EFFECTS OF ADULT ATTACHMENT STYLE ON EMOTION: EVIDENCE FROM PHYSIOLOGICAL AND ACOUSTIC MEASURES

Han Hu[1] and Wentao Gu[1,2]

[1]School of Chinese Language and Literature, Nanjing Normal University, Nanjing, China
[2]School of Communication Sciences and Disorders, McGill University, Montreal, Canada
huhandon@gmail.com, wtgu@njnu.edu.cn

ABSTRACT

This study investigated how one's adult attachment style affected physiological responses and speech production in different emotional states. We selected affective film clips for each of four basic emotions, and designed pseudo Mandarin sentences (syntactically valid but semantically meaningless). With a paradigm of subliminal priming and elicitation, 44 participants with love experience were physiologically measured while watching the film clips, and then were recorded while producing the pseudo sentences in the emotion perceived from each film clip. Multivariate analysis of three physiological indices showed significant differences among attachment styles only in anger and sadness, while analysis of 14 acoustic measures illustrated significant differences primarily in happiness and sadness. Among the four attachment styles, only the patterns of 'fearful' individuals varied with emotion. Attachment styles were effectively identified from acoustic measures, and redundant analysis of physiological and acoustic measures indicated that the relationship between these two aspects varied with attachment style.

Keywords: attachment style, emotion, physiological index, acoustic measure.

1. INTRODUCTION

Emotion plays indispensable roles in daily life since it affects decision-making, social communication and well-being. Recent years have witnessed numerous studies on physiological and acoustic signals in emotional states [1, 2]. However, no consensus has been reached, and more attention should be paid to the potential factors affecting physiological responses and acoustic manifestations of emotions [3, 4].

The adult attachment theory [5], which is closely associated with emotion regulation in romantic relationships, provides an effective framework to account for those inconsistent findings in literature [6]. The theory posits that early interactions with caregivers shape the Internal Working Models (IWMs) of self and others. The model of self (i.e., attachment anxiety) indicates one's internalized sense of self-worth, and is associated with levels of anxiety and dependency experienced in close relationships. Individuals with high attachment anxiety prefer a hyper-activating strategy of emotion regulation, exaggerating their emotional needs to capture the partners' attention. The model of others (i.e., attachment avoidance) denotes one's general expectation of others as supportive and available, and is related to the propensity to seek or avoid closeness in relationships. Individuals with high attachment avoidance struggle with trust and emotional openness, leading them to prefer a suppression strategy of emotion regulation [6, 7].

Attachment style can be classified into four types in terms of the polarities of IWMs: secure (low anxiety and avoidance), dismissive (low anxiety and high avoidance), preoccupied (high anxiety and low avoidance), and fearful (high anxiety and avoidance). Since the four types differ in emotion regulation strategy which has direct impacts on physiological arousal and emotional expressive consequences [8], attachment style is expected to affect physiological responses and acoustic production in emotional states.

According to physiological studies, dismissive individuals has a high skin conductance level (SCL) when recalling painful memories [9], whereas secure individuals are associated with a low ratio of low-frequency to high-frequency power (LF/HF) in electrocardiogram (ECG) when they are rejected [10]. As reported in acoustic studies, fundamental frequency variability is negatively correlated with attachment avoidance when producing neutral words [11], while jitter and shimmer are positive predictors of attachment dimensions while producing sustained vowel /a/ [12]. An effective classification of four attachment styles based on intimate speech was also attained with nine acoustic parameters [13].

Although many previous studies examined the effects of attachment style or emotion on physiological responses or acoustic manifestations in speech production, few of them looked into the combined effect of attachment style and emotion, and the relationship between physiological responses and acoustic manifestations has yet to be explored. Hence, we aimed to address these issues using multivariate analysis, to find the effects of attachment style on experience and expression of four basic emotions.

2. METHODS

2.1. Materials

2.1.1. Emotional film clips

Twenty film clips were selected from the Chinese Emotion Video Stimuli (CEVS) database [14], with five clips evoking each of the four basic emotions (happiness, anger, sadness and fear). Fifteen graduate students (12F, 3M; age: 25.33±2.82 years) assessed the film clips using a 5-item self-report inventory (happiness, anger, sadness, fear and neutrality) on a 5-point Likert scale, from 1 (weak) to 5 (strong). For each emotion, the film clips ranked top three (in terms of the number of participants giving the highest score to the emotion) were selected. Thus, we obtained 12 film clips with an average duration of 153.58 s (*SD*=57.87 s).

