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Perception of emotion across cultures: Norms of valence, arousal, and sensory experience for 4923 Chinese words translated from English in Warriner et al. (2013)

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Abstract
Perception of emotion conveyed through language is influenced by embodied experiences obtained from social interactions, which may vary across different cultures. To explore cross-cultural differences in the perception of emotion between Chinese and English speakers, this study collected norms of valence and arousal from 322 native Mandarin speakers for 4923 Chinese words translated from Warriner et al., (*Behavior Research Methods*, 45, 1191–1207, 2013). Additionally, sensory experience ratings for each word were collected. Analysis demonstrated that the reliability of this dataset is satisfactory, as indicated by comparisons with previous datasets. We examined the distributions of valence and arousal for the entire dataset, as well as for positive and negative emotion categories. Further analysis suggested that valence, arousal, and sensory experience correlated with various psycholinguistic variables, including the number of syllables, number of strokes, imageability, familiarity, concreteness, frequency, and age of acquisition. Cross-language comparison indicated that native speakers of Chinese and English differ in their perception of emotional valence and arousal, largely due to cross-cultural variations associated with ecological, sociopolitical, and religious factors. This dataset will be a valuable resource for research examining the impact of emotional and sensory information on Chinese lexical processing, as well as for bilingual research investigating the interplay between language and emotion across different cultural contexts.

Keywords Emotion · Valence · Arousal · Sensory experience · Cultural differences

Introduction

Emotion plays an important role in our daily lives. We experience positive and negative emotions from time to time, and these emotional experiences influence not only our well-being but also fundamental cognitive processes, such as attention, learning, memory, and decision-making (Dukes et al., 2021). Emotions can be defined as transient, bio-psycho-social reactions to events that impact us (Matsumoto & Hwang, 2012). They can also be systematically represented as two bipolar dimensions, namely, valence and arousal (Russell, 2003). Valence captures the degree to which an emotion is pleasant or unpleasant, whereas arousal describes the degree of physiological activation elicited by a stimulus, varying from calm to excited (Lang et al., 1997). Emotion can be expressed through multiple channels, including facial expressions, body movements, and language. Needless to say, language plays a crucial role in the perception and expression of human emotions. On the one hand, language reflects the affective states of humans; on the other hand, it also guides and impacts the perception, recognition, and categorization of emotional experiences (Ogarkova et al., 2009). When it comes to linguistic units such as words, it is well accepted that words do not merely convey conceptual information but also vary in valence and arousal levels (Lindquist & Gendron, 2013), with a large number of studies showing that valence and arousal moderate the accuracy and speed of visual word processing in various cognitive tasks (e.g., Citron, 2012; Crossfield & Damian, 2021; Herbert et al., 2008; Hinojosa et al., 2010; Kissler et al., 2006).

Despite the debate surrounding the universality of emotion among psychologists, it is now widely acknowledged

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that the perception and expression of emotion can vary significantly within individuals over time, across individuals within the same culture, and across cultures (Barrett, 2009). The variation in emotion across cultures has been widely reported. For instance, some emotion categories exist only in specific cultures, and the same physiological experience can be categorized as distinct emotion categories across cultures. Cross-cultural differences in emotion production and perception are not difficult to understand. Emotional content in language is processed not only linguistically but also through sensory-motor representations (Kousta et al., 2009), with emotional concepts such as "anger" and "sadness" often associated with bodily and physiological experience. According to constructivist theories of emotion, although the physical experience activated by emotions is largely determined biologically, the process of learning to express and perceive emotion is heavily shaped by sociocultural context and highly dependent on cultural factors (Barrett et al., 2007). This has been confirmed by many researchers. For instance, Loderer et al. (2020) investigated achievement-related emotions tied to concepts of success or failure. They compared the perceptions of achievement-related emotions among Canadian, German, Colombian, and Chinese students and identified cultural differences in the physiological characteristics of emotions, particularly for boredom. In a large-scale study, Jackson and colleagues (2019) examined emotion semantics across 2474 spoken languages and found significant variation in networks of emotion concepts, which were predicted by the geographic proximity of language families. Chen and colleagues (2019) provided further evidence of cultural variation in emotional processing at the neural level. In their study, Eastern and Western participants exhibited distinct neural activation patterns when processing emotional words, with Eastern participants showing greater activation in regions related to emotion regulation, while Western participants demonstrated increased activation in areas associated with emotional experience and evaluation.

Chinese and English are the two most spoken languages in the world. Previous studies have collected norms of valence and arousal for Chinese (e.g., Xu et al., 2021; Yao et al., 2017) and English words (Citron et al., 2014; Warriner et al., 2013). To the best of our knowledge, Xu et al. (2022) is the only study that has compared the most highly valenced and arousing Chinese words in their dataset with their English translations. However, their study primarily focused on collecting norms of valence and arousal for Chinese words, rather than systematically comparing emotion perception between Chinese and English. To provide a comprehensive analysis of cultural commonalities and differences in emotion perception between Chinese and English, and to offer deeper insights into cross-cultural variation in emotion, the present study collected ratings of valence and arousal for 4923 Chinese words that are translations of their English equivalents, originally derived from the norming study by Warriner et al. (2013). Unlike Warriner et al. (2013), we excluded dominance ratings (i.e., the degree of feeling in control or being controlled as suggested by a word), because valence and arousal are generally regarded as the two primary dimensions of affect representation (e.g., Russell, 2003). Additionally, valence and arousal have demonstrated robust effects on word recognition (e.g., Kuperman et al., 2014). We extended the work of Warriner and colleagues by collecting sensory experience ratings for these words, aiming to examine the relationship between emotion and embodied experience. Various psycholinguistic variables have been reported to be associated with emotional valence, including familiarity (Citron et al., 2014; Yao et al., 2017), frequency (Hinojosa et al., 2016; Warriner et al., 2013; Yao et al., 2017), concreteness (Hinojosa et al., 2016; Warriner et al., 2013), and imageability (Citron et al., 2014). Similarly, several variables have been found to correlate with emotional arousal, including familiarity (Citron et al., 2014), frequency (Hinojosa et al., 2016), and imageability (Monnier & Syssau, 2014). Additionally, research has documented robust age-of-acquisition effects in L1 and L2 lexical processing, where early-learned words are processed significantly faster than late-learned words (e.g., Dirix & Duyck, 2017). Thus, this study also retrieved other psycholinguistic variables from previous research, including imageability (Su et al., 2023b), familiarity (Su et al., 2023a), concreteness (Xu & Li, 2020), frequency (Tsang et al., 2018), and age of acquisition (Xu, Li & Guo, 2021), to explore their relationships with valence, arousal, and sensory experience. Our research aims to illuminate cross-cultural differences in emotion perception between Chinese and English, providing insights into how linguistic and cultural contexts shape emotional experiences. Our dataset will be a valuable resource for research examining Chinese-English bilingual lexical processing from the perspective of emotion and embodiment, as well as for investigations into the interplay between language and emotion across different cultural contexts.

Method

Participants

This study involved 322 participants, who were college students from universities and colleges in Beijing, China. They were all native speakers of Mandarin Chinese. Among the participants, 160 were male and 162 were female. Regarding their education background, 154 participants were undergraduate students, 152 were masters students, and 16 were PhD students. Their ages ranged from 17 to 34 years ($M = 23.1$, $SD = 3.3$). All participants reported themselves to be mentally and physically healthy.

Stimuli

The words included in our stimulus set were translated from Warriner et al. (2013). Warriner and colleagues included 13,915 words that were widely distributed across parts of speech and frequently used in English, making them an excellent fit for our research purposes. To begin with, we translated all the English words from Warriner et al. (2013) into Chinese using online English-Chinese dictionaries. Subsequently, these Chinese translations were re-translated back into English using online Chinese-English dictionaries. To ensure the quality of the translations, only those with matched forward and backward translations were retained (i.e., the English translations of a Chinese word provided by the online Chinese-English dictionary should include the original English word). All Chinese-English translation pairs were cross-checked by two proficient Chinese-English bilingual speakers. Following this, the authors reviewed the English-Chinese translation pairs and removed those that met one of the following conditions: (1) the English word was not translated correctly into Chinese; (2) the Chinese word did not match the English word in terms of part of speech; (3) the Chinese translation turned out to be a phrase rather than a single word (e.g., intimacy-亲密关系; highway-高速公路; decade-十年); (4) the Chinese translation was not frequently used by native speakers of Mandarin (e.g., constituency-选区; corporal-下士); (5) the Chinese translation was semantically ambiguous (e.g., uniform-制服, where "制服" can also be used as a verb in Chinese, meaning "to bring someone under control"); (6) the Chinese translation was a technical term used in certain fields (e.g., acetylene-乙炔; hemoglobin-血红蛋白). Following this procedure, a final set of 6153 Chinese words was selected, of which 53.1% were nouns, 23.7% were verbs, and 8.8% were adjectives. In terms of syllabic structure, a majority of words were disyllabic (81.5%) and trisyllabic (12.5%).

