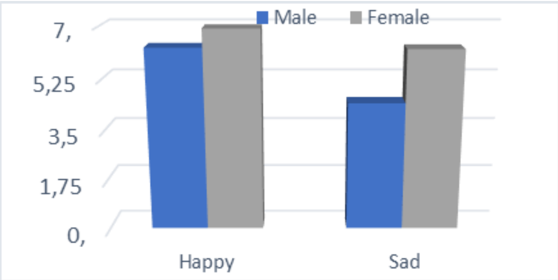

Fig. 2. Mean value of participants' evaluation of the intensity of the emotion in the *happy* and *sad* pictures

It may be that female participants experience emotions with higher intensity than male participants. This will be tested in bigger samples of participants.

EEG data analysis.

***Happy* emotion.** Images 'a' and 'b' on the left depict EEG activity of the female participant, whereas images 'c' and 'd' on the right illustrate EEG activity for the male participant (Fig. 3).

The main observations are: a. Prominent frontal delta activity at 1Hz peaking at 4 micro-volts towards the left (F8) and reducing to around 1 micro-volts towards the right (F7).

Large activity towards the left temporal lobe is also seen, which fades to the left parietal at 1Hz and is more localised in the later region at 7Hz in b. which depicts the higher theta activity. The right frontal, temporal and parietal activations were observed which involves the 'feeling center' or the amygdala of the brain.

For the male participant, c. the 1Hz delta activity at the frontal, a similar temporal activation and consequently the parietal activity, were observed.

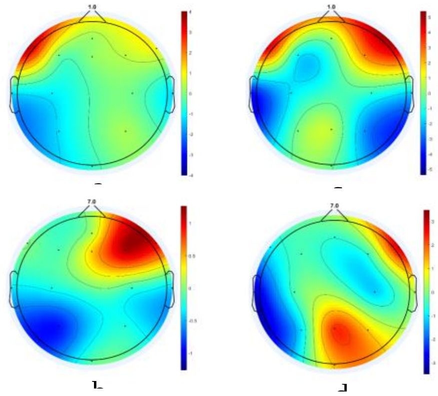

Fig. 3. EEG activations for the *happy* emotion (female to the left; male to the right)

These observations hold similarity to those of the female activations in 'a'. The right hemisphere dominance of theta (7Hz in d.) in the frontal area, is also parallel to that of the female in b. The left hemispheric dominance in the temporal and activations in parietal areas are important observations.

***Sad* emotion**. Images 'a' and 'b' (Fig. 4) on the left depict EEG activity of the female participant, whereas images 'c' and 'd' illustrate EEG activity for the male participant for the images perceived as *sad*.

a. In the delta band, at 3Hz, prominent frontal lobe activity is the activation over the left parietal area that extends to left temporal area. b. For the 7Hz theta band, the frontal activations at F4, F8, and inferior activations in the parietal occipital and temporal regions were observed. c. In comparison, at 3Hz, the frontal activity with dominance in the right hemisphere, occipital, and left temporal activity were observed for the male participant. d. The occipital theta activity at 7Hz, concurrently with the right temporal and frontal activations were observed.

The comparison of the brain charts reveals different patterns of activations for *sad* and *happy* images for both participants. Delta and theta activity are the slowest waves in the human brain.

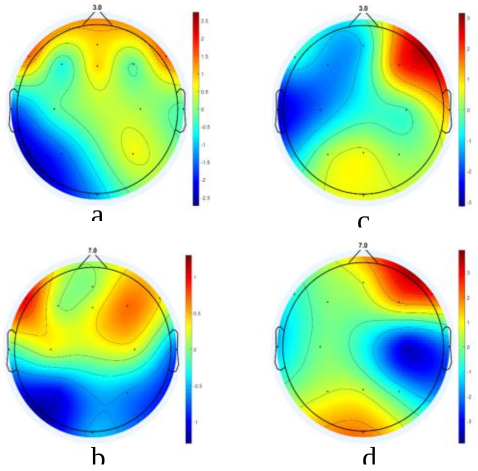

Fig. 4. EEG activations for the *sad* emotion (female to the left; male to the right)

Delta is associated with deep sleep and relaxation, whereas theta is associated with involvement of memory processes. Moreover, the involvement of delta in episodic memory formation during sleep was proposed in [5]. Since delta and theta are involved in forming and retrieving episodic memories, their involvement in EEG patterns while viewing *happy* and *sad* images, signifies the distinct way, in which memory is engaged, in viewing pictures of different valences. General indicators in the EEG activity have to be identified in order to be able to detect the valence of the emotion from the different way the memory is being engaged.

The gender difference in reporting the intensity of the observed emotion is the main outcome of the present study. It raises several issues. One possibility is that intensity is linked to *empathy* since the case involves viewing emotional pictures. In such a case this will be a trait feature, rather than a gender dimension. If, however, gender difference reaches significance, then this process will be beyond the trait theory and will require different EEG configuration to signify the gender in the EEG. Future studies will give answers to such questions in order to implement them in novel rehabilitation systems.

CONCLUSION

The paper presents the current methodology being implemented in order to be able to identify factors, which can influence the neural processing as reflected in the observed EEG patterns. The first novelty in our methodology was that we begin with the perception of the participants to the given images instead of imposing perception of the validated dataset. The later approach would miss out not only the actual perception of the participant but also a spectrum of emotions that a given instance of a picture can trigger in an individual given their unique past experiences, memories and thus their individual framework of emotion processing. The second perspective in the present study is that, followed by the participant perception of the emotions, their EEG activity is observed for traces of positive and negative emotion perception. Both individual differences and certain regularities were observed in the presented set of data.

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References

[1] Lee, Y.Y., Hsieh, S. (2014). Classifying Different Emotional States by Means of EEG-Based Functional Connectivity Patterns. PLoS ONE 9(4): e95415.

https://doi.org/10.1371/journal.pone.0095415

[2] Bekkedal, M. Y., Rossi III, J., & Panksepp, J. (2011). Human brain EEG indices of emotions: delineating responses to affective vocalizations by measuring frontal theta event-related synchronization. Neuroscience & Biobehavioral Reviews, 35(9), 1959-1970, https://doi.org/10.1016/j.neubiorev.2011.05.001

[3] Costa, T., Rognoni, E., & Galati, D. (2006). EEG phase synchronization during emotional response to positive and negative film stimuli. Neuroscience letters, 406(3), 159-164. https://doi.org/10.1016/j.neulet.2006.06.039

[4] Harmon-Jones, E., Harmon-Jones, C., & Summerell, E. (2017). On the importance of both dimensional and discrete models of emotion. Behavioral sciences, 7(4), 66, https://www.mdpi.com/2076-328X/7/4/66

[5] Hobson, J. A., Pace-Schott, E. F. (2002). The cognitive neuroscience of sleep: neuronal systems, consciousness and learning. Nature Reviews Neuroscience, 3(9), 679-693, https://www.nature.com/articles/nrn915?frame=0&nav=1