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Psychophysiological and Oculomotoric Changes During Emotion Elicitation

Braj Bhushan*

Ankita Asai

Indian Institute of Technology Kanpur, India

Abstract

With an aim to examine behavioural and physiological changes during emotion elicitation, 30 participants were shown audio, video or audio-video versions of movie clips depicting anger, fear, happiness, sadness, surprise and neutral expressions. While watching these stimuli, the eye-tracking glass was used to record oculomotoric changes. Heart rate, blood volume and respiration rate were also recorded. After viewing each clip the participants had to label and rate the emotion depicted in the movie clip. The data was analyzed with respect to valence, motoric direction and arousal dimensions of emotions. Findings of the behavioural data and corresponding change in the respiration rate suggest that fear is the only emotion that equally impacted participants psychologically as well as physiologically. The number of fixations and saccades for positive and negative emotions differed significantly.
Key words: emotion, physiological changes, blood volume pressure, eye tracking.

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Novelty and Significance

What is already known about the topic?

- Although ANS activities (heart rate, blood volume and respiration) during emotion elicitation have been studied well, the relationship between oculomotoric parameters and ANS activities needs in-depth examination. The present study attempts to fill this gap.

What this paper adds?

- With reference to valence, arousal and directionality, our study suggests that the behavioural as well as the physiological indicators are robust enough to assess emotions in terms of motoric direction (avoidance/ withdrawal).
- The novel finding of this study was search for cues to decipher anger and fear. While facial cue were attended to decipher anger, fear was characterized by search for cue in the visual frame.

It is well established that affective processes involve activation of the central and autonomic nervous system which directs the actions depicted on face, body and voice. Experience of emotion involves the activation of brain as well as the autonomic nervous system (ANS). Physiological activities have implicit relationship with the activation of emotion; thus any stimuli eliciting emotion also leads to change in physiological parameters such as heart rate (HR), galvanic skin response (GSR), breathing rate and electromyogram (EMG). Emotions are central and physiological processes contribute to the ongoing emotional and cognitive experience.

Several researchers have reported changes in the ANS functions as a result of emotion eliciting stimulus. For instance, Philippot, Chapelle, and Blairy (2002) have reported variation in the breathing patterns of joy, anger and fear. They found this variation

* Correspondence concerning this article should be addressed to: Braj Bhushan, Department of Humanities and Social Sciences, Indian Institute of Technology Kanpur, Kanpur- 208 016, India. Email- brajb@iitk.ac.in

even for voluntarily produced emotions. Intense positive affect cause transient increase in heart rate and blood pressure (Herring, Burleson, Roberts, & Devine, 2011). Heart rate variation has been reported during positive as well as negative affect (Brosschot & Thayer, 2003) and studies have found positive correlation between cardiac activation and amusement (Herring *et alii*, 2011). The increase in heart rate and/ or decrease in HRV have also been associated with increase in the neocortical activity (Boucsein & Backs, 2000). Oculomotor activities include the functions of extraocular muscle as well as intrinsic ocular muscles and the autonomic system innervates the intrinsic ocular muscles. However, oculomotoric parameters such as fixations, saccades and blinks have not been analyzed to check their promise as biosignals during emotional states. Researchers have established changes in the heart rate, blood volume and respiration during emotion elicitation but the relationship between oculomotoric parameters and ANS activities is far from clear. Studies based on measures of autonomic nervous system functions and oculometric measurements are scarce (Wagner, Hirsch, Vogel-Farley, *et alii*, 2013). The present study attempts to examine the oculomotoric parameters and the corresponding changes in select ANS indicators, namely heart rate, blood volume and respiration, to check its potential as biosignal during emotional states.