Data collection

Following Warriner et al. (2013), we employed a nine-point scale to gather ratings of valence and arousal for the stimulus words. Unlike Warriner and colleagues, our scale was not reversed; they ranged from 1 to 9, with 1 indicating unhappy or calm emotions and 9 indicating happy or excited emotions. Following the practice of Xu et al. (2022), we included the option "I am not familiar with this word" alongside the nine-point scale. The 6153 Chinese words were distributed across 10 lists, each containing 658–662 words. In order to give participants a sense of the entire range of the stimulus words that they would encounter, calibrator words were selected from Warriner et al. (2013). For each list of words, three dimensions, namely valence, arousal, and sensory experience, were normed using nine-point scales. The calibrator words were presented in fixed order at the beginning of each list, with the remaining words randomized. Participants were divided into 20 groups (16–17 individuals per group). Each group of participants was randomly assigned to rate two dimensions for each list of words (i.e., valence and sensory experience, or arousal and sensory experience), one dimension at a time. We collected ratings of valence, arousal and sensory experience for the Chinese words through online questionnaires created and delivered by Qualtrics. Participants were instructed to respond based on their intuition and at their own pace. On average, assignments were completed in approximately 1 h. Participants received 60 yuan per completed assignment.

Results

Data cleaning

A total of 322 respondents contributed to the final dataset. Altogether, 344,033 ratings were collected for the three dimensions (i.e., valence, arousal, and sensory experience). Approximately 4% of the data were removed due to missing responses. Participants who had more than 15% of responses of "I am not familiar with this word" were excluded, resulting in the removal of one participant for valence ratings and one for sensory experience ratings. Additionally, we removed participants who showed little variability in their ratings (i.e., with more than 85% of responses being the same). This resulted in the removal of 1428 valence ratings, 4810 arousal ratings, and 2575 sensory experience ratings. Ratings where participants selected "I am not familiar with this word" were also excluded (1293 ratings for valence, 1228 ratings for arousal, and 1804 ratings for sensory experience). To ensure adherence to the screening criteria outlined in the Stimuli section, the first author re-screened the 6153 English-Chinese translation pairs, removing Chinese words identified as phrases, technical terms, or incorrect translations of English words. Following this, 4923 Chinese words were retained in the final database, including 3066 nouns, 1276 verbs, and 485 adjectives. With regard to valence, 64 words received fewer than 15 valid ratings (minimum: 10). For arousal, 89 words received fewer than 15 valid ratings (minimum: 6). For sensory experience, 108 words received fewer than 15 valid ratings (minimum: 8).

Descriptive statistics

Distribution for valence, arousal, and sensory experience ratings

Table 1 presents descriptive statistics for valence, arousal, and sensory experience ratings of 4923 Chinese words and

Table 1 Descriptive statistics for valence, arousal, and sensory experience ratings

	M	Median	*Min*	*Max*	*SD*	Skewness	Kurtosis
Valence. CH	5.12	5.29	1.06	8.31	1.16	−0.71	0.41
Arousal. CH	4.97	4.93	1.94	7.62	0.80	0.27	−0.07
Sensory. CH	4.43	4.44	1.56	7.75	0.97	0.06	−0.29
Valence. EN	5.24	5.38	1.30	8.53	1.30	−0.48	−0.16
Arousal. EN	4.15	4.05	1.67	7.74	0.92	0.57	0.13

CH: Chinese; EN: English

their English translations from Warriner et al. (2013). The distribution of valence ratings is negatively skewed, while arousal ratings are positively skewed. In contrast, the distribution of sensory experience ratings is nearly symmetrical, as illustrated in Fig. 1. Further, as depicted in Table 1 and Fig. 2, the distributional patterns of valence and arousal ratings are consistent between Chinese words and their English translations, with the exception that the valence ratings for Chinese words exhibit a more leptokurtic distribution, indicating a higher concentration of data around the mean. Additionally, the variability in the ratings of valence and arousal between the Chinese words and their English translations is comparable, as evidenced by similar standard deviations.

Figures 3 and 4 display the means of the ratings for valence, arousal, and sensory experience for Chinese words and their English translations, plotted against their standard deviations. Each scatterplot includes a smoother lowess line that illustrates the overall trend in the variability of the data. For both languages, the variability in valence ratings increases notably at the lower and upper extremes around the average valence rating (Fig. 3). This suggests that words with moderate valence ratings were rated more consistently, whereas words at the extremes (very positive or very negative) were rated more variably. Similarly, arousal ratings exhibit a U-shaped distribution in variability, with words at the minimal and maximal ends of arousal eliciting a broader range of emotional responses. This U-shaped pattern is more pronounced in the ratings of sensory experience for the Chinese words, as illustrated in Fig. 4.

Distribution of valence and arousal ratings for emotion categories

Xu et al. (2008) developed a dictionary consisting of 27,466 Chinese words and tagged the emotion categories for each word. Based on emotion categories extracted from Xu et al. (2008), we grouped our data into subsets and created scatterplots illustrating the distribution of the means of valence and arousal ratings for 403 Chinese words spanning six positive emotions (Happy: 59 words; Affection: 40 words; Respect: 36 words; Ease: 18 words; Trust: 26 words; Praise: 224 words) and 445 Chinese words spanning six negative

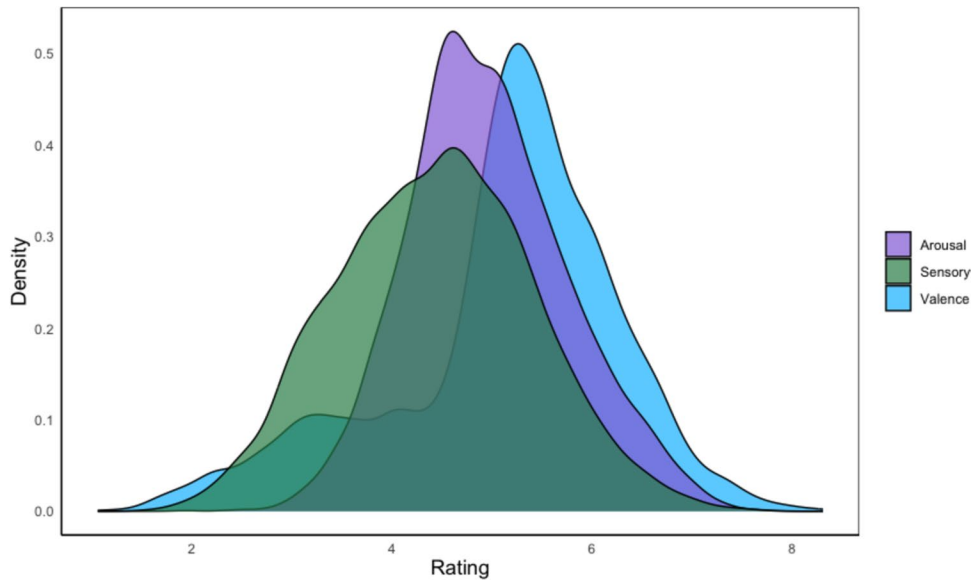

Fig. 1 Distributions of valence, arousal, and sensory experience ratings for the Chinese words

