



Perception of Emotional Speech by Individuals with High Borderline Personality Features

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Abstract

Borderline personality disorder (BPD) is characterized by emotional dysregulation. Prior research on facial emotion recognition has revealed that BPD individuals have emotion perception abnormalities. This study examined whether these findings extended to emotional speech recognition. Mandarin emotional speech (neutral, angry, happy, and sad) was synthesized at varying emotional intensities by adjusting the fundamental frequency. A perceptual experiment was conducted with Chinese university students with high and low borderline personality features (BPF). High-BPF participants showed lower accuracy in identifying neutral speech, more frequently misidentifying it as other emotions, and were less accurate in identifying high-intensity happy speech, tending to misclassify it as neutral. They also exhibited marginally higher confidence in recognizing angry speech. The results contribute to the phenomenological understanding of emotional dysregulation in BPD.

Index Terms: emotional speech, borderline personality disorder, emotion recognition, Mandarin

1. Introduction

Speech is a crucial medium for conveying emotions in daily life. There exists established evidence that basic emotions are associated with distinct prosodic patterns [1]. People can identify emotions based solely on prosodic features [2]. Given the strong relationship between emotional functioning and mental disorders, emotional speech and prosody have emerged as promising digital biomarkers in psychiatric research for the diagnosis of mental disorders [3]. For example, meta-analyses have shown that patients with schizophrenia, depression, and bipolar disorders exhibit overall deficits in recognition of emotional prosody [4, 5].

Borderline personality disorder (BPD) is a severe mental disorder characterized by a pervasive pattern of emotion dysregulation, unstable interpersonal relationships, impulsivity, and identity disturbance [6]. Some BPD theorists argue that emotional dysregulation and impaired social functioning are linked to abnormalities in the perception, interpretation, and response to emotional cues [7, 8]. A substantial body of research has been conducted building on this view, primarily focusing on facial emotion recognition (FER). Based on previous studies on FER of BPD, Daros et al. [9] conducted a meta-analysis and proposed the following model: due to heightened sensitivity to emotional stimuli, BPD individuals have a lower threshold for perceiving low-intensity negative emotions, enhancing their recognition ability. However, when exposed to high-intensity negative emotional stimuli, BPD individuals often experience hyperarousal, which depletes the cognitive resources needed for

emotion recognition, leading to poor recognition. Subsequent studies have provided some evidence supporting this model [10, 11].

Additionally, BPD individuals show particularly prominent differences in the recognition of anger and disgust compared to healthy controls [9]. As these two emotions are highly related to social threats and rejection that are closely tied to BPD traits like fear of abandonment [6], they may hold special significance in BPD. Another notable pattern observed in FER of BPD is negative bias, which refers to a preference for processing negative emotional cues and a tendency to perceive them as more negative [12, 13, 14]. Furthermore, it was reported that BPD individuals displayed lower confidence in FER, particularly when faced with happy facial expressions, which may contribute to their withdrawal from social situations and avoidance of intimate relationships [15, 16].

As mentioned, the emotion recognition patterns in BPD outlined above are primarily based on facial expressions. The present study aims to investigate whether these patterns, including the model proposed by Daros et al. [9], negative bias [12], and reduced confidence [15], similarly apply to the recognition of emotional speech in BPD individuals with a perceptual experiment. To manipulate different intensities of emotional speech, we applied the idea of facial morphing techniques to modify the fundamental frequency (F0) of speech stimuli, a key prosodic feature for distinguishing emotions [17, 18]. Regarding emotion types, besides neutral, we selected one basic positive emotion (happiness) and two basic negative emotions (anger and sadness). Given that anger holds particular significance for BPD compared to sadness [9], we expect BPD participants to exhibit differential responses to these two emotions.

2. Speech data

2.1. Recording materials

Seventeen commonly used, two-syllable, neutral-meaning Mandarin Chinese nouns with similar frequency were selected as the text material for emotional speech data collection. Dialogue contexts were designed to elicit anger, happiness, and sadness for each target word (no contexts for neutral emotion). Each dialogue consisted of 2 turns and target words appeared isolated in the second turn. The dialogues were designed to be realistic, simple, natural, and conversational.