There is a dearth of empirical findings pertaining to human affect using eye-tracking technology. Of the available studies, most of them have exclusively attempted to examine eye behaviour in clinical population. Researchers using eye-tracking technology for the study of emotions in the normal population have found the influence of facial expression on visual search before the target is attended (Reynolds, Eastwood, Partanen, *et alii*, 2009). Noh, Lohani, and Isaacowitz (2011) have argued that eye fixation and attention might successfully regulate mood. Based on their electrophysiological study, Lien, Taylor, and Ruthruff (2013) have argued that fearful facial expression might not arrest "spatial attention against our will" (p. 873). Studies have found rapid detection of anger expressions as compared to happy faces (Öhman, Soares, Juth, *et alii*, 2012). This is due to evolutionary adaptation. Studying affective valence, Calvo, Nummenmaa, and Avero (2010) found faster recognition of happy expressions. Reynolds *et alii*i (2009) have reported that facial expression control eye fixation for the first time. Studies indicate that memory of emotional stimuli is determined by emotional arousal (intensity) rather than emotional valence (Dolcos, LaBar, & Cabeza, 2006). Studies reporting association between oculometric and ANS functions are scant. Although, Causse, Baracat, Pastor, and Dehais (2011) studied decision-making, they used cardiovascular and oculometric measures. We did not find similar studies for emotion.

Further, two contrasting viewpoints have been proposed with respect to processing of emotions. One view consider emotion processing automatic and free from available processing resources (Vuilleumier, Armony, Driver, & Dolan, 2001) whereas the second view propose emotion processing to depend on attentional resources (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002). Although Vuilleumier *et alii* (2001) provided fMRI evidence suggesting emotion processing to be independent of attention there is also evidence supporting emotion processing to be dependent on attentional resources (Pessoa, 2005). The automatic versus attention-dependent nature of emotion processing is still a matter of debate. Some researchers argue that parallel processing incorporates both automatic preattentional processing and enhanced processing improves due to engagement of attentional mechanisms (Shaw, Lien, Ruthruff, & Allen, 2011). Does emotion elicitation depend on what one attends to? If so, fixation count should be a robust indicator as it reflects attention allocation. As optic mechanism, heart rate, blood volume and respiration share some ANS innervations, oculometric measures and ANS functions should show certain pattern. In view of this, the present study contributes to the understanding of human emotions at a time when the literature shows insufficient experimental work using eye-tracking technology and ANS functions.

One of the criticisms of attention-dependent view is “not using powerful enough emotional stimuli to capture attention” (Dolcos, Iordan, & Dolcos, 2011). By using film clips we have ensured that powerful enough stimuli are being used in the present study to understand the interplay of attention allocation on emotional stimuli. Further, eye tracking has been used to identify exact oculomotoric parameters for determining attention allocation. An overview of the modus operandi adopted by various researchers to elicit emotion clearly shows the importance given to film clippings as they have been found to induce emotions comparable to naturally occurring emotions. Schaefer, Nils, Sánchez, and Philippot (2010) have validated film clips as effective method for eliciting emotions. These clips have been found to effectively elicit emotions on criteria such as arousal and valence. Arguing in favour of films, Gross and Levenson (1995) endorse films to “have a relatively high degree of ecological validity, in so far as emotions are often evoked by dynamic visual and auditory stimuli that are external to the individual” (p. 87). It merits mention that films have been used to study emotions within the dimensional viewpoint as well as discrete emotions perspective.

Films have a wonderful blend of visual and auditory effects. Studies suggest automatic integration of visual and auditory signals. Studies also indicate the influence of facial expressions on the judgment of emotional connotations of speech (Hietanen, Leppänen, Illi, & Surakka, 2004) and music (Thompson & Russo, 2007). Thompson, Russo, and Quinto (2008) found that the judgement of emotion in music was influenced by the facial expressions during performance. Emotional stimuli are likely to capture our attention more and thus are also likely to affect our cognitive processes. Researchers have reported attenuated perception of emotional tension due to gesture (Vines, Krumhansl, Wanderley, & Levitin, 2006). Davidson (1993) has argued that even in the absence of auditory information performance gestures can act as indicators of musical expressiveness. In such a situation one should be able to identify (label) emotion with or without auditory input. If so, how does it affect rating of such emotional states? There is evidence of perceptual integration of auditory and visual sources of information to form an integrated interpretation of emotion. Researchers studying cross-modal integration of information suggest the dominant encoding of visual stimulus when presented unimodally compared to when paired with auditory stimulus, thus indicating auditory overshadowing. Developmental studies confirm a pattern of overshadowing, auditory overshadowing in infants (Robinson & Sloutsky, 2004), both auditory and visual overshadowing in young children (Robinson & Sloutsky, 2004) and visual overshadowing in adults (Colavita & Weisberg, 1979). Do valence, arousal and motoric direction get affected by such overshadowing?