2.1.2. Vocal emotional stimuli

Forty pseudo-sentences were designed by replacing the content words in real sentences with a meaningless random combination of Chinese characters, while keeping the function words intact to convey the syntactic information [15]. To ensure the acceptability of the pseudo-sentences, the 15 students mentioned in section 2.1.1 evaluated the degree of "language-likeness" on a 5-point Likert scale (1: very unlike; 5: very like), and the score of each pseudo-sentence was averaged from all evaluators. Hence, 15 pseudo-sentences giving the highest scores (*M*=4.09, *SD*=0.36) were selected, with a length of 7–12 syllables (*M*=8.8 syllables).

2.2. Participants

We recruited 44 participants (28F, 16M; age: 24.30±3.08 years; 25 in relationships) who were self-reported heterosexual with love experience (times of relationships: 2.02±0.98). Among the participants in relationships, 56% were in long distant relationships. The mean relationship stage was 2.88 on a 5-point Likert scale (1: boring; 5: passionate). All participants spoke Mandarin fluently without any reported history of hearing, speech or emotion impairments. Among them, there were 27% secure, 16% dismissive, 18% preoccupied and 39% fearful individuals.

2.3. Measurement

2.3.1. Self-report inventories

Experiences in Close Relationship Questionnaire (ECR) in Chinese [16] was used to assess participants' attachment styles. ECR consisted of two subscales, i.e., attachment avoidance and attachment anxiety, each including18 items. Each item was rated on a 7-point Likert scale, from 1 (highly disagree) to 7 (highly agree), and then each subscale was scored by averaging the scores from the 18 items. Attachment type was derived from these scores. The McDonald's ω's were 0.89, 0.83, and 0.86 for avoidant subscale, anxious subscale, and the whole scale, respectively.

2.3.2. Physiological indices

Skin Conductance Levels (SCL) in microsiemens (μS) were measured with the Galvanic Skin Response (GSR) Amp (ADInstruments Ltd.) at a rate of 1 kHz. A pair of bipolar finger electrodes (snap lead) made of polished stainless steel were attached to the medial phalanges of digits II and IV of the participant's non-dominant hand. SCL is a pure measure of the arousal of the sympathetic nervous system (SNS) [17].

Heart Rate Variability (HRV) was derived from the finger ECG signals through an electric finger transducer attached to the distal phalanges of the middle finger of the participant's non-dominant hand. Root Mean Square of Successive Difference (RMSSD) between normal heartbeats, as a measure of the short-term fluctuation of HRV, represented the activity of the parasympathetic nervous system (PNS). LF/HF, as the ratio of spectral power in low frequency bands (0.05 Hz-0.15 Hz) to high frequency bands (0.15 Hz-0.4 Hz), denoted the sympathovagal balance [18].

2.3.3. Acoustic parameters

For each validated utterance, the following prosodic and voice quality parameters were extracted using the Praat toolkit [19]: fundamental frequency (F0, in semitone), intensity (INT, in dB), articulation rate (ARTRATE, in 1/s), corrected harmonic differences (H1–H2, H2–H4, in dB) [20], Harmonic-to-Noise Ratio (HNR, in dB), Jitter and Shimmer (both in %). For F0 and INT, the descriptive statistics including mean (M), standard deviation (SD), minimum (MIN) and maximum (MAX) were calculated.

2.4. Procedure

Physiological signals were collected through PowerLab 16/35 (ADInstruments). Speech signals were recorded via a high-quality head-mounted microphone connected to Zoom H4N portable digital recorder sampled at 44.1 kHz with a 16-bit precision.

Firstly, participants were invited into a soundproof booth after signing the informed consents. They were seated comfortably in front of a monitor at a 70 cm distance. After participants were familiarized with the pseudo-sentences, they said the sentences in a neutral style with a head-mounted microphone 10 cm in front of their mouths and biosensors firmly attached to their fingers. After relaxing for 3 min to get baseline measurements, participants took a short training session using a neutral-emotion film clip from CEVS.