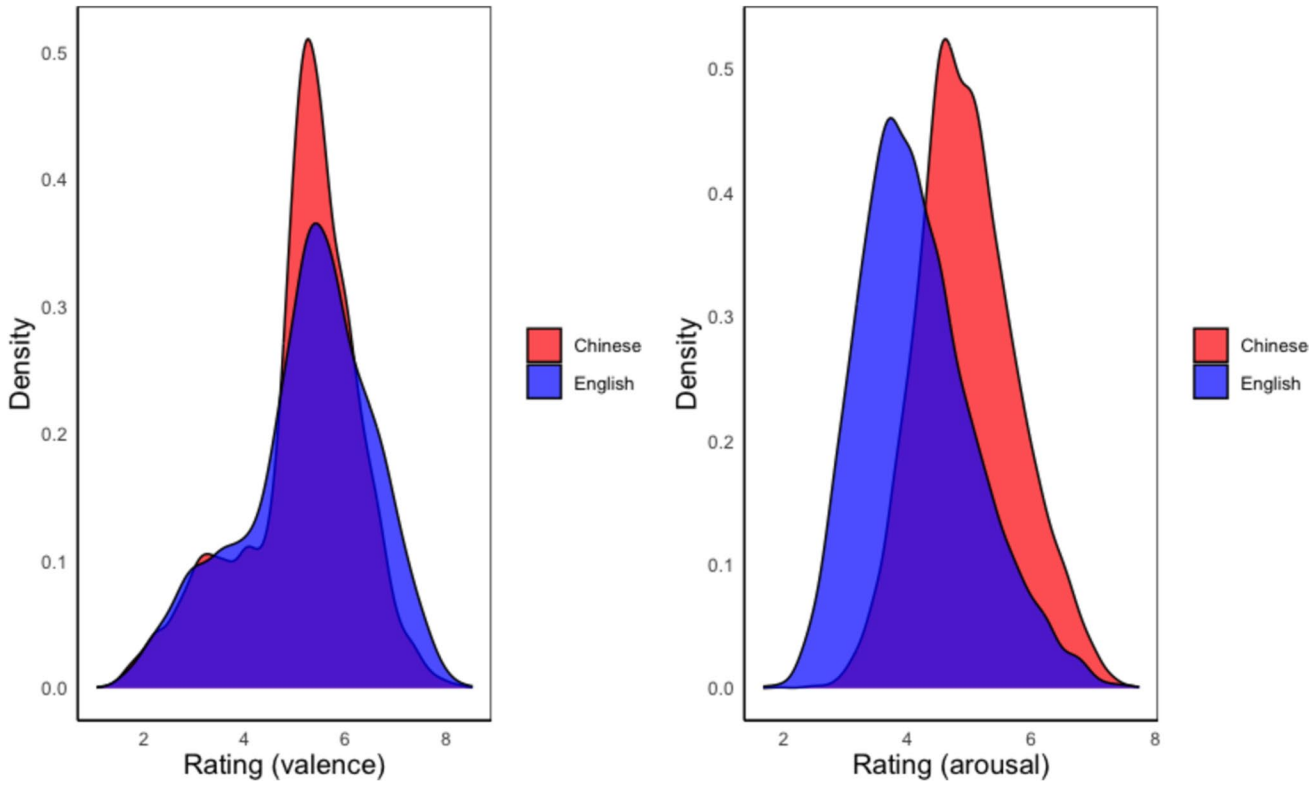

Fig. 2 Distributions of valence and arousal ratings for the Chinese words and their English translations in Warriner et al. (2013)

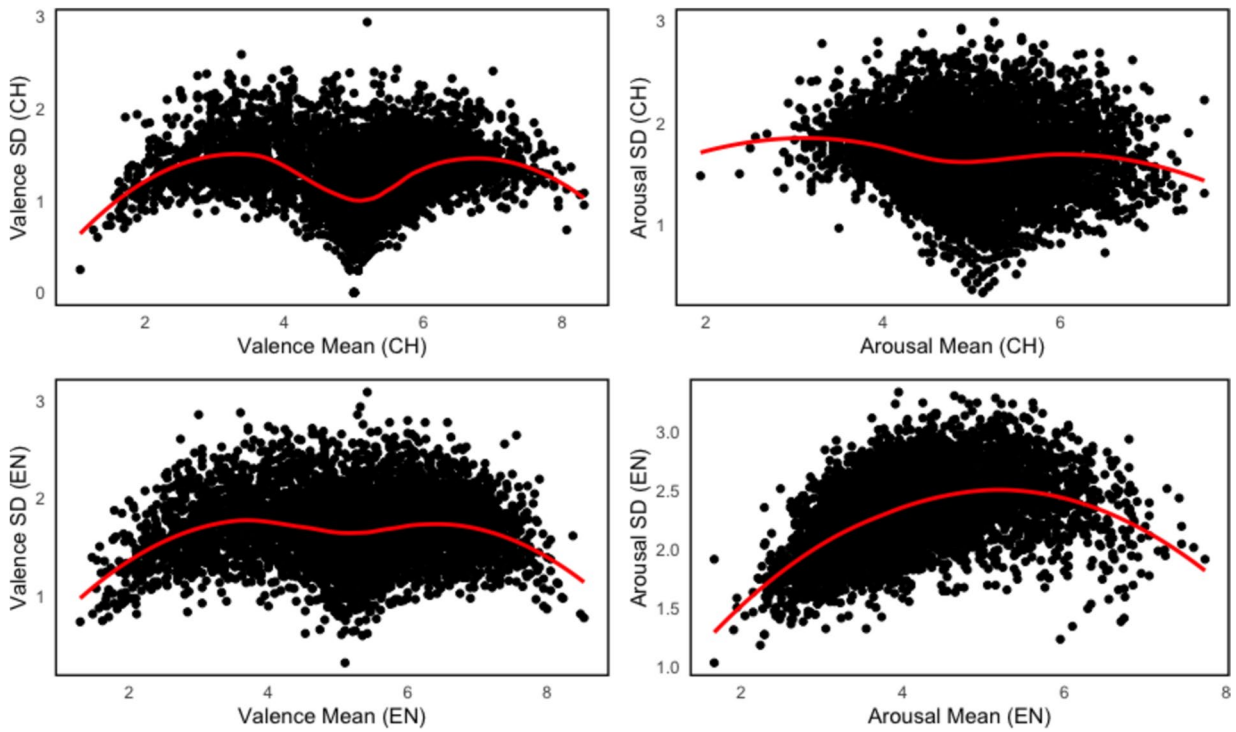

Fig. 3 Standard deviations of ratings for valence and arousal plotted against respective mean ratings for the Chinese words (top left and right) and their English translations (bottom left and right)

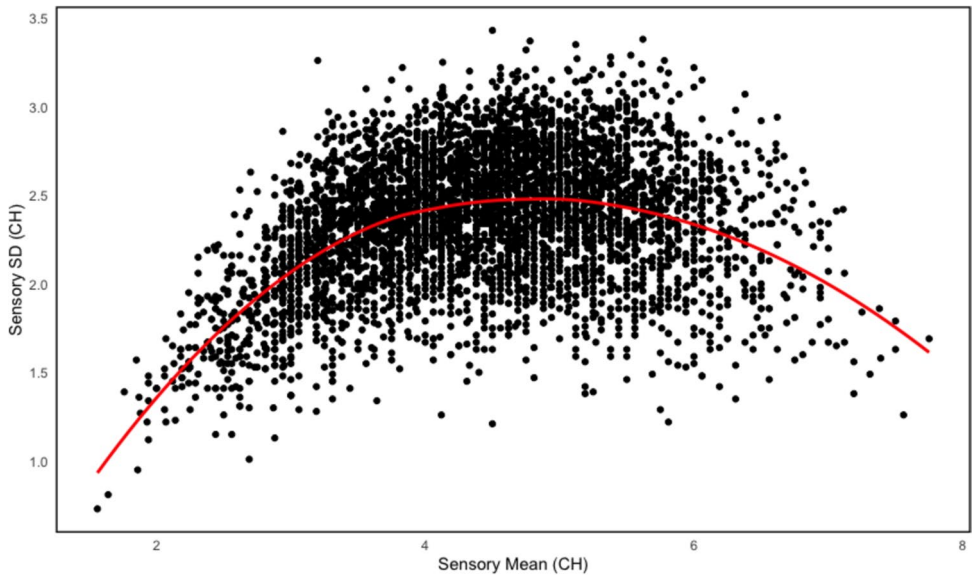

Fig. 4 Standard deviation of ratings for sensory experience plotted against the mean ratings for the Chinese words

emotions (Angry: 9 words; Sad: 44 words; Fear: 30 words; Hatred: 81 words; Disappointment: 11 words; Criticism: 270 words). Overall, as illustrated in Figs. 5 and 6, each emotion category demonstrates unique characteristics in terms of valence and arousal. For instance, the distribution of the "Happy" class, marked in orange, predominantly clusters in the high-valence range (5 – 8), with corresponding arousal ratings primarily in the middle to high range (3–6). This indicates that words associated with happiness are perceived as highly positive and moderately to highly arousing. The "Praise" class, depicted in purple, spans a high valence range (5–8), with arousal ratings variably extending from moderate to high (3–6). This suggests that words of praise are viewed positively and can vary significantly in arousal, potentially reflecting the intensity of the praise. Regarding negative emotions, for instance, words in the "Angry" class (marked