With the aim to examine the behavioural and physiological response resulting into emotion elicitation, the present study compared the labeling and subjective rating of emotion expressed in the stimuli and the consequent physiological changes in the heart rate, blood volume and respiration rate. Further, three oculomotoric parameters, number of fixations, number of saccades and number of blinks were analyzed to see if attention allocation plays a role similar to ANS functions. We also checked oculomotoric parameters for their promise as biosignals during emotion elicitation. It was hypothesized that: (i) the labeling and rating of emotion would differ for the audio, video and audio-video stimuli; (ii) the changes in heart rate, blood volume and respiration rate corresponding to emotion elicited while watching movie clips would differ for different emotions; (iii) the number of fixations, number of saccades and number of blinks would differ for different emotions depicted in the movie clips; and (iv) oculomotoric parameters (number of fixations, saccades and blinks) should significantly correlate to ANS parameters (heart rate, blood volume and respiration rate).

Method

Participants

Thirty undergraduate students of a professional course (15 females) were recruited for this study. Participation was voluntary and the study was carried out after due approval of the IEC. The mean age of the participants was 21 years (*SD* 0.74). The mean of education was 15.86 years (*SD* 0.86). All participants were good at spoken and written Hindi and it was their first language. This was the inclusion criteria. The participants had to declare if they were on medication. Consumption of vasoactive medication, caffeine, nicotine, etc. was an exclusion criteria. As the stimuli were taken out of mainstream cinema posing the risk of familiarity differences and priming effects, participants had to state if they had been exposed to them before. This was also an exclusion criteria.

Procedure

Three types of stimuli, audio, video and audio-video, were used in this study. Six movie clips of 30 seconds duration each was taken out from different mainstream Hindi cinema. These clips depicted anger, fear, happiness, sadness, and surprise, respectively. One clip was neutral in nature (no emotion expression). These clips were used in three different formats to create the above mentioned three different stimuli type. These movie clips were the audio-video stimuli. Further, the audio tracks of each of these clips were extracted and used as audio stimuli. The mute video clips constituted the video stimuli.

The participants were randomly divided into three groups with each group consisting of equal number of females and males. Each group was exposed to audio, video or audio-video stimuli. Physiological changes during the course of attending each of the stimuli were recorded using NEXUS-10. Sensors were attached for recording heart rate, blood volume and respiration rate. The participants were made to wear the sensors and relax. This was done to see the baseline data. The groups exposed to video and audio-video stimuli were also asked to wear SMI eye-tracking glass (ETG) while the stimuli were screened. The eye-tracking glass was used to record oculomotoric changes (number of fixations, number of saccades and number of blinks) while viewing the stimuli after a 3-point calibration. ETG captured the data of movement of both eyes at 30 Hz. The participants were made to sit comfortably in the laboratory. After playing each clip they were asked to identify the emotion they perceived in that clip and label it (happy, sad, fear, anger, surprise or neutral). Once the emotion depicted in the clip was labeled, they were asked to rate the intensity of those emotions on a 5-point scale where 1 represented minimum intensity and 5 depicted maximum intensity of that specific emotion. The clips were presented at a gap of 15 seconds to allow adequate time between stimulus presentations for the psychophysiological (and emotional) responses to recover.

Results

For the purpose of analyses, responses were trifurcated on the basis of valence, motoric direction and arousal dimensions of emotions. Valence refers to whether a given emotion is positive (happy) or negative (sad) whereas motoric direction explains emotions on the basis of inherent approach and withdrawal associated with it. While emotions such as anger involve approaching the source, fear involves running away from the source.

Considering that processing of an emotional content would require identifying any specific emotion and assessing its intensity, the labeling and rating of the clips were analyzed. This phenomenon would be instrumental in eliciting emotion in the viewers. Thus, the labelling of various emotions was analyzed on the basis of valence (positive and negative emotions), motoric direction (approach and withdrawal emotions) and arousal level (high and low).