2.2. Recording procedure

Two speakers, one male and one female, recorded the speech stimuli in a sound-proof studio. They were both native Mandarin speakers who had received professional voice acting training and possessed strong emotional expression abilities. To

avoid interference from emotions induced later, the speakers first read isolated target words in a calm, neutral state to record the neutral speech. Then they recorded angry, happy, and sad speech in a role-play manner. To ensure consistency in emotional expression, recording for each emotion type was completed in a single session. In total, 136 speech samples were produced (2 speakers \times 17 words \times 4 emotion types).

2.3. Perceptual validation

To validate the effectiveness of the emotional expression, 10 native Mandarin speakers (50% female; mean age 22.0 years; normal hearing; none of them overlapping with the formal experiment participants) were recruited for perceptual validation. The speech stimuli from the same speaker were grouped into one block, with the playback order of the two blocks randomized. Participants were instructed to identify the emotion expressed in each speech stimulus, choosing from neutral, anger, happiness, and sadness. The correct identification rate of each stimulus was calculated. Following the standard by Liu and Pell [19], stimuli with a correct rate lower than 75% (three times the random level) were excluded. For stimuli from the same speaker and word, if one emotion was excluded, all other emotions for that word were also excluded. As a result, stimuli for 11 words from each speaker (a total of 2 speakers \times 11 words \times 4 emotion types = 88 stimuli) were retained.

2.4. Acoustic analyses

To provide further reference for the artificial modulation of speech stimuli, an acoustic analysis was conducted to compare the differences in acoustic parameters between different types of emotional speech. The Praat software was used to extract 5 parameters: Mean F0, F0 range, duration, mean amplitude, and amplitude range.

Repeated measures ANOVAs were conducted using SPSS 25 software to examine whether there were significant differences in the acoustic parameters across the four emotional speech types, with stimuli matched by the same speaker and word. The results indicated significant differences across all five parameters ($ps < .01$). Based on post hoc tests using the Bonferroni correction, the relative orders of the four types of emotional speech across the five parameters are as follows: Mean F0: Anger = Happiness $>$ Neutral $>$ Sadness. F0 range: Anger $>$ Happiness $>$ Neutral $>$ Sadness. Duration: Sadness $>$ Anger = Neutral $>$ Happiness. Mean amplitude: Anger = Happiness $>$ Neutral $>$ Sadness. Amplitude range: Neutral = Anger = Sadness $>$ Happiness. These findings are highly consistent with the conclusions summarized by Murray and Arnott [1]: Angry speech exhibits an extremely high mean F0 and extremely wide F0 range with high amplitude; happy speech also has a high mean F0, a wide pitch range, high amplitude, and a fast speech rate; sad speech features a low mean F0, narrow pitch range, low amplitude, and a slightly slow speech rate. These results further validate the emotional expression effectiveness of the speech stimuli in this study. The significant differences in the two F0 parameters of anger, happiness, and sadness compared to neutral support the feasibility of modulating F0 toward neutral speech to alter the emotional intensity of these three types of speech. Moreover, even without considering F0, the four types of speech can still be differentiated by duration and amplitude, indicating that after F0 modulation, the emotional cues of anger, happiness, and sadness may still be preserved to some extent and thus remain recognizable by participants.

2.5. Emotional intensity modulation

The original angry, happy, and sad speech (0%) was used as a fully expressive high-intensity version, with the global F0 progressively modulated at 50% intervals toward that of neutral speech (100%) from the same speaker and word, producing medium- and low-intensity versions. Specifically, the F0 of the high-intensity speech was adjusted to match the corresponding neutral speech at every time point using the pitch-synchronous overlap-add (PSOLA) technique in Praat software, resulting in the corresponding low-intensity stimuli. For each high-intensity speech and its corresponding neutral speech, the midpoint of the F0 at each point was calculated. The F0 of the high-intensity speech was then adjusted to this midpoint level at every time point using the same PSOLA technique, yielding the medium-intensity stimuli. All other acoustic parameters of medium- and low-intensity stimuli remained unchanged. As a result, 22 speech samples (2 speakers \times 11 words) were obtained for neutral and high-, medium-, and low-intensity versions of anger, happiness, and sadness, totaling 220 stimuli.

