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The Adaptive Value of Mandarin Tones for Affective Iconicity

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Abstract

Affective iconicity is an important mechanism for signaling emotions due to its adaptive significance. However, existing evidence predominantly focuses on emotional valence in Indo-European languages, leaving the more adaptation-related dimension, emotional arousal, relatively underexplored. Our study examined the adaptive significance of Mandarin tones in affective iconicity. We analyzed two Mandarin Chinese corpora datasets with arousal and valence ratings of bi-syllabic words. Hierarchical linear regression models were used to explore whether individual lexical tones associated with the first and second syllables of a disyllabic word predict arousal and valence ratings of the word. Results indicated that the valence of a word is predicted by the first tone, with negative words more likely to carry a falling tone than a rising tone. Lexical tones of both syllables predict the arousal rating of the word, with high-arousing words more likely to have a falling tone than a rising or low-dipping tone. These findings emphasize the importance of lexical tone pitch contour in predicting the affective iconicity of tone-carrying words. Our study extends the literature by showing that affective iconicity signals both dimensions of emotion-related adaptation (i.e., emotional arousal and valence) with evidence from a Sinitic lexical tone language.

Index Terms: affective iconicity, Mandarin tone, emotional arousal, emotional valence, adaptation

1. Introduction

Emotions carry profound significance across diverse cultures and languages, serving as a crucial tool for individuals to assess their relationship with emotional stimuli, establish action orientation, and adapt to varying circumstances [1]. The expression of emotion, particularly through emotional words, has been extensively studied. Negative and positive valence words consistently exhibit processing advantages, characterized by faster and more accurate responses in lexical decision tasks and enhanced neural responses, compared to neutral words, which indicates a cognitive benefit of emotional salience in information processing. These processing advantages also hint at the evolutionary significance of emotions, with rapid processing of emotional words being rooted in adaptations that prioritize swift identification and response to potentially survival or socially relevant stimuli [2], [3], [4].

An intriguing question is how adaptive significance is encoded in the lexicon. Specifically, how certain components of a word contribute to its overall arousal and valence. For example, recent research [5] revealed the crucial role of the first phoneme in predicting the emotional valence (i.e., degree of pleasantness) of words in Indo-European languages, with evidence from English, Spanish, Dutch, German, and Polish. In English and German, quickly pronounced phonemes (i.e., shorter response time) were also found to more likely initiate negative words, while initial phonemes with longer response time correlated better with positive words. Such association between form and meaning in the lexicon of some Indo-European languages is termed emotional sound symbolism by Adelman et al. [5], who argued that sound symbolism came about because it provides an immediate advantage to humans for survival. Phonemes can convey emotions, due to their adaptive significance, in the form of sound symbolism, which serves as an early warning system in human language, akin to alarm calls in other species.

In this paper, we will adopt the term “affective iconicity” to refer to emotional sound symbolism [5]. Two disclaimers are to be made. First, different from traditional sound symbolism where specific phonetic features are associated with particular meanings (such as the bouba/kiki sound-shape symbolism [6], we take “iconicity” to encompasses various forms, such as speech, sign, gesture, and word [7]. Second, rooted in the embodied view of language, the term “affect” encompasses both behavioral and neural emotional responses across species and cultures [8].

We consider arousal and valence to be the two primary affective dimensions [9]. Emotional valence typically involves cognitive appraisal based on contextual cues, while arousal reflects the contribution of physiological responses, renowned for their spontaneity and sustenance [10]. Yet, despite extensive investigation into emotional valence and its role in adaptation, the contribution of emotional arousal in adaptation remains underexplored. As arousal is considered more ancient and innate than valence, with its evolutionary roots predating the emotional dimension of valence [11], we expected that arousal might offer a more profound understanding of how emotional information has contributed to adaptation and, in turn, facilitated the development of affective iconicity in language.

Four further observations motivated the design of the current study. First, emotional arousal and valence are often related to each other. There is evidence that positive and negative valence are more likely to associate with high arousal while neutral valence with low arousal, forming a V-shaped relationship between arousal and valence [12]. The treatment of arousal as a constant in studies such as [5], therefore, overlooks the intricate and dynamic nature of emotions, where arousal and valence are inherently interconnected. Our study addressed this issue by investigating both arousal and valence to obtain a better understanding of affective iconicity.