Valence: The level of accuracy in labeling emotions with positive (happiness and surprise) and negative valence (sadness and fear) were compared across the three stimuli formats. The participants did not commit error in identifying happiness (positive valence) irrespective of the mode of presentation. However, surprise was accurately labelled when presented either in audio or visual mode only and the accuracy level dropped by 30% when the stimulus was presented in the audio-video mode. For negative valence, audio-video mode of presentation elicited accurate labelling of sadness and fear, both. When presented only in the video format the accuracy level dropped by 10% for both the emotions. However, fear was accurately labelled in the audio format but the accuracy of labelling sadness dropped by 10%. Figure 1 illustrates the findings.

Motoric direction: The accuracy of labelling was examined on the basis of motoric direction-approach (anger) and withdrawal emotions (fear). As illustrated in Figure 1, anger was accurately labelled when presented in the video format and the accuracy level dropped by 20% when the stimulus was presented in the audio format and 10% when presented in the audio-visual format. On the other hand, fear was accurately labelled

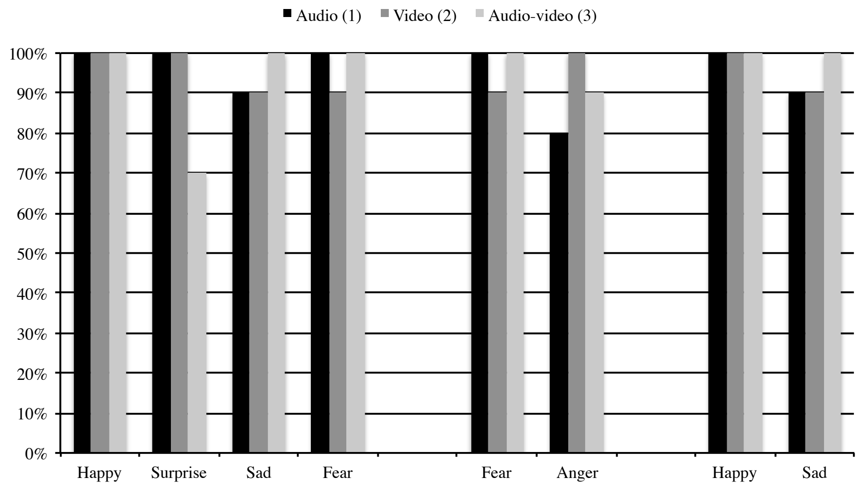

Figure 1. Accuracy of labeling emotions in terms of positive-negative valence, approach-withdrawal emotions, and low-high arousal levels.

when presented in the audio as well as audio-visual format. The accuracy level dropped by 10% when the stimulus was presented in the video format.

Arousal: Comparison in the accuracy level of emotions with high (happiness) and low (sadness) levels of arousal indicated the most striking finding. Happiness was correctly labelled by the participants irrespective of the mode of presentation (Figure 1). On the other hand, sadness was accurately labelled only when presented in the audio-visual format. The accuracy rate dropped by 10% for both audio as well as video formats.

The participants rated the emotion on a 5-point scale where 1 represented least degree of expression and 5 represented very high degree of expression. Once again rating of various emotions was analyzed on the basis of valence, motoric direction and arousal level.

The mean rating of happiness (*M*= 3.80, *SD*= .80) and surprise (*M*= 3.13, *SD*= .86) was higher compared to rating of sadness (M= 2.93, *SD*= .87). However, fear was rated high (*M*= 3.60, *SD*= 1.04). The rating of withdrawal emotion (fear: *M*= 3.60, *SD*= 1.04) was little higher compared to the mean rating of approach emotion (anger: *M*= 3.47, SD .68). The mean rating of happiness (*M*= 3.80, *SD*= .80) was higher than the mean rating of sadness (*M*= 2.93, *SD*= .87).