3. Perceptual experiment

3.1. Participants

Given the rarity of official BPD diagnoses in China and the difficulty in obtaining clinical participants, we recruited a community sample from university students with different levels of borderline personality features (BPF) as measured by the McLean Screening Instrument for Borderline Personality Disorder (MSI-BPD) [20]. The MSI-BPD is a self-report scale that has been validated as an effective tool for screening BPD and assessing BPF, particularly in late adolescence and early adulthood [21, 22]. The scale includes ten yes-or-no items, each scored as either 1 or 0, yielding total scores ranging from 0 to 10. Higher total scores indicate more severe BPF, with a recommended cutoff of 7 points for BPD diagnosis, based on its sensitivity and specificity [20]. Accordingly, 16 participants scoring 7 or higher (56.25% female; mean age 21.94 years) were assigned to the high-BPF group, and 16 participants scoring 0 to 3 (68.75% female; mean age 21.31 years) were assigned to the low-BPF group. All participants were native Mandarin speakers with normal hearing. Informed consent was obtained from the participants.

3.2. Procedure

The experiment was programmed with PsychoPy software. Before the formal experiment, participants listened to example speech stimuli of the four emotion types. To ensure familiarity with the procedure, participants first completed eight practice trials, with each of the four emotion types presented randomly twice. The practice trials had the same procedure as the subsequent formal experiment. In the formal experiment, the 220 stimuli were randomly divided into four blocks. To minimize anchor effects, balanced randomization was used to ensure that no block contained stimuli that differed only in emotional intensity. The blocks were presented randomly, and the stimuli within each block were also randomized. During each trial, a fixation point appeared on the screen for 500 ms, followed by the playback of the speech stimulus. Participants were required to press a key to identify the emotion type of the speech. Afterwards, participants clicked on a line segment displayed on the screen to rate the perceived emotional intensity of the speech on a scale from 1 (extremely low) to 5 (extremely high). If the

participant identified the speech as neutral, they were instructed to rate it as 1. Then, participants rated their confidence in their judgment on the same scale, where 1 meant no confidence and 5 meant full confidence. After the confidence rating, participants proceeded to the next trial.

3.3. Results

The accuracy, intensity and confidence ratings for correct judgments, and the proportion of incorrect judgments for each emotion type were calculated. The perception results for each group are presented in Table 1. The Shapiro–Wilk test indicated that intensity and confidence ratings followed a normal distribution, while most accuracy and error rates did not. Therefore, an independent samples *t*-test (for neutral speech only) and 2 (group: high/low-BPF) × 3 (intensity level: high/medium/low) repeated measures ANOVAs (for angry, happy, and sad speech, respectively) were performed to compare the ratings, while the non-parametric Mann–Whitney *U* test was used to compare accuracy and error rates between the groups across emotion types and intensity levels. All data analyses were conducted using SPSS 25 software.

There was no significant group difference of confidence in identifying neutral speech ($t = -1.11, p = .278$). The ANOVAs revealed that the main effects of intensity level were significant for both intensity and confidence ratings of angry, happy, and sad speech ($ps < .001$). A marginally significant main effect of group was found for the confidence rating of angry speech ($F(1, 30) = 3.47, p = .072, \text{partial } \eta^2 = .104$), with the high-BPF group showing higher confidence. No other main effects of group or interactions were significant ($ps > .05$). Post hoc tests showed that except for the difference between low- and medium-intensity happy speech which only reached marginal significance ($p = .087$), the differences in intensity ratings between the three intensity levels were significant in all other pairwise comparisons for angry, happy, and sad speech ($ps < .05$). Overall, the intensity ratings displayed a gradient decrease from high- to low-intensity level across the three emotions.

The Mann–Whitney *U* tests showed that high-BPF participants showed significantly lower accuracy in recognizing neutral speech than low-BPF group ($Z = -2.83, p = .005$). They were significantly more likely to misidentify neutral speech as happy ($Z = -1.97, p = .049$) and sad ($Z = -2.21, p = .034$), and the group difference in misidentifying neutral speech as angry also approached significance ($Z = -1.83, p = .067$). For happy speech, high-BPF participants were significantly more likely to misidentify high-intensity happy speech as neutral ($Z = -2.01, p = .044$). The group differences between accuracy in high-intensity happy speech and the error rate of misidentifying medium-intensity happy speech as angry also reached marginal significance ($Z = -1.86, p = .063; Z = -1.84, p = .066$). No significant differences were found in the accuracy and error rates of angry and sad speech ($ps > .05$).