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Second, results from ERP studies show that higher-arousal emotions elicit more pronounced EPN and LPC components, compared to neutral stimuli. This suggests not only immediate and enhanced voluntary allocation of attention (EPN) but also more extensive and prolonged processing of emotions (LPC) [2], [13], [14], [15], [16]. Such a time course of the neural processing of emotions may result from not only the initial but also subsequent phonemes of a word being relevant for triggering higher emotional arousal. Thus, our current study included both initial and non-initial sound elements of a word for analysis.

Third, iconicity differs across language families, with claims suggesting a higher occurrence of iconic words in non Indo-European languages (such as Japanese and Korean which contain more ideophones than Indo-European languages [5], [17]). It is important to note that iconicity extends beyond specific ideophones, as Adelman et al. [5] have found in the general lexicon in English, Spanish, Dutch, German, and Polish. Nevertheless, the exploration of iconicity in the general lexicon of non Indo-European languages remains limited. This study therefore addresses this important knowledge gap by examining the iconicity of the general lexicon in Standard Chinese, a Sinitic language.

Last but not least, research on affective iconicity has predominantly focused on segments. Although half if not more languages of the world have lexical tones, little is known about how lexical tones contribute to affective iconicity. Our investigation specifically explores whether lexical tone, marked by pitch variations, biases the emotional arousal and valence rating of the tone-carrying word. This investigation draws parallels with emotional intonation patterns; studies on emotional prosody consistently show that high-arousing emotions typically exhibit higher global pitch levels and more dynamic fluctuations (including wider pitch ranges and steeper slopes), compared to low-arousing emotions [18]. While less conclusive, positive emotions are more likely to be associated with a higher pitch level and a greater pitch range [19]. Even though there is general consensus that the function of lexical tone in tonal languages is completely separate from affective meanings, we investigate whether pitch contours at the lexical tone level might nonetheless evoke similar emotional arousal and valence due to their phonetic similarities to emotion-induced pitch modulations at the sentence level.

The empirical base of this study is lexical tones in Standard Chinese, the official language spoken in Mainland China, which is a Mandarin variety, the largest dialect family of Sinitic Chinese [20]. It has four distinctive lexical tones: the high-level tone (T1, H) maintains a consistently high and steady pitch; the rising tone (T2, R) initiates with a mid-level pitch, ascending gradually to a higher pitch with an upward slope; the low-dipping tone (T3, L) commences with a mid-level pitch, dipping down before a slight rise, resulting in an overall low pitch; and the falling tone (T4, F) starts at a high pitch and sharply descends to a low pitch, creating a pronounced, steep decline in pitch. These pitch contour distinctions present a unique opportunity to investigate the possible encoding of emotional information within the Mandarin Chinese general lexicon, as what has been done for segments in non-tonal languages.

We aimed to extend the adaptation account of emotional sound symbolism proposed by Adelman et al., based on phoneme-induced valence, to encompass a broader range of emotional dimensions (i.e., both arousal and valence), linguistic levels (i.e., both segment phonemes and lexical tones), and languages (i.e., a Sinitic variety which is very different from Indo-European languages).

In this exploratory study, we hypothesized that lexical tone serves to signal both arousal and valence, thereby contributing to the emotional adaptive value of words in a tone language. Regarding the time course of emotion processing, we anticipated effects of tone throughout the word although valence is more likely to exhibit an effect on the initial position of a word, whereas arousal over the entire word, due to their distinctive processing characteristics. Moreover, we predicted that both pitch height and pitch contour contribute to predicting arousal and valence ratings, in line with the effects of pitch in non-tonal languages to express emotion. Finally, to mitigate potential influences on the prediction of arousal and valence ratings, we considered lexical factors such as word frequency [21], onset consonant category [22], and part-of-speech [23] as control variables.

2. Methods

2.1 Corpus Datasets

We selected two existing corpora containing normative ratings for a large set of Chinese words from a psycholinguistic database. All disyllabic words were annotated with their underlying lexical tones.