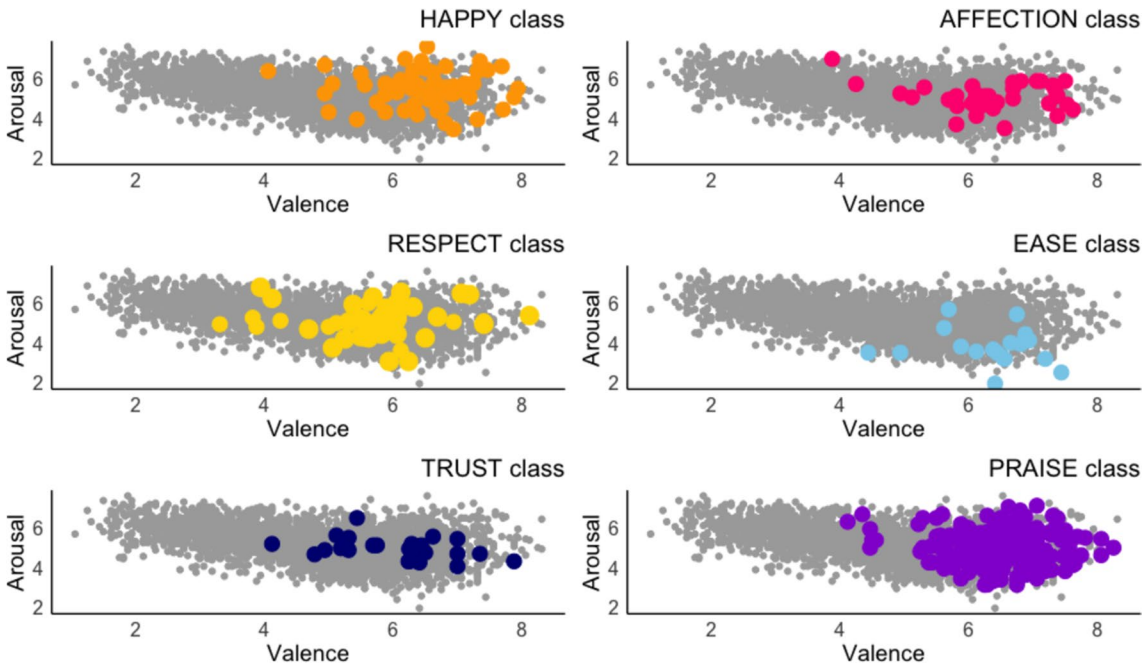

Fig. 5 Distribution of valence and arousal ratings for positive emotion categories of the Chinese words

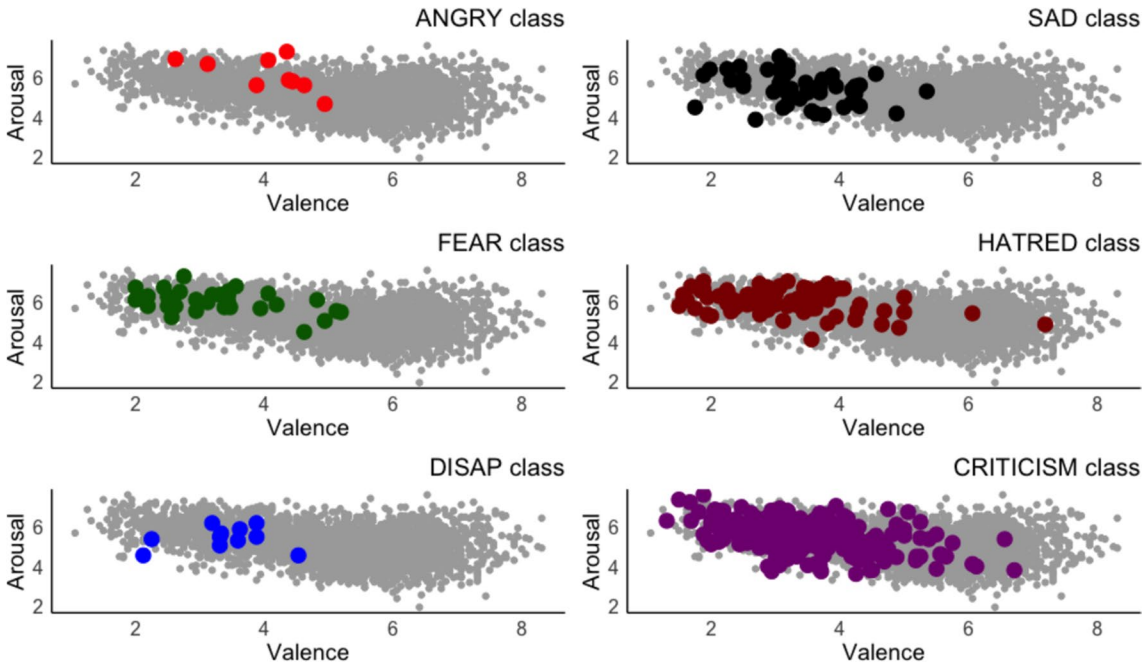

Fig. 6 Distribution of valence and arousal ratings for negative emotion categories of the Chinese words

in red) cluster predominantly in the low valence area (2–5), with moderate to high arousal levels (4–6). This suggests that anger-related words are perceived as highly negative and evoke a moderate to high level of emotional arousal. In comparison, the "Disappointment" category shows a moderate to low valence (2–4), with low arousal levels (2–3), suggesting words associated with disappointment are seen as negative but relatively less arousing, depicting a more subdued emotional state.

Reliability

To evaluate the reliability of the valence and arousal ratings in the current study, we compared our ratings with those collected in previous studies. For valence ratings, 2654 Chinese words in our study were also included in Xu et al. (2022), and the correlation between our valence ratings and those in Xu et al. (2022) was relatively high ($r = 0.84$, $p < 0.001$). A high correlation was found between our arousal ratings and those collected by Xu et al. (2022), with a correlation coefficient $r = 0.63$, $p < 0.001$. We also computed the correlation between our valence and arousal ratings for the 4923 Chinese words and the ratings collected for their English translations by Warriner et al. (2013). Moderate to high correlations were observed: the correlation for valence ratings was $r = 0.72$, $p < 0.001$, whereas the correlation for arousal ratings was $r = 0.50$, $p < 0.001$. As can be seen, valence ratings in our study aligned more closely with previous studies than arousal ratings. Similar patterns have been observed by Warriner et al. (2013), Xu et al. (2022), and Yao et al. (2017), who also reported that the reliability of arousal ratings—measured through inter-rater reliability or split-half reliability—tends to be lower than that of valence ratings. This difference is likely due to the more subjective and context-dependent nature of arousal. Valence ratings typically involve clearer positive or negative judgments, whereas arousal might be more influenced by individual interpretations and emotional states, leading to greater variability in ratings.

Correlations between dimensions

We conducted correlation analyses on the valence, arousal, and sensory experience ratings for the Chinese words in our dataset. Specifically, we found a weak negative correlation between valence and arousal ratings, suggesting that words perceived as more positive tend to be rated as less arousing. The correlation between valence and sensory experience was nonsignificant. However, arousal and sensory experience ratings exhibited a weak but positive correlation, suggesting that more arousing words are more likely to invoke stronger sensory experiences.

To further dissect these relationships, we divided the 4923 Chinese words into positive (valence ratings: 7–9, 141 words) and negative categories (valence ratings: 1–3, 346 words) based on their average valence ratings and analyzed the correlations within each category. The analysis yielded distinct correlational patterns for positive versus negative

words. For positive words, the correlation between valence and arousal ratings was not significant. However, negative words showed a weak but significant negative correlation between valence and arousal ratings. Such correlational patterns can also be observed in Fig. 7. Regarding the sensory experience, positive words showed a weak positive correlation with valence, but for negative words, the correlation between valence and sensory experience was weak and negative. Furthermore, the correlation between sensory experience and arousal was slightly stronger for negative words than for positive words (see Table 2 for the correlation coefficients).

Correlations with lexical properties

We computed Spearman correlations between ratings of valence, arousal, and sensory experience for the Chinese words with the number of syllables, number of strokes of the characters within each word, and lexical properties retrieved from previous studies. These lexical properties included imageability (retrieved from Su et al., 2023b), familiarity (retrieved from Su et al., 2023a), concreteness (retrieved from Xu & Li, 2020), frequency (retrieved from Tsang et al., 2018, and the Modern Chinese Corpus), and age of acquisition (retrieved from Xu et al., 2021). Out of the 4923 Chinese words, 1554 were shared with previous studies (nouns: 766; verbs: 541; adjectives: 240; adverbs: 6; pronouns: 1), and the correlations between valence, arousal, and sensory experience ratings with lexical properties were computed based on these observations. As can be seen in Fig. 8, distinct correlation patterns were revealed. Overall, valence, arousal, and sensory experience ratings correlated weakly with lexical properties. For valence, negative correlations were found with the number of strokes ($r = -0.05$, $p < 0.001$), concreteness ($r = -0.05$, $p < 0.001$), and age of acquisition ($r = -0.18$, $p < 0.001$), and positive correlations were found with frequency (for frequency based on Tsang and colleagues, $r = 0.15$, $p < 0.001$; for frequency based on the Modern Chinese Corpus, $r = 0.15$, $p < 0.001$), imageability ($r = 0.06$, $p < 0.001$), and familiarity ($r = 0.21$, $p < 0.001$). For arousal, negative correlations were found with familiarity ($r = -0.07$, $p < 0.001$), imageability ($r = -0.09$,