4. Discussion

This study synthesized different intensities of angry, happy, and sad speech by progressively adjusting the F0 toward that of neutral speech and employed these samples as stimuli in a perceptual experiment with individuals at high and low BPF levels. The intensity perception for angry, happy, and sad speech exhibited a stepwise decrease from high- to low-intensity level, thereby supporting the effectiveness of the manipulation of

speech emotional intensity in this study. Additionally, the distinctive emotional speech perception patterns of high-BPF individuals were identified through the results of their performance in the experiment.

High-BPF participants demonstrated impaired ability to accurately identify neutral and happy speech. For neutral speech, they showed not only lower accuracy but also a greater tendency to misidentify it as any of the other three emotions compared to the low-BPF group. The higher rate of misjudging neutral as happy challenges the negative bias identified in previous studies [12]. These findings suggest that emotion perception in high-BPF individuals is not simply biased towards negative valence, but rather presents a more extreme and disordered orientation. They tend to categorize emotional cues as either positive or negative, with fewer instances of perceiving middle-ground emotions. This polarized emotion perception pattern closely aligns with the cognitive style observed in interpersonal relationships in BPD: individuals with BPD frequently switch between idealizing others and devaluing them. For example, they tend to exaggerate the care and support from a partner in the early stages of an intimate relationship, leading to unrealistic expectations, only to quickly experience disillusionment and distress when they feel their partner's care and support no longer meet their demands [6]. Fossati et al. [23] also found that individuals with heightened BPF tended to act more impulsively not only under negative but also positive emotions. In summary, emotional dysregulation in BPD may not be confined to disruptions and outbursts of negative emotions alone.

However, unlike neutral speech, the findings regarding happy speech strongly support the phenomenon of negative bias. High-BPF participants were significantly more likely to misidentify high-intensity happy speech as neutral, and their accuracy in recognizing it was marginally significantly lower. For medium-intensity happy speech, although there was no significant group difference in accuracy, high-BPF participants marginally significantly more often misidentified it as angry. These results suggest that high-BPF individuals have an impaired ability to perceive happy cues in speech, tending to interpret positive emotions as less positive or even negative. Notably, high-BPF individuals demonstrated different biases depending on the intensity of happy speech. Their tendency to misidentify high-intensity happy speech as neutral appears to contradict the pattern of polarized responses to neutral speech outlined before. This may further reflect the general confusion in emotion perception among high-BPF individuals and indicate potential differences in how they process varying types of emotional cues, underscoring the need for further research to clarify these patterns and their underlying mechanisms.

High-BPF participants also showed a marginally significantly higher level of confidence when correctly identifying angry speech compared to low-BPF participants. While inconsistent with previous studies, this result reflects the characteristics of BPD and partly supports the negative bias. Specifically, high-BPF individuals may have a processing advantage for anger-related stimuli, which could contribute to their higher confidence when interpreting angry speech. This advantage was observed only for angry speech, further highlighting the prominent position of anger in BPD [9]. In social interactions, the expression of anger may signal rejection, a type of interpersonal signal to which BPD patients are particularly sensitive. They tend to maintain an anxious expectation of rejection and respond intensely to it [24].

Finally, the present study found no different perception patterns in high-BPF participants when exposed to varying intensi-

Table 1: The perception results of each group. Data are given as $M \pm SD$. Response rate refers to the rate of identifying the given type of speech stimuli as the corresponding emotion type. Bold font indicates significant group differences.