Next, each trail contained a random 20 ms subliminal presentation of one of the two primes ("separation" and "failure"), paired with two 500 ms grid images as anterior and posterior masking stimuli before film-watching, which proved efficient at activating IWMs [21]. The film-watching task was divided into 4 blocks in terms of emotion, with presentation order counterbalanced among participants. Each block included a random presentation of three film clips on the monitor, followed by five random sentences. Participants were required to say these sentences to their partners in the emotion they perceived from the clips. Breaks between blocks ensured participants to return to the baseline level, and a 30 s blank was presented before each block to get the baseline level. There were 75 productions (15 items × 5 emotions) per speaker.

Finally, participants filled in ECR inventories and demographic information. The entire procedure took about 1 hour and all participants were remunerated.

3. RESULTS

All above measures were normalized to reduce inter-speaker variation, using $X_{norm} = \frac{X_{ijk} - X_{refjk}}{X_{refjk}}$, where i, j, k denote observation, measure and participant, respectively, X_{ref} refers to the value at the baseline level. The average and minimum values at the baseline level prior to film-watching served as X_{ref} for HRV and SCL, respectively. F0- and INT-related indices were normalized, with X_{ref} as the mean F0-MIN and INT-MIN over all neutral utterances [14]. Other acoustic measures were normalized in reference to the mean values in the neutral state. All normalized measures were converted into z-scores for statistical analysis in R [22].

3.1. Physiological indices

Permutational Multivariate Analysis of Variance (PMANOVA) was separately conducted to geometrically partition multivariate variation in the space of Euclidean distance measure according to a given ANOVA design, with attachment style as between-subjects factor and p-values obtained through 1,000 permutations, for each emotion. The difference among four attachment styles was significant only in sadness (F=3.29, p=0.027, η^2=0.20), and a marginal significance was reached in anger (F=2.12, p=0.080, η^2=0.14).

Spatial representation of attachment styles in anger and sadness with Nonmetric Multidimensional Scale (NMDS) is illustrated in Fig. 1. NMDS is an indirect gradient technique that ordinates objects in a low-dimensional space with dissimilarity matrix. The goodness of fit was assessed by stress which quantifies the discrepancy between the distances in the original and ordination space. The stress values were 0.022 for anger and 0.032 for sadness in a two-dimensional solution, indicating a good fit to the empirical data [23]. For both emotions, the 1st dimension can separate secure individuals from dismissive and preoccupied ones. The location of fearful individuals, however, varies with emotion: closer to preoccupied ones in anger and closer to secure ones in sadness.

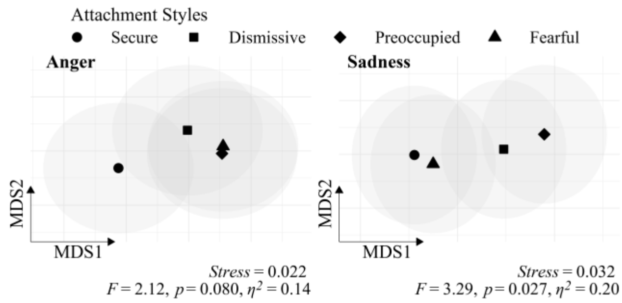

Figure 1: Spatial representation of attachment styles based on physiological markers. The points refer to the centroids of each attachment style. The shadow ellipses surrounding the centroids denote half of the mean distance among attachment styles.

3.2. Acoustic measures

PMANOVA on acoustic measures showed that the effect of attachment style was significant only in happiness (F=1.88, p=0.048, η^2=0.12) and sadness (F=2.09, p=0.010, η^2=0.14).

Spatial representation of four attachment styles is illustrated in Fig. 2. Stress values were 0.171 and 0.182 for happiness and sadness in two-dimensional solution, exhibiting a medium fit to empirical data. Secure individuals can be distinguished from insecure individuals on the 1st dimension in happiness and on the 2nd dimension in sadness. Fearful individuals are at equidistant from preoccupied and secure ones in happiness, while closest to dismissive ones in sadness.

Attachment styles were classified using support vector machines with radial kernel (SVMR) and random forest (RF) based on 14 acoustic measures. Given a small sample size, classifiers were fitted on the whole dataset of all emotions that consisted of 2,608 tokens, including 700 (27%) from secure, 415 (16%) from dismissive, 479 (18%) from preoccupied, and 1,014 (39%) from fearful individuals. The dataset was divided into 70% for training and 30% for testing.

Hyper-parameters were optimized with a 5-repeated 10-fold cross validation, and Synthetic Minority Oversampling Technique (SMOTE) with 10-nearest neighbours was used to balance the tokens of four attachment styles. Two performance metrics, i.e., accuracy and F1-score, were adopted.