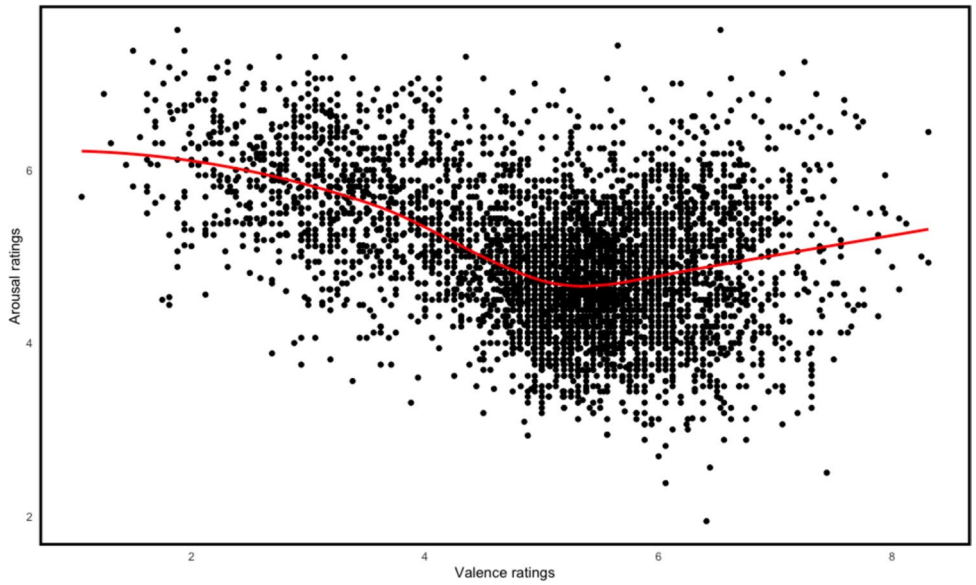

Fig. 7 Correlations between valence and arousal ratings of the Chinese words

Table 2 Correlations between valence, arousal, and sensory experience ratings for positive and negative Chinese words

	Overall			Positive words only			Negative words only		
	Valence	Arousal	Sensory	Valence	Arousal	Sensory	Valence	Arousal	Sensory
Valence	1			1			1		
Arousal	−0.29*	1		0.09	1		−0.20*	1	
Sensory	0.06	0.21*	1	0.22*	0.16*	1	−0.10*	0.20*	1

* $p < 0.05$

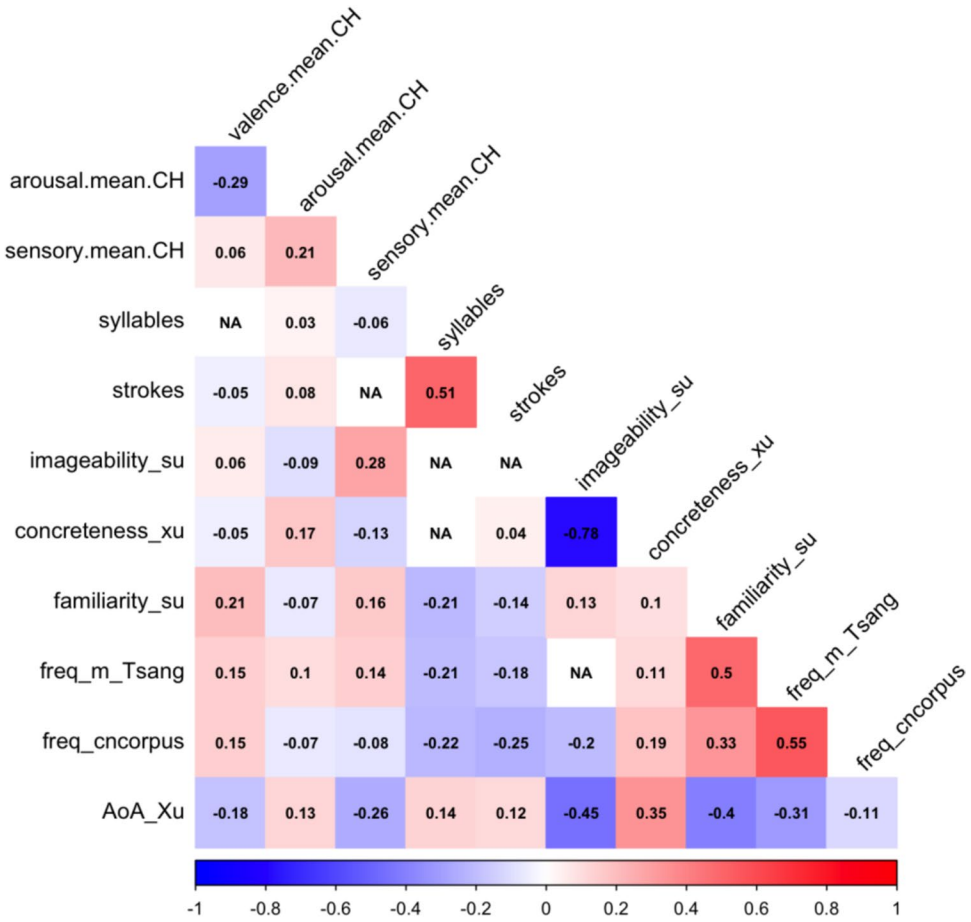

Fig. 8 Correlations between valence, arousal, and sensory experience ratings and lexical properties (NA denotes nonsignificant correlations.)

$p < 0.001$), and frequency based on the Modern Chinese Corpus ($r = -0.07$, $p < 0.001$), and positive correlations were found with number of syllables ($r = 0.03$, $p < 0.001$), number of strokes ($r = 0.08$, $p < 0.001$), concreteness ($r = 0.17$, $p < 0.001$), age of acquisition ($r = 0.13$, $p < 0.001$), and frequency based on Tsang and colleagues ($r = 0.01$, $p < 0.001$). For sensory experience, negative correlations were found with frequency obtained from the Modern Chinese Corpus ($r = -0.08$, $p < 0.001$), number of syllables ($r = -0.06$, $p < 0.001$), concreteness ($r = -0.13$, $p < 0.001$), and age of acquisition ($r = -0.26$, $p < 0.001$), and positive correlations were found with imageability ($r = 0.28$, $p < 0.001$), familiarity ($r = 0.16$, $p < 0.001$), and frequency obtained from Tsang and colleagues ($r = 0.14$, $p < 0.001$).

Regression analysis

To investigate the influence of valence, arousal, sensory experience, and other lexical properties on lexical processing, we fitted a linear regression model using the aforementioned variables to predict reaction time collected from a lexical decision task by Tsang et al. (2018). A total of 1894 words were used for the linear regression analysis (nouns: 911; verbs: 633; adjectives: 298; adverbs: 6; pronouns: 1). Both reaction time and the predictors were standardized. The final model explained approximately 19% of the variance (multiple R^2: 0.194; adjusted R^2: 0.191). The analysis revealed significant effects for all predictors except concreteness and number of syllables, which were therefore removed from the final model. Specifically, valence, arousal, sensory experience, familiarity, and frequency were negatively associated with reaction time. This suggests that Chinese words perceived as more pleasant, more arousing, more familiar, more frequent, and those that activate more sensory experiences are processed faster. By contrast, number of strokes, imageability and age of acquisition were positively associated with reaction time, indicating that Chinese words that are visually more complex, more imageable, and acquired later are processed more slowly.

To assess the unique variance in lexical decision time explained by valence, arousal, and sensory experience, we also conducted a hierarchical regression. The baseline model included the lexical properties described in the previous section. Before running the analysis, we evaluated

multicollinearity among the predictors by calculating variance inflation factor (VIF) values. We found that both concreteness (VIF = 3.1) and imageability (VIF = 3.3) had VIF values greater than 3.0, indicating moderate multicollinearity. Additionally, we observed that the number of syllables exhibited little variability and did not contribute unique information to the baseline model. Therefore, we removed the number of syllables from the baseline model. Given that concreteness and imageability represent conceptually distinct constructs, we residualized imageability with respect to concreteness and included the residualized variable in the regression model. The baseline model explained 17.2% of the variance in lexical decision time. Adding valence and arousal increased the explained variance to 18.8%, with a ΔR^2 of 1.6%. Including sensory experience in the updated model further increased the explained variance to 19.4%. Both additions were small but statistically significant ($p < 0.001$), suggesting that valence, arousal, and sensory experience provide unique predictive value beyond lexical properties in explaining lexical decision time Table 3.

Cross-cultural comparisons

To examine cross-cultural differences in the perception of emotion between Chinese and English speakers, we ranked valence and arousal ratings for the Chinese words in our dataset and their English translations from Warriner et al. (2013). We listed the top 25 words with the highest valence ratings in both Chinese and English and present them in Table 4. Additionally, we listed the top 25 words with the highest arousal ratings in both languages and present them in Table 5.

As shown in Table 4, highly valenced English words include terms expressing positive emotions and feelings (e.g., happiness, smile), positive personal qualities or relationships (e.g., honest, lover), and celebrations and vacations (Christmas, vacation). This category also encompasses words related to rewards or benefits (prize, bonus) and pleasant places, weather, or food (e.g., oasis, sunny, pizza). Similarly, highly valenced Chinese words include terms that express positive emotions and personal qualities (e.g., comfortable, modest), achievements or success (e.g., success, medal), and pleasant food or places (candy, home). Notably, Chinese native speakers also assigned high valence ratings to words representing positive values and ideals (e.g., freedom, peace), as well as family and national identity (e.g., home, patriotic). Among the top-ranked valenced words, only the translation pair "vacation-假期" was shared between English and Chinese.