One way analysis of variance (ANOVA) was performed for labelling and rating of emotions in the three formats of stimuli (audio, visual and audio-visual) across the three categories-valence, motoric direction and arousal. As summarized in Tables 1a and 1b, the rating of only fear (positive valence) was significantly different across the stimuli formats ($F(2, 27)= 8.67$, $p <.001$). Post-hoc comparison using Tukey HSD confirmed that visual stimuli was rated higher than audio-visual (*M* difference= 1.40, $p <.002$) and audio stimuli (*M* difference= .10, $p <.005$), thus confirming the first hypothesis.

In order to examine changes in the autonomic nervous system activities while processing the stimuli, sensors were attached to the participant's body and data was recorded using NEXUS. Respiration sensor was used to monitor abdominal breathing and the data indicated the relative depth of breathing. Similarly, sensors were used to record heart rate and blood volume variability. One-way analysis of variance (ANOVA) showed significant difference in the respiration rate for motoric direction. The three formats of stimulus presentation elicited significant difference in the respiration rate

Table 1a. One-way ANOVA for rating of Fear.

	Sum of Squares	df	Mean Square	*F*	*p*
Between Groups	12.2	2	6.1	8.668	.001
Within Groups	19	27	.704		
Total	31.2	29			

Table 1b. Post-hoc comparison for Fear among three experimental conditions.

Experimental Conditions (I)	(J)	Mean Difference	*SE*	*p* (95% Confidence Interval)	Lower Bound	Upper Bound
Audio	Visual	-.1	.37	*NS*	-1.03	.83
	Audio-visual	1.3	.37	.005	.37	2.23
Visual	Audio	.1	.37	*NS*	-.83	1.03
	Audio-visual	1.4	.37	.002	.47	2.33
Audio-visual	Audio	-1.3	.37	.005	-2.23	-.37
	Visual	-1.4	.37	.002	-2.23	-.47

Notes: SE= Standard Error; *NS*= Not Significant of approach (Anger: $F(2, 27)= 4.58$, $p <.01$) and withdrawal (Fear: $F(2, 27)= 4.21$, $p <.02$) emotions (Tables 2a and 2b). Post-hoc comparison using Tukey HSD confirmed that respiration rate during anger was highest during audio-visual stimuli compared to visual stimuli (*M* difference= 66.19, $p <.008$) and audio stimuli witnessed least respiration rate (*M* difference= 51.59, $p <.033$). Post-hoc comparison established that in case of fear respiration rate was highest during audio-visual stimuli compared to visual stimuli (*M* difference= 68.34, $p <.01$) and audio stimuli witnessed least respiration rate (*M* difference= 60.49, $p <.027$), thus partly supporting the second hypothesis.

Although only changes in the respiration rate turned out to be statistically significant, respiration rate has the capability of influencing blood volume and heart rate. Respiration can influence the heart rate if one breaths around 6 times per minute. In such situation the heart rate becomes faster while inhaling and slower while exhaling. Figure 4 shows the change in the BVP amplitude corresponding to the change in the RSP amplitude for anger (Figure 2a) and fear (Figure 2b), respectively.

Three indicative oculomotoric parameters, number of fixations, number of saccades and number of blinks, were also analyzed to see their pattern during specific emotions. Only audio-visual format of stimuli was acquired using SensoMotoric Instruments (SMI) eye-tracker glass and the data was analyzed using BeGaze Analysis software. Paired sample *t*-test was performed to examine the difference between the three oculomotoric parameters

Table 2a. One-way ANOVA outcome with significant difference in the respiration rate for motoric direction (approach and withdrawal).

		Sum of Squares	df	Mean Square	*F*	*p*
Anger	Between Groups	24188.37	2	12094.18	4.58	.01
	Within Groups	71295.18	27	2640.56		
	Total	95483.55	29			
Fear	Between Groups	27969.20	2	13984.60	4. 207	.026
	Within Groups	89750.56	27	3324.09		
	Total	117719.76	29			

Table 2b. Post-hoc comparison for respiration rate for motoric direction (approach and withdrawal) among three experimental conditions.