The Chinese Affective Word System (CAWS) dataset [24] comprises arousal and valence ratings for 1,492 disyllabic words in Mandarin Chinese. A total of 64 undergraduate students rated arousal and valence on a 9-point Likert scale. A retest was subsequently conducted with 30 undergraduates (aged 18-21 years). Arousal values ranged from low (1, e.g., peaceful) to high (9, e.g., alert), while valence ratings spanned from negative (1, e.g., unhappy) to positive (9, e.g., happy).

The Affective Norms for Chinese Words dataset [25], hereafter NORM, contains arousal and valence ratings of 9,573 disyllabic words in Mandarin Chinese. Arousal ratings were collected from 1,189 participants, and valence ratings from 1,232 participants (aged 18-62 years). Most participants (96.9%) received college-level education or higher. The NORM dataset employed a 5-point Likert scale for arousal (0-4) and a 7-point scale for valence (-3 to +3).

2.2 Data Analysis

We first visually inspected the graphs displaying emotional arousal and valence ratings for all words to examine the relationship between the ratings of arousal and valence in each dataset.

We then explored how lexical tone in different positions (first vs. second syllable) predicts the emotional arousal and valence of disyllabic words, separately in the CAWS and NORM datasets. To observe how lexical tone contributes to account for the arousal and valence variances, we conducted a set of hierarchical linear regression analysis (HLM) in each dataset [26]. The HLM helps to determine whether lexical tone explains a statistically significant amount of variance in the arousal and valence after accounting for all other variables such as word frequency, onset consonant, and part-of-speech. The HLM analysis consisted of three blocks: lexical factors in the first block, the addition of an individual tone (either on the 1st or 2nd syllable) in the second block, and tonal sequences (i.e. tones of both syllables), along with the lexical factors, in the

third block. Three models were therefore generated for the three blocks. The dependent variables were the aggregated emotional arousal and valence rating scores. The HLM results highlighted the influence of individual tones on emotional ratings. Pairwise multiple comparisons, adjusted with Bonferroni correction using the *emmeans* package [27], were employed to examine differences across individual tones. All necessary data and codes to reproduce the findings reported below are available at https://osf.io/kacmp/.

3. Results

3.1 V-shaped Relationship between Arousal and Valence

As illustrated in Figures 1-2, where the numerical values on axes correspond to Likert scale ratings, a distinctive V-shaped relationship emerged between arousal and valence in both datasets, confirming that positive and negative valence tend to associate with high arousal, while neutral valence aligned with low arousal. In each panel, 'H' is used for high-level tone (T1), 'R' for rising tone (T2), 'L' for low-dipping tone (T3), and 'F' for falling tone (T4).

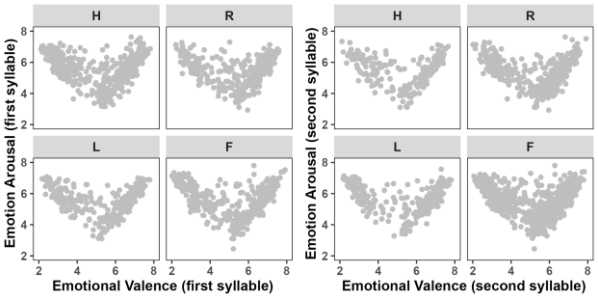

Figure 1: *The V-shaped relationship between emotional arousal and valence in the CAWS dataset.*

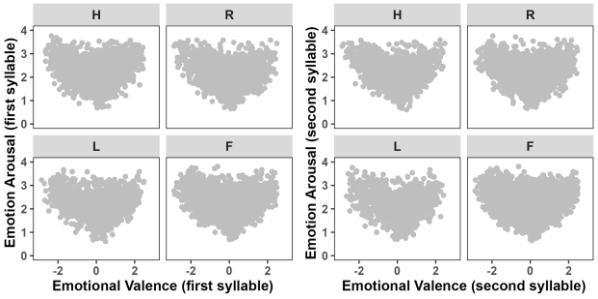

Figure 2: *The V-shaped relationship between emotional arousal and valence in the NORM dataset.*

3.2 Effects of Individual Lexical Tone on Arousal and Valence Ratings

Regression diagnostics confirmed the fulfillment of linearity, homoscedasticity, and normality assumptions, with no identified collinearity issues. No violations of independence existed for the average score of arousal and valence ratings across participants.