Regarding arousal ratings, as shown in Table 5, words that received high arousal ratings in English include terms related to violence and crime (e.g., gun, murderer), natural disasters, accidents, and health conditions (e.g., tornado, shipwreck, diarrhea), as well as romantic and sexual experiences (e.g., lover, sex), and rewards (money, bonus). Similarly, highly arousing words as perceived by Chinese native speakers also included terms representing crimes and misconduct (e.g., treason, aggressor), natural disasters, accidents, or health conditions (e.g., amputate, tumor), sexual experiences (adulterer, aphrodisiac), and rewards (e.g., money). Uniquely, highly arousing words in Chinese also included terms expressing negative personal qualities or situations (e.g., ungrateful, unemployment). Among the top-ranked arousing words, the following translation pairs were shared between English and Chinese: arsonist-纵火犯; rape-强奸; terrorist/terrorism-恐怖主义/恐怖分子; money-钱.

To decipher potential differences in the perception of emotion between Chinese and English speakers, we filtered our dataset and selected English-Chinese translation pairs that received discrepant valence and arousal ratings. Specifically, we focused on pairs with a difference in valence or arousal ratings of at least two points. This included Chinese words receiving valence or arousal ratings that were no less than two points higher or lower than their English translations, and vice versa. Overall, 88 Chinese words received valence ratings that were no less than two points lower than their English translations, 54 Chinese words received valence ratings that were no less than two points higher than their English translations, three Chinese words received arousal ratings that were no less than two points lower than their English translations, and 368 Chinese words received arousal ratings that were at least two points higher than their English translations.

We then randomly selected 55 Chinese words that received significantly higher arousal ratings than their English translations and plotted the data points as two scatterplots (Figs. 9 and 10), showing the distribution of valence and arousal ratings for the total of 200 words that fall into the aforementioned categories. As illustrated in Figs. 9 and 10, three Chinese words received much lower

Table 3 Regression analysis results

	Estimate	*SE*	*t*
Intercept	−0.462	0.005	−96.261***
Valence	−0.025	0.004	−5.795***
Arousal	−0.016	0.005	−3.487***
Sensory	−0.018	0.005	−3.775***
Strokes	0.032	0.005	6.236***
Imageability	0.013	0.005	2.695***
Familiarity	−0.071	0.006	−11.360***
Frequency	−0.018	0.005	−3.955***
Age of acquisition	0.028	0.005	5.136***

3074 observations were deleted due to missingness. Multiple R^2: 0.1941. Adjusted R^2: 0.1906. ***: $p < 0.001$

Table 4 Highly valenced words in English vs. Chinese

English word	Chinese translation	Valence rating in English	Chinese word	English translation	Valence rating in Chinese
vacation	假期	8.53	妈妈	mom	8.31
happiness	幸福	8.48	祖国	motherland	8.31
Christmas	圣诞节	8.37	优秀	outstanding	8.25
magical	神奇	8.23	尊重	respect	8.12
joyful	欢乐	8.21	杰作	masterpiece	8.06
honest	诚实	8.16	美好	nice	8.06
sunshine	阳光	8.14	母亲	mother	8.00
bonus	奖金	8.05	幸运	lucky	7.94
laughter	笑声	8.05	奖章	medal	7.94
comedy	喜剧	8.05	自由	freedom	7.92
lover	情人	8.05	乐观	optimistic	7.88
love	爱	8.00	妈咪	mommy	7.88
oasis	绿洲	8.00	信任	trust	7.88
prize	奖	8.00	精通	mastery	7.81
live	活着	7.95	糖果	candy	7.76
faithful	忠实	7.95	假期	vacation	7.75
sunny	晴朗	7.95	可爱	lovely	7.75
wisdom	智慧	7.94	无忧无虑	carefree	7.71
pizza	披萨	7.89	金条	bullion	7.71
smile	微笑	7.89	成功	success	7.69
joke	笑话	7.88	爱国	patriotic	7.69
rest	休息	7.86	家	home	7.67
winner	赢家	7.86	舒适	comfortable	7.65
create	创造	7.86	和平	peace	7.62
sweetheart	甜	7.84	谦虚	modest	7.62

arousal ratings than their English translations: 欣慰 (pleasure), 银河系 (galaxy), and 生活 (life). By contrast, a group of Chinese words received significantly higher arousal ratings than their English translations, including words related to military (军队-army, 刺刀-bayonet), health (e.g., 眩晕-vertigo), religion (e.g., 拯救-salvation), food and drinks (肉汤-broth, 茶-tea), business and economics (e.g., 赚-earn, 股东-shareholder), and nature (e.g., 池塘-pond, 大海-sea).

Regarding the perception of valence in emotion, Chinese words receiving much higher valence ratings than their English translations include those describing violence and war (e.g., 攻击-attack, 战舰-warship), political concepts (e.g., 立法-legislation, 政治家-politician), and health and body (水泡-blister, 锁骨-clavicle). Conversely, some Chinese words received significantly lower valence ratings than their English translations, including words representing concepts related to finance and commerce (e.g., 美元-dollar, 退款-refund), immoral or criminal acts (e.g., 偷看-peek, 盗版-piracy), holidays (圣诞节-Christmas), and political or religious concepts (殖民地-colony, 红衣主教-cardinal).

Discussion

This study reports the valence, arousal, and sensory experience ratings of 4923 Chinese words translated from their English equivalents as listed in Warriner et al. (2013). The reliability of these ratings was established through correlation analyses with prior studies (Warriner et al., 2013; Xu et al., 2021). Descriptive statistics indicate that the distributional patterns of valence and arousal ratings for the Chinese words are consistent with their English counterparts from Warriner et al. (2013). For both positive and negative emotion categories, variations were observed in the distribution of valence and arousal ratings. Our correlation analyses revealed that while valence and arousal ratings were not associated for positive words, a weak negative association existed for negative words. Sensory experience ratings exhibited a weak correlation with both valence and arousal ratings across positive and negative words. Specifically, sensory experience ratings correlated positively with both valence and arousal for positive words, but correlated negatively with valence and positively with arousal for negative

Table 5 Highly arousing words in English vs. Chinese

English word	Chinese translation	Arousal rating in English	Chinese word	English translation	Arousal rating in Chinese
gun	枪	7.74	叛国	treason	7.62
sex	性	7.60	狂欢	revel	7.62
lover	情人	7.45	过山车	rollercoaster	7.44
tornado	龙卷风	7.45	折磨	torment	7.38
terrorism	恐怖主义	7.42	忘恩负义	ungrateful	7.38
erotic	情色	7.27	纵火犯	arsonist	7.31
penetration	插入	7.25	致命	fatal	7.31
rape	强奸	7.24	惊悚片	thriller	7.31
seduction	诱惑	7.16	爆发	burst	7.31
attack	攻击	7.05	钱	money	7.25
frostbite	冻伤	7.05	诱拐	abduct	7.25
mafia	黑手党	7.05	奸夫	adulterer	7.25
killer	杀手	7.05	战争	war	7.19
bullshit	瞎扯	7.00	截肢	amputate	7.19
naughty	顽皮	6.95	肿瘤	tumor	7.19
arsonist	纵火犯	6.95	艾滋病	AIDS	7.19
spider	蜘蛛	6.91	流产	abortion	7.13
bonus	奖金	6.90	奖学金	scholarship	7.12
money	钱	6.86	失业	unemployment	7.12
grenade	手榴弹	6.86	酗酒	alcoholism	7.12
arrest	逮捕	6.86	强奸	rape	7.06
shipwreck	海难	6.85	侵略者	aggressor	7.06
diarrhea	腹泻	6.85	冒险	adventure	7.06
climax	高潮	6.83	恐怖分子	terrorist	7.06
murderer	凶手	6.83	春药	aphrodisiac	7.06

words. The analysis also identified weak but significant correlations between valence, arousal, sensory experience ratings, and various psycholinguistic variables, including number of syllables, number of strokes, imageability, familiarity, concreteness, frequency, and age of acquisition. Regression analysis further demonstrated that these ratings, along with psycholinguistic variables, significantly predicted visual word recognition, as indicated by lexical decision time retrieved from Tsang et al. (2018). Cross-cultural comparisons of valence and arousal ratings between Chinese words and their English equivalents highlighted both similarities and differences in emotional perception, with most differences attributable to ecological or sociopolitical factors.