Dependent Variable	Experimental Conditions (I)	(J)	Mean Difference	*SE*	*p* (95% Confidence Interval)	Lower Bound	Upper Bound
Anger	Audio	Visual	14.6	22.98	*NS*	-32.55	61.75
		Audio-visual	-51.59	22.98	.033	-98.74	-4.44
	Visual	Audio	-14.6	22.98	*NS*	-61.75	32.55
		Audio-visual	-66.19	22.98	.008	-113.34	-19.04
	Audio-visual	Audio	51.593	22.98	.033	4.44	98.74
		Visual	66.19	22.98	.008	19.04	113.34
Fear	Audio	Visual	7.85	25.78	*NS*	-45.05	60.75
		Audio-visual	-60.49	25.78	.02	-113.39	-7.58
	Visual	Audio	-7.85	25.78	*NS*	-60.75	45.05
		Audio-visual	-68.34	25.78	.01	-121.24	-15.43
	Audio-visual	Audio	60.49	25.78	.02	7.58	113.39
		Visual	68.34	25.78	.01	15.43	121.24

Notes: SE= Standard Error; *NS*= Not Significant

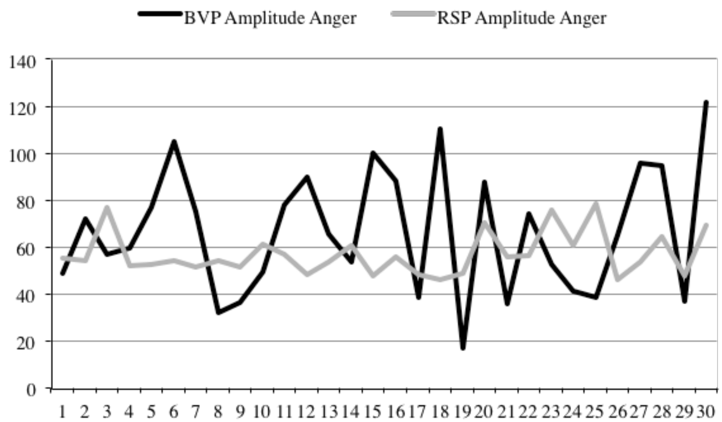

Figure 2a. BVP and RSP amplitude during audio-visual stimuli depicting anger.

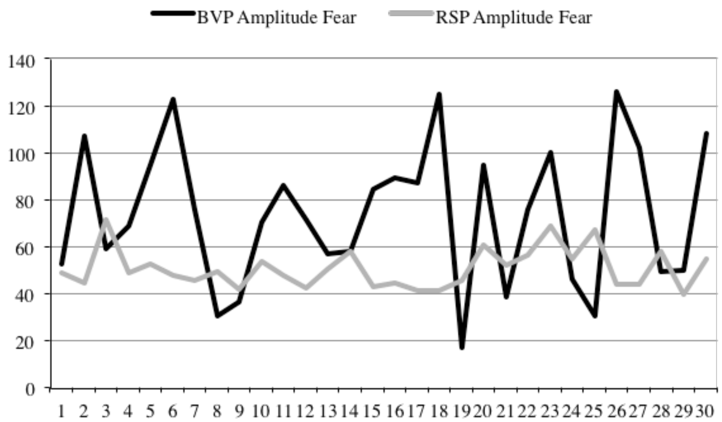

Figure 2b. BVP and RSP amplitude during audio-visual stimuli depicting fear.

across the three categories of emotion, valence, motoric direction and arousal (Table 3). To examine eye-movement pattern with respect to valence of emotions the positive (happiness and surprise) and negative (sadness and fear) emotions were compared for the number of fixations, number of saccades and number of blinks. On two parameters, namely number of fixations and number of saccades, significant differences were found between positive and negative emotions. Number of fixations for positive emotions were higher compared to the negative emotions and the difference was significant (happiness-sadness: t= 2.79, df= 29, p <.009; surprise-sadness: t= 5.935, df= 29, p <.001). Similar trend was observed for the number of saccades as well (happiness-sadness: t= 3.093, df= 29, p <.004; surprise-sadness: t= 6.773, df= 29, p <.001). However, an interesting trend was found for fearfulness. The number of fixations and saccades were very high for fear. This resulted into significant difference between positive and negative emotions, but with negative t values (happiness-fear: t= -3.525, df= 29, p <.001; surprise-fear: t= -4.112, df= 29, p <.001).