Regarding the arousal ratings, individual tones in both the first and second syllables significantly impacted the unique variance across the two datasets. Specifically, the lexical tone of the first syllable collectively contributed to 0.88% and 0.15% (ΔR^2) of the arousal variance in both the CAWS and NORM datasets, respectively. Similarly, the lexical tone of the second syllable collectively contributed to 0.96% and 0.22% (ΔR^2) of the arousal ratings in the CAWS and NORM datasets, respectively. Zooming into individual lexical tones, we observed that the falling tone was consistently associated with higher arousal ratings compared to the rising tone in both the first ($\Delta M = 0.26$, $p < 0.001$) and second syllables ($\Delta M = 0.21$, $p < 0.01$) within the CAWS dataset. In the NORM dataset, the falling tone was also found to be associated with higher arousal levels compared to the rising tone in both the first ($\Delta M = 0.05$, $p < 0.01$) and second syllables ($\Delta M = 0.06$, $p < 0.001$). In addition, the falling tone was associated with higher arousal levels compared to the low-dipping tones in both the first ($\Delta M = 0.05$, $p < 0.05$) and second ($\Delta M = 0.05$, $p < 0.05$) syllables.

Regarding the valence ratings, only the lexical tone of the first syllable demonstrated a noteworthy influence ($\Delta R^2 = 0.12\%$) within the NORM dataset. Specifically, the rising tone was perceived as more positive compared to both the high-level tone ($\Delta M = 0.08$, $p < 0.05$) and the falling tone ($\Delta M = 0.08$, $p < 0.05$).

Figures 3 and 4 illustrate further individual tones' different contributions to the emotional arousal and valence ratings in our two corpora. In these plots, lexical tones are organized in ascending order based on their average rating scores for each syllable (first syllable on the left) and dimension in each panel (arousal rating scores on the top). The mean rating scores for each individual tone are connected to show the overall trends. Take the left-upper panel of Figure 3 as an example. For the first syllable, the rising tone is associated with the lowest mean arousal rating score (score 5.50), while the falling tone with the highest mean arousal rating score (score 5.75).

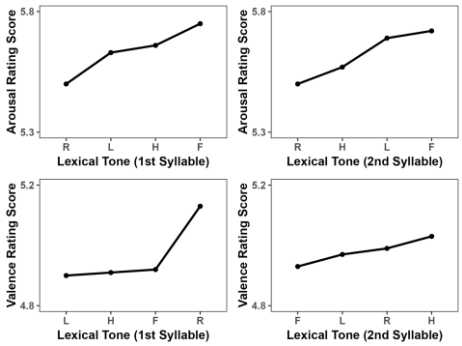

Figure 3: *Arousal and valence rating scores for each tone at the 1st and 2nd syllable in the CAWS dataset.*

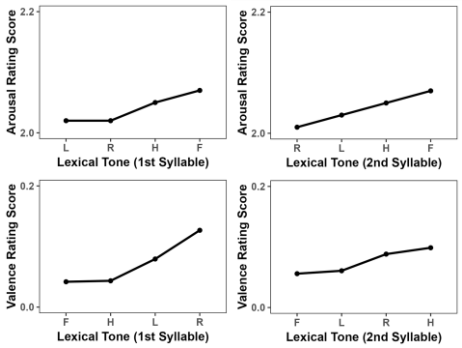

Figure 4: *Arousal and valence rating scores for each tone at the 1st and 2nd syllable in the NORM dataset.*

4. Discussion and Conclusion

This study investigated the affective iconicity of Mandarin Chinese lexical tones. Analyzing two corpus datasets while controlling variables such as word frequency, part-of-speech, and onset-consonant category, we found that individual tones significantly impacted the arousal and valence ratings of Mandarin disyllabic words. Our findings, as discussed below, lend support to the adaptive value of lexical tones in affective iconicity.

First, we confirmed the commonly observed V-shaped relationship between arousal and valence [12], [28], signifying the interdependence of these dimensions. This suggests that both arousal and valence should be taken into account in the investigation of affective iconicity. Overlooking their potential interaction may lead to misunderstandings of nuanced emotional expressions.