Previous studies have reported that valence and arousal ratings are correlated for both positive and negative words, with the relationship between these ratings being U-shaped for English words (Citron et al., 2014; Warriner et al., 2013) and for Chinese words (Xu et al., 2021; Yao et al., 2017). Specifically, words that are either positive or negative are more arousing than those that are neutral. Our study partially replicates this U-shaped relationship between valence and arousal. This pattern was corroborated by the significant correlation found between valence and arousal ratings for negative words. However, no significant correlation between valence and arousal was found for positive words, which may largely be due to the limited number of highly valenced words included in our sample (see Fig. 7).

Sensorimotor information deeply influences our physical experience and linguistic knowledge about the world. In recent years, a growing number of researchers have begun to collect sensory experience ratings for words (e.g., Bonin et al., 2015; Diez et al., 2019; Juhasz & Yap, 2013; Muraki et al., 2022; Wu & Mu, 2024), which are thought to reflect the extent to which a word evokes an actual sensation (taste, touch, sight, sound, or smell) experienced when reading the word. Sensory experience ratings are not limited to a single sensation. Thus, they can establish the link between lexical-semantics and embodied cognition across different sensory/perceptual modalities. Regarding the relationship between sensory experience and emotion, Diez et al. (2019) found that sensory experience ratings correlated positively with valence ($r = 0.11$) and arousal ($r = 0.25$) for Spanish

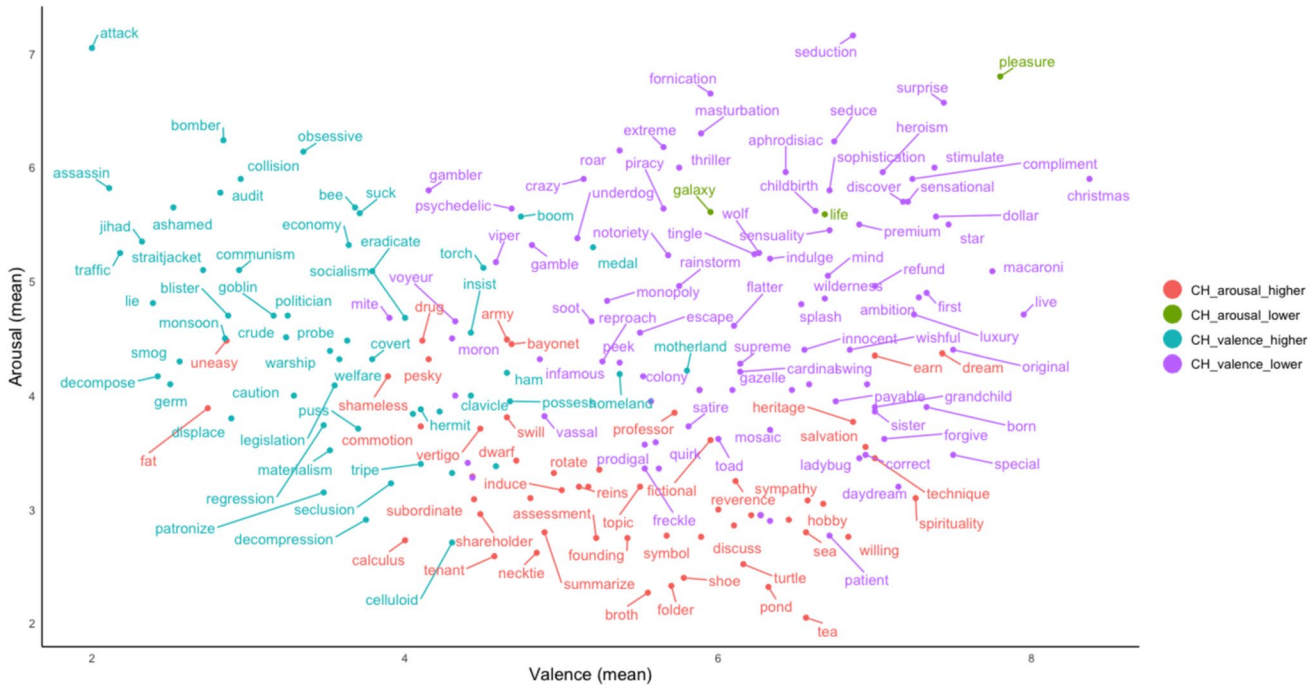

Fig. 9 Discrepancies in valence and arousal ratings between English words and their Chinese translations (*X*- and *Y*-axis represent ratings for English words in Warriner et al., 2013. CH: Chinese)

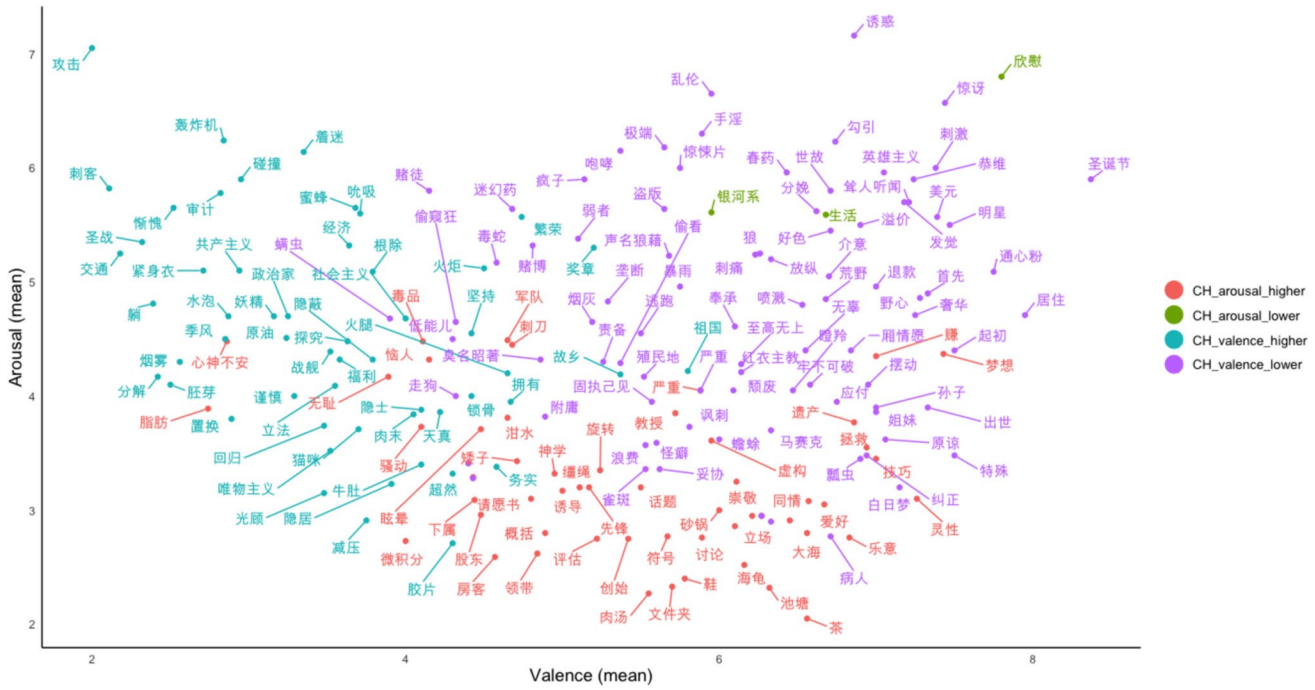

Fig. 10 Discrepancies in valence and arousal ratings between Chinese words and their English translations (*X*- and *Y*-axis represents ratings for English words in Warriner et al., 2013. CH: Chinese)

words. Similarly, Muraki et al. (2022) found that sensory experience correlated with valence ($r = 0.09$) and arousal ($r = 0.23$) for English words. To the best of our knowledge, Wu and colleagues (Wu & Mu, 2024) are the first to collect sensory experience ratings for Chinese words. Except for a negative correlation with valence ratings retrieved from

Xu et al. (2022), they did not find evidence indicating that sensory experience is associated with emotion. In our study, we partially replicated the findings reported in Spanish and English, with positive correlations found between sensory experience and valence, as well as between sensory experience and arousal, among positive words. However, for negative words, similar to Wu and Mu (2024), we found that sensory experience ratings correlated negatively with valence, which suggests that more negative words are likely to evoke a stronger sensational experience. To verify such patterns, more studies (especially Chinese studies) should be conducted to collect sensory experience and emotion ratings to examine their relationship. Additionally, future studies should carry out correlational analysis between sensory experience and emotional valence and arousal by splitting materials into positive and negative words.