To test the difference in eye-movement pattern in terms of motoric direction, a comparison between approach (anger) and withdrawal (fear) emotions was performed. The number of fixations as well as saccades was relatively high for anger compared to fear, thus resulting into significant difference (fixations: t= 2.99, df= 29, p <.006; saccades: t= 4.49, df= 29, p <.001). When compared for arousal, the number of fixations (t= 2.79, df= 29, p <.009) and the number of saccades (t= 3.09, df= 29, p <.004) for emotions with high (happiness) and low (sadness) degree of arousal differed significantly.

Spontaneous eye blinks are the most promising biosignal for stress and inattentiveness. The number of blinks was not significantly different when compared for motoric direction and arousal, but for valence the findings were dissimilar. The total number of blinks for fearful clips was much higher compared to any other clip, thus resulting into significant difference between happiness-fear (t= -4.396, df= 29, p <.001) and surprise-fear (t= -4.618, df= 29, p <.001).

Having seen change in the BVP amplitude corresponding to the change in the RSP amplitude we computed correlation between number of fixations, saccades and blinks to check the possible relationship between respiration rate, blood volume, heart rate and oculomotoric parameters. BVP amplitude was significantly correlated with number of fixations for surprise (r= .411, p <.05) and fear (r= .371, p <.05). BVP amplitude was also significantly correlated with number of blinks for surprise (r=.487, p<.01) and sadness (r= .419, p <.05). The finding partly confirms the fourth hypothesis supporting relationship only between BVP amplitude and fixation and blink count for surprise, fear, and sadness.

An interesting pattern of oculomotoric behaviour was also evident while looking at the visual frames of films depicting anger and fear. Almost all participants focused at the face of the character (actor/ actress) while the character concerned was expressing anger. On the other hand, the participants mostly looked at areas of the visual frame other than the face of the character during the movie clip depicting fear. This behaviour represents search for a possible fear-inducing cue in the visual frame.

Table 3. Paired sample *t*-test comparison showing significant difference for number of fixations, saccades and blinks for valence, motoric direction and arousal.

		Emotion pairs	*Mean*	*SD*	*SE*	95% Confidence Interval Difference Lower	95% Confidence Interval Difference Upper	*t*	*df*	*p*
Valence	Number of fixations	Happiness-Sadness	40.66	79.82	14.57	10.85	70.47	2.790	29	.009
		Happiness-Fear	-106.83	165.97	30.3	-168.81	-44.85	-3.52	29	.001
		Surprise-Sadness	18.66	17.22	3.14	12.23	25.09	5.93	29	.001
		Surprise-Fear	-128.83	171.6	31.32	-192.9	64.75	-4.11	29	.001
	Number of saccades	Happiness-Sadness	43	76.13	13.9	14.56	71.43	3.09	29	.004
		Happiness-Fear	-83	147.21	26.87	-137.96	-28.03	-3.08	29	.004
		Surprise-Sadness	26.16	21.15	3.86	18.26	34.06	6.77	29	.001
		Surprise-Fear	-99.83	148.06	27.03	-155.11	-44.54	-3.69	29	.001
	Number of blinks	Happiness-Fear	-34.16	42.56	7.77	-50.06	-18.27	-4.39	29	.001
		Surprise-Fear	-40.66	48.22	8.8	-58.67	-22.65	-4.61	29	.001
Motoric direction	Number of fixations	Anger-Fear	72.66	132.8	24.24	23.07	122.25	2.99	29	.006
	Number of saccades	Anger-Fear	82	99.9	18.23	44.69	119.3	4.49	29	.001
Arousal	Number of fixations	Happiness-Sadness	40.66	79.82	14.57	10.85	70.47	2.79	29	.009
	Number of saccades	Happiness-Sadness	43	76.13	13.9	14.56	71.43	3.09	29	.004

