Title.
Metaphor or Emotion: Image-based color associations among the senses of the Chinese color terms *hēi* 'black' and *bái* 'white'

Jinmeng Dou[1] & Meichun Liu[2]
[1]City University of Hong Kong, jmdou2-c@my.cityu.edu.hk
[2]City University of Hong Kong, meichliu@cityu.edu.hk

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Regarding embodied cognition, concepts are fundamentally grounded and anchored in the simulations of actual perceptual experience (Barsalou, 1999, 2008; Glenberg, 1997; Gibbs, 2005). Perceptual information includes sensory-motor and emotional experience (Barsalou, 1999, 2008). Regarding the multimodality of embodied perceptual experience, this study explores how conceptual metaphor and emotional experience interact with each other when representing abstract concepts with regards to the metaphorical uses of the two earliest-acquired Chinese color terms (CTs) *hēi* 'black' and *bái* 'white' (Berlin & Kays, 1969; Wu, 2011).

Methodologically, an image-based visual corpus analysis approach (Guilbeault et al., 2020) was adopted in the current study, which can represent target terms (concept) as eight-dimensional vectors (color distribution) based on the color information extracted from their Google Image searching results. Such color distribution can simultaneously capture the metaphorical mappings and affective associations among cross-domain concepts. Focusing on twenty-four concepts in three types of semantic domains (Table 1), a dataset consisting of 2400 images (100 images for each concept) was collected from Google Image. Based on the dataset, we investigated the perceptual (dis)similarity between the twenty-two literal and metaphorical meanings of *hēi* 'black' and *bái* 'white', and the influence of emotional valence on the degree of their perceptual (dis)similarity with several statistical techniques. Precisely, it includes (i) general observation of their distributional pattern with *t*-distributed stochastic neighbor embedding (Figure 1); (ii) examination of their emotional valence with Correspondence Analysis (Figures 2 & 3); (iii) visualization of their perceptual (dis)similarity employing Correspondence Analysis and Hierarchical Agglomerative Clustering (Figures 4 & 5).

Regarding the empirical results, three major findings were obtained: first, the metaphorical meanings of both *hēi* and *bái* tend to carry stronger emotionality than their literal senses; second, although most metaphorical meanings of *hēi* and *bái* tend to share consistent emotional valence with their corresponding literal senses, valence inconsistency does exist regarding pairs of literal and metaphorical meanings of *bái*; third, perceptual congruity is found between the literal and metaphorical meanings of *hēi*, so is the case of *bái*, and the distinctiveness of such congruity can be influenced by whether the pair of literal and metaphorical senses have consistent emotional valence.

In short, the current study not only provides non-linguistic evidence for the conceptual mapping relations between the literal and metaphorical meanings of *hēi* and *bái* via depicting their perceptual congruity, but also reveals the important but limited influence of emotional valence on such perceptual congruity - we cannot predict the existence or distinctiveness of perceptual congruity between pairs of literal and metaphorical senses only based on whether they have consistent emotional valence. It is noted that the second finding partly contradicted the theories of embodied abstract semantics (Vigliocco et al., 2009; Kousta et al., 2011), which argued that emotional experience plays a greater role in representing abstract concepts than sensory-motor information. Hence, the present study may also shed new light on the issues pertaining to the role of emotional experience in representing and understanding abstract concepts.

(1). Terms pertaining to the literal meanings of *hēi* and *bái*				
	Black		White	
(2). Terms pertaining to the metaphorical meanings of *hēi* and *bái*				
hēi	Angry	Evil	Illegal	Network attack
	Sullen	Malevolent	Underground	Hack
	Slander	Secret	Unfavorable	Unexpected
	Entrap	Mysterious	Bad	Surprising

bái	Acceptable Approved	Clear Transparent	Clarify Express	Empty Blank
	Free of charge Cost-free	In vain For no reason	Inexperience Untalented	Lawful Legal
	Ordinary Unflavored	Pure Clean	Sorrowful Woeful	Undisguised expression
(3). Terms of affective polarity				
	Morality		Immorality	
	Positivity		Negativity	

Table 1: Search terms in three semantic domains. Note: The metaphorical meanings and their corresponding terms were identified based on the relevant previous studies (Wu, 1986; Xing, 2008; Li & Bai, 2013; Lai & Chung, 2018) and the Contemporary Chinese Dictionary (7th ed.).