Regarding the relationship between emotion and other psycholinguistic variables, our study replicated most of the findings reported in previous studies. Earlier research indicated that highly valenced positive words tend to be less concrete (Hinojosa et al., 2016; Warriner et al., 2013), more vivid in mental imagery (Citron et al., 2014), more frequent (Hinojosa et al., 2016; Warriner et al., 2013), and more familiar to language users than negative words. Our results confirmed these outcomes, as evidenced by positive correlations between valence and imageability, frequency, and familiarity, alongside a negative correlation between valence and concreteness. The relationship between emotional arousal and psycholinguistic variables presents a more complex picture. Previous studies (Citron et al., 2014; Yao et al., 2017) reported that highly arousing words are more familiar to language users than less arousing words. However, our findings contradict this, showing a negative association between arousal ratings and familiarity ratings retrieved from Su et al. (2023a). Regarding the relationship between arousal and variables such as concreteness, imageability, and frequency, research findings have been inconsistent. For example, some studies have found that highly arousing words are more imageable than less arousing words (Citron et al., 2014), while others, such as Monnier and Syssau (2014), observed the opposite. In line with Monnier and Syssau (2014), we found a negative correlation with imageability ratings, suggesting that more arousing words are less imageable. Yao et al. (2017) found that highly arousing words tend to be less concrete. However, we observed a positive correlation between arousal ratings (from Su et al., 2023a) and concreteness ratings (from Xu et al., 2021), indicating that more arousing words might be more concrete. Moreover, counterintuitively, we found a strong negative correlation between concreteness and imageability ($r = -0.78$). After reevaluating the rating instructions for concreteness in Xu and Li (2020) and for imageability in Su et al. (2023b), it was discovered that the numerical scale used by Xu and colleagues is reversed compared to that of Su and colleagues., with a range from "very concrete" to “very abstract” (instead of from “very abstract” to “very concrete”). Thus, the negative correlation between concreteness and imageability actually reflects a positive relationship between these two variables, and the seemingly inconsistent negative correlation between arousal and concreteness is aligned with previous findings, indicating that more arousing words in this study are indeed less concrete. For frequency, previous studies have shown that highly arousing words are less frequent than less arousing words (Hinojosa et al., 2016), and our results confirmed this pattern. Finally, little research has examined the relationship between emotion and age of acquisition. We found a negative correlation between valence and age of acquisition, and a positive correlation between arousal and age of acquisition. To validate these findings, further studies will be needed.

Our study identified correlations between sensory experience ratings of Chinese words and various linguistic attributes. Specifically, we found positive correlations with familiarity ($r = 0.16$) and imageability ($r = 0.28$), and a negative correlation with age of acquisition ($r = -0.26$). These results suggest that words evoking stronger sensory experiences are typically more familiar, more imagery-provoking, and acquired earlier. Our findings regarding the relationship between sensory experience and familiarity replicate previous studies on Spanish (Diez et al., 2019) and English words (Juhaz et al., 2015). Similarly, our findings are consistent with previous research on imageability across various languages, including English (Juhasz et al., 2015; Pexman et al., 2019), Spanish (Diez et al., 2019), French (Bonin et al., 2015), and Chinese (Wu & Mu, 2024). Additionally, our findings on the association between sensory experience and age of acquisition are consistent with previous studies (Diez et al., 2019; Juhasz et al., 2015; Pexman et al., 2019; Wu & Mu, 2024). Previous research indicates a positive correlation between sensory experience and concreteness (Diez et al., 2019; Muraki et al., 2022; Pexman et al., 2019); however, our study found a negative association. As mentioned in our manuscript, the concreteness ratings scale in Xu and Li (2020) was reversed, with 1 indicating “very concrete” and 5 indicating “very abstract.” Therefore, our finding of a negative association between concreteness and sensory experience ($r = -0.13$) actually aligns with previous findings. Regarding the relationship between sensory experience and word frequency, some studies report negative correlations (Bonin et al., 2015; Pexman et al., 2019; Wu & Mu, 2024), while others (e.g., Diez et al., 2019) report positive correlations. In our study, depending on the corpus used to measure word frequencies, both positive and negative correlations were observed. This suggests that the choice of corpus may influence the relationship between sensory experience and word frequency.

We conducted a regression analysis incorporating valence, arousal, sensory experience, and other psycholinguistic

variables as predictors of standardized reaction time, using data from Tsang et al. (2018) in a lexical decision task. The model accounted for a significant portion of the variance in word recognition latency (19%). Moreover, our hierarchical regression model suggests that valence, arousal, and sensory experience made significant contributions to word recognition, in addition to lexical properties such as the number of strokes, imageability, concreteness, frequency, and age of acquisition of individual words. Our findings reveal that both valence and arousal negatively affect word recognition speed: words perceived as more pleasant or more arousing are processed faster than those that are less so. These results align with previous studies on the impact of valence in word recognition (Kuperman et al., 2014; Yao et al., 2017). However, our findings diverge from those of Yao et al. (2017), who reported no significant influence of arousal, and from Kuperman et al. (2014), who observed that highly arousing words are recognized more slowly than calming ones. Regarding sensory experience, earlier research (Bonin et al., 2015; Juhasz et al., 2011) indicates that words with higher sensory experience ratings are associated with faster reaction time in lexical decision tasks. In contrast, Wu and Mu (2024) did not find a significant effect of sensory experience on prediction of lexical decision latencies. Our data confirm the observations of Juhasz et al. (2011) and Bonin et al. (2015), suggesting that sensory information plays an active role during word processing, and that the recognition of a visual word entails accessing sensory representations. Additionally, our analysis confirms the significant roles of familiarity, frequency, and age of acquisition as predictors of lexical decision latency, supporting findings from previous studies (Su et al., 2023a, 2023b; Xu et al., 2022; Yao et al., 2017). Given that all predictors in our regression model were standardized, it is possible to compare their relative contributions directly, as shown by the regression coefficients. As can be seen in Table 3, familiarity, age of acquisition, and valence emerged as the most influential predictors, contributing significantly to the prediction of lexical decision latency.

This study is the first to systematically examine cross-cultural differences in emotion perception between Chinese and English speakers. Xu et al. (2022) analyzed the valence ratings for the top ten most positively and negatively perceived words in both languages, without considering arousal differences. Our research expanded their research by collecting both valence and arousal ratings for 4923 Chinese words and their English equivalents from Warriner et al. (2013), facilitating a comprehensive cross-linguistic comparison. We identified and analyzed the top 25 words with the highest valence and arousal in each language to better understand these cross-cultural differences. We observed similarities and distinct differences in emotional valence and arousal. Both Chinese and English speakers rated words linked to positive emotions, virtues, romantic relationships, celebrations, vacations, rewards, achievements, and pleasant environments as highly valenced. However, Chinese speakers assigned higher valence to words associated with positive ideals (freedom, peace, respect, trust), family and national identity (home, mom, motherland, patriotism), and political concepts (motherland, communism, socialism, welfare, legislation), and viewed words related to violence and conflict (e.g., attack, assassin, bomber, jihad, warship) as less negative. In terms of arousal, both groups found words associated with violence, crime, disasters, accidents, health conditions, and sexual experiences highly arousing. Moreover, Chinese speakers rated words linked to negative personal qualities (ungrateful, treason, alcoholism, unemployment), as well as military, health, religion, business, economics, and nature, as more arousing than their English counterparts. Our findings confirm significant cross-cultural differences in emotion perception, which can be attributed to differences in ecology, values, religious beliefs, and sociopolitical contexts.

Finally, this study has several limitations that may impact the reliability and generalizability of our ratings. First, all participants were college students. Previous research (e.g., Warriner et al., 2013) indicates that educational level can influence the perception of emotion. Therefore, the lack of diversity in educational background may limit the generalizability of our findings to a broader population. Second, the reliability of our ratings may be compromised for some words due to a limited number of responses (see *Data cleaning*). Lastly, cross-cultural comparisons in this study were made based on Chinese-English translation equivalents. However, certain English words can be translated into multiple Chinese synonyms (e.g., acquaintance: 相识, 熟人). Consequently, differences observed between Chinese and English in this study could also stem from variations in translation practices.

Conclusion

To conclude, this study provides subjective ratings of valence, arousal, and sensory experience for 4923 Chinese words translated from English in Warriner et al. (2013). Our database is a valuable resource for research exploring the impact of emotional and perceptual information on Chinese lexical processing, as well as for studies investigating cross-cultural differences in emotion perception between Chinese and English. Future research should extend our efforts by collecting emotional and sensory norms from a broader selection of Chinese words and from a variety of cultural backgrounds. Our database, instructions for collecting ratings, and R codes for analyses can be downloaded as supplementary materials from Open Science Framework at https://osf.io/vn9wc/?view_only=4a67691a0fef40a9b8f8ec7296c1e1da.

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Data availability The data for the experiment are available at https://osf.io/vn9wc/?view_only=4a67691a0fef40a9b8f8ec7296c1e1da.

Code availability R codes used in this study are available at https://osf.io/vn9wc/?view_only=4a67691a0fef40a9b8f8ec7296c1e1da.

Declarations

Conflicts of interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval Approval was obtained from the Ethics Committee of the authors' University. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent to participate All participants provided their informed consent to participate.

Consent for publication All participants signed informed consent regarding publishing their data.

Open practices statement The data for the experiment are available at https://osf.io/vn9wc/?view_only=4a67691a0fef40a9b8f8ec7296c1e1da. None of the experiments was preregistered.

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