RF (0.74, 95%CI: 0.70–0.77) obtained a slightly higher classification accuracy than SVMR (0.69, 95% CI: 0.66–0.72), and both models performed significantly better than the non-information rate (0.39; binomial test: *p*s<0.001). For F1-score, fearful and secure individuals obtained higher scores than dismissive and preoccupied ones.

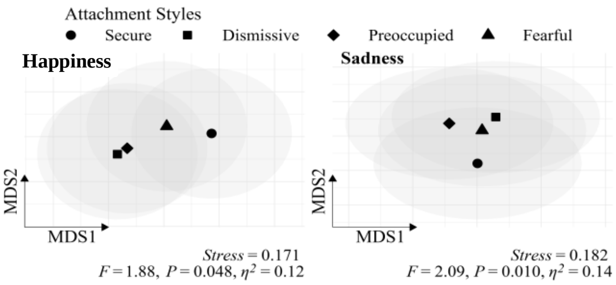

Figure 2: Spatial representation of attachment styles based on acoustic measures.

3.3. Concordance between physiological and acoustic measures

Redundant Analysis (RDA) was employed to reveal emotional concordance between explanatory data (3 physiological indices) and response data (14 acoustic indices) for each attachment style. ANOVA like permutation test (1,000 permutations) was performed to test the multivariate effect of physiological data. The hierarchical partitioning algorithm was applied to calculate the contribution of each predictor in physiological data cloud to explained variation [24].

The multivariate effect was significant for preoccupied (F=2.14, p=0.008) and fearful individuals (F=1.61, p=0.035), but not for dismissive ones. Marginally significant effect was found in secure individuals (F=1.45, p=0.094). The greatest contributions to explained variance were from LF/HF ratio in secure (56.88%), from SCL in preoccupied (63.33%), and from RMSSD in fearful ones (43.75%).

Triplots of RDA of vocal emotion in relation to physiological responses of emotions for attachment styles, in which the significant effect of explanatory data on response data emerged, are illustrated in Fig. 3. The percentage of total explained variance contributed from the first two canonical eigenvalues were indicated by the two axes. The response and explanatory variables were plotted as vectors, in grey line with cross, and in solid line with arrow, respectively. The cosine of the angle between two vectors approximates the correlation between them.

Visual inspection of secure individuals suggests that LF/HF is expected to be positively correlated with the parameters indicating irregularity of voice. For preoccupied individuals, most acoustic indices decreased with SCL. For fearful individuals, RMSSD can be viewed as a negative predictor of parameters related to F0 and INT (excluding F0-SD and INT-SD).

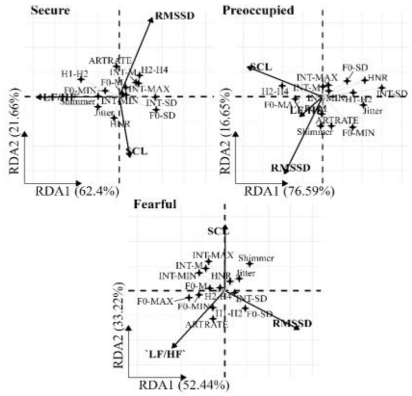

Figure 3: Triplots of redundant analysis of acoustic measure related to physiological responses.

4. CONCLUSION

This study explored both physiological and acoustic distributions of four attachment styles in four basic emotions, and revealed how the relationship between physiological and acoustic measures varies with attachment style.

The distribution of attachment styles in acoustic and physiological spaces turned out to vary with emotion. Four attachment styles differed significantly in physiological indices only in anger and sadness, and differed in acoustic measures only in happiness and sadness. In both cases, secure individuals were most distinct, dismissive and preoccupied ones were close to each other, while fearful ones varied with emotion. A supervised classification based on acoustic measures further verified the impacts of attachment style on acoustic patterns.

The relationship between physiological and acoustic measures turned out to be moderated by attachment style. Significant effects were found for all attachment styles but dismissive. Secure individuals showed an increased voice irregularity when the SNS activity increased or when the PNS activity decreased, suggesting that physiological and acoustic measures are positively correlated. A preference to inhibit vocal emotion was found in preoccupied individuals, showing a negative correlation between the SNS activity and most acoustic measures. For fearful individuals, the PNS activity and most F0 or INT related measures were negatively correlated.

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