Discussion

The primary objective of the present study was to examine the behavioural and physiological changes during emotion elicitation. We compared the labeling and rating of emotions expressed in movie clips on the basis of valence, arousal and directionality along with corresponding physiological changes, namely heart rate, blood volume and respiration rate and determined the overshadowing effect. Findings of the behavioural data show ease in labeling the emotion. Facial expressions have been found to influence the judgment of emotion (Hietanen, Leppänen, Illi, & Surakka, 2004) during speech and music (Thompson & Russo, 2007). The present study found the highest accuracy for the identification of happiness. Studies have even found faster recognition of happy expressions (Calvo, Nummenmaa, & Avero, 2010). Findings of the behavioural data suggest that only the rating of fear (negative valence/ withdrawal) was significantly different across the stimuli formats. Fear was rated higher in the visual format (of the stimuli) than audio-visual and audio formats of the stimuli. The participants of the present study were adults and researchers have reported visual overshadowing in adults (Colavita & Weisberg, 1979). However, a little different result was observed in the physiological changes. Respiration rate which was highest during the audio-visual stimuli compared to the visual stimuli. This change was slightest during the presentation of the audio stimuli. Thus, perception of emotional expressions and corresponding change in the respiration rate suggests that fear is perhaps the only emotion that equally impacts us psychologically as well as physiologically. Although the behavioural data did not show significant difference for anger, the physiological data did show significant difference in respiration rate when stimuli depicting anger were presented in three different formats. The rate of respiration was highest during audio-visual stimuli compared to the visual stimuli, and least for the audio stimuli. It is not possible to generalize the findings on the basis of limited sample size, but the findings of the present study suggest that respiration rate is more susceptible to audio-visual inputs whereas behavioural assessment shows visual overshadowing. With reference to the dimensions of emotions the behavioural and physiological data suggest that both the indicators are robust enough to assess emotions in terms of motoric direction (avoidance/ withdrawal). Other researchers have also reported variation in the breathing patterns of fear (Philippot, Chapelle, & Blairy, 2002). Further, evolutionary adaptation enforces rapid detection of anger expressions (Öhman *et alii*, 2012) as well as fear.

The other objective of this study was to evaluate changes in oculomotoric parameters, namely number of fixations, number of saccades and number of blinks and check their promise as biosignals for studying emotional states. It merits mention that eye fixation and attention might successfully regulate mood (Noh, Lohani, & Isaacowitz, 2011). Hence, variation in the oculomotoric parameters during attending to emotional stimuli seems obvious. The occulomotor control system directs the eyes during visual scanning (Nuthmann & Henderson, 2010). The eye moves at an average of 3-5 times per second from one point to another (Rayner, 2009) during visual search. Such movements are saccades and the period when the eye is steady at a point is termed as fixation. According to Glaholt and Reingold (2012) the duration and spatial distribution of fixations can reflect upon the underlying cognitive mechanism. The findings show that number of fixations for positive (happiness and surprise) and negative (sadness and fear) emotions differed significantly. A different pattern was observed for the number of saccades. The number of saccades was significantly higher for positive (happiness and surprise) emotions as compared to sadness (negative emotion) but the saccade count as well as total number of blinks was high for fear, thus indicating cognitive regulation of emotion. However, this was not the mandate of the present study.

Although, Reynolds *et alii* (2009) have suggested that facial expression influences visual search before the stimulus (target) is attended, our study indicates that number of fixations is also affected by the valence of the emotion. Further, Pessoa (2005) and Pessoa *et alii* (2002) have endorsed that emotion processing is dependent on attentional resources, but our findings suggest that it might be free from the available processing resources. Vuilleumier *et alii* (2001) have provided fMRI evidence suggesting emotion processing to be independent of attention. It merits mention that spontaneous eye blinks are considered the most promising biosignal for stress and inattentiveness. Nonsignificant number of blinks for the audio-visual stimuli suggests that the participants were attentive while watching the audio-visual clips.

Although small sample size is a major limitation of this study, the findings do indicate limited mapping of behavioural response and physiological changes during emotion recognition. The evolutionary importance of processing of emotion is glaring visible for fear at both the levels. The significance of oculomotoric changes during emotion perception is also evident.

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