Neutral Speech		Low-BPF		High-BPF			
Response Rate (%)	Neutral	93.18±9.82		76.70±21.44			
	Angry	0.28±1.14		2.27±4.07			
	Happy	0.57±1.55		2.27±2.87			
	Sad	5.97±8.74		18.75±21.63			
Confidence Rating		3.98±0.70		4.21±0.45			
Angry Speech		High-intensity		Medium-intensity		Low-intensity	
		Low-BPF	High-BPF	Low-BPF	High-BPF	Low-BPF	High-BPF
Response Rate (%)	Angry	84.94±15.46	89.49±10.46	81.82±11.13	81.53±12.02	71.02±11.84	69.89±18.99
	Neutral	1.99±4.69	0.85±2.47	3.69±5.80	3.98±5.22	13.92±9.60	14.20±14.93
	Happy	13.07±13.27	8.81±8.54	13.07±9.37	10.80±10.48	10.80±8.11	11.36±8.30
	Sad	0.00±0.00	0.85±1.83	1.42±2.18	3.69±6.89	4.26±5.37	4.55±7.23
Intensity Rating		4.03±0.46	3.86±0.52	3.74±0.47	3.64±0.54	3.54±0.50	3.47±0.53
Confidence Rating		4.05±0.50	4.34±0.47	3.95±0.51	4.25±0.44	3.76±0.46	4.06±0.50
Happy Speech		High-intensity		Medium-intensity		Low-intensity	
		Low-BPF	High-BPF	Low-BPF	High-BPF	Low-BPF	High-BPF
Response Rate (%)	Happy	95.74±4.83	89.20±10.74	84.38±10.36	77.27±16.26	58.24±21.91	45.17±20.83
	Neutral	1.99±3.70	5.40±5.56	11.36±8.62	12.78±10.26	30.40±22.25	35.23±16.47
	Angry	1.70±4.02	4.26±6.31	3.69±5.31	9.09±11.38	10.51±10.59	17.61±20.92
	Sad	0.57±2.27	1.14±3.52	0.57±1.55	0.85±1.83	0.85±1.83	1.99±2.86
Intensity Rating		3.43±0.53	3.55±0.62	3.00±0.57	3.16±0.68	2.80±0.56	3.13±0.80
Confidence Rating		4.02±0.33	4.23±0.47	3.85±0.40	4.05±0.43	3.62±0.44	3.90±0.56
Sad Speech		High-intensity		Medium-intensity		Low-intensity	
		Low-BPF	High-BPF	Low-BPF	High-BPF	Low-BPF	High-BPF
Response Rate (%)	Sad	97.73±4.98	94.89±6.40	94.89±6.40	91.19±10.16	86.08±12.69	84.09±17.33
	Neutral	1.70±4.66	4.55±5.98	4.55±5.50	7.95±9.61	12.22±11.94	13.35±14.80
	Angry	0.28±1.14	0.57±2.27	0.57±2.27	0.57±1.55	1.14±3.52	1.42±3.20
	Happy	0.28±1.14	0.00±0.00	0.00±0.00	0.28±1.14	0.57±1.55	1.14±2.03
Intensity Rating		3.05±0.61	2.85±0.99	2.91±0.58	2.74±1.01	2.75±0.51	2.62±0.92
Confidence Rating		3.91±0.63	4.15±0.72	3.85±0.63	4.10±0.71	3.71±0.64	3.96±0.70

ties of negative emotional speech. The results do not support the model proposed by Daros et al. [9], which might be explained by the following factors: First, their model was based on facial stimuli, whereas this study used auditory speech stimuli, indicating potential differences in emotional stimulus recognition across sensory channels in BPD. Second, participants in this study were community samples with BPF, possibly with less severe or less typical symptom presentations. Third, although this study successfully created a significant gradient of emotional intensity by adjusting F0, the intensity range was limited—angry, happy, and sad speech intensity rating scores ranged between approximately 4–3.5, 3.5–3, and 3–2.5, respectively, covering only a small proportion of the 1-5 scale. As a result, the low-intensity negative emotional speech, especially anger with a rating still around 3.5, may not have been low enough to detect differences in the recognition thresholds between the groups. Likewise, the high-intensity angry and sad speech stimuli may not have been exaggerated enough to induce overwhelming or uncontrollable emotional arousal in high-BPF participants. Particularly, high-intensity sad speech only had an average rating of around 3, which could be influenced by the generally low arousal nature of sadness, complicating the perception of its intensity. The difficulty in expressing highly in-

tense sadness through prosody alone may have also contributed to this result, as semantic content is also crucial for emotional expression but the stimuli used in this study were all neutral nouns. Future research could improve the speech materials by exaggerating high-intensity emotional speech and adjusting both F0 and other parameters for low-intensity emotional speech to further weaken emotional cues, thereby broadening the emotional intensity range.

5. Conclusion

In summary, this study conducted perceptual experiments with synthesized emotional speech of varying intensities, revealing a disordered, polarized pattern of emotion perception for neutral speech, perceptual deficits in recognizing happy speech, and an advantage in confidence when identifying angry speech among individuals with high BPF. The findings illuminate the abnormal emotional speech perception patterns of individuals high in BPF, contributing to the phenomenological understanding of emotional dysregulation in BPD. Furthermore, after further validation, the findings may serve as potential markers for early screening and prognosis of BPD in clinical practice and provide valuable implications for BPD interventions.

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7. References

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