Second, we found that the lexical tone of both the initial and second syllables predicted the arousal ratings of words. Specifically, the falling tone correlated better with high-arousing words, while the rising and low-dipping tones correlated better with low-arousing words. In contrast, the valence ratings were primarily influenced by the lexical tone of the first syllable. An initial rising tone is more likely to associate with positive words than an initial high-level or falling tone.

Such a positional effect of the lexical tone in predicting valence ratings is in line with the findings of [5] that the first sound element of a word is critical in predicting valence information. Adelman et al. [5] introduced the concept of negative priority to account for the differences in the pronunciation latency of the first phoneme between negative and positive words. According to this concept, negative information or stimuli are given preferential attention due to their potential significance for survival and adaptive behavior. Consequently, negative words tend to be initiated with rapidly uttered phonemes to avoid negative outcomes, which are more urgent than positive ones.

One caveat to be noted is that in Mandarin Chinese, the lexical tone f0 contrasts are predominantly realized within the rhyme of a syllable, especially for syllables with a voiceless onset. So, the negative priority account of segmental affective iconicity may have limited applicability to lexical tones. Further investigation is necessary to explore the positional influence of both segmental phonemes and lexical tones on affective iconicity. It is plausible that there exist two distinct mechanisms for the positional effects of segmental and suprasegmental tonal iconicity, or a more general mechanism that extends and further refines the negative priority developed for segments (as defined in [5]).

Third, individual lexical tones showed varying effects on valence and arousal ratings. Such differences are likely to be rooted in their respective tonal pitch patterns. These lexical tonal pitch contours (in terms of both pitch height and shape) bear similarities to pitch variations used to convey different emotions. For instance, the falling tone in Standard Chinese is realized with a higher pitch level, greater pitch range, and steeper slope, compared to rising and low-dipping tones. Consequently, these attributes in the falling tone's pitch pattern may contribute to higher arousing ratings of words that carry a falling tone. As for the valence judgment, the falling tone and high-level tone are found to lead to more negative ratings than the rising tone, which, however, are not predicted by pitch variation patterns observed for emotions ([19]; cf. [29]). The effects of pitch level and range, as well as the direction of pitch variation, on valence ratings need further research to understand the valence affective iconicity of lexical tones.

While investigating the mechanisms underlying the relationship between tonal patterns and arousal, it is crucial to distinguish between arousal and attention, which are intertwined yet distinct concepts, each engaging different neural substrates [30]. Arousal typically refers to the physiological and psychological changes influencing the overall state of alertness or readiness to respond to stimuli. In contrast, attention involves the selective focus on specific aspects of stimulation. Arousal can impact attentional processes by increasing alertness and enhancing stimulus salience. Elevated arousal can lead to increased vigilance, manifested by the modulation of neural activity in sensory cortices, which in turn facilitates attention and influences subsequent cognitive performance [31]. In our data, a falling tone seems to evoke higher arousal than a rising tone, which could lead to more engaged attention and conscious processing (but see [32] for an attention-orienting effect of a rising tone in German). Further research is imperative to fully understand the processing of pitch contour in relation to arousal and valence and its potential impact on cognitive processing.

Across all findings, the magnitude of the average arousal and valence differences among lexical tones are relatively small, but it is important to note that they are comparable with previous studies regarding the effects of phonemes on valence ratings [5]. Nevertheless, researchers need to be cautious while theorizing these findings. Besides, this study only focused on the underlying lexical tone without taking into consideration possible variations such as tonal coarticulation, sandhi, and neutralization for disyllabic words. This is an issue to emphasize especially considering that most raters also speak Mandarin varieties that could differ from Standard Chinese in lexical tonal realizations. More research is needed to investigate how emotion ratings may be affected by more nuanced acoustic characteristics in tonal realizations.

To conclude, the effects of lexical tones on the arousal and valence ratings suggest the possibility that tones in the general lexicon of Mandarin Chinese exhibit affective iconicity. This lends some support to the adaptation account of iconicity and extends it from segmental level to suprasegmental level, from Indo-European language to Sinitic language, and from one dimension (valence) to two primary dimensions (valence and arousal). Future investigations must delve deeper into the adaptation account of lexical tone affective iconicity and elucidate the underlying mechanism(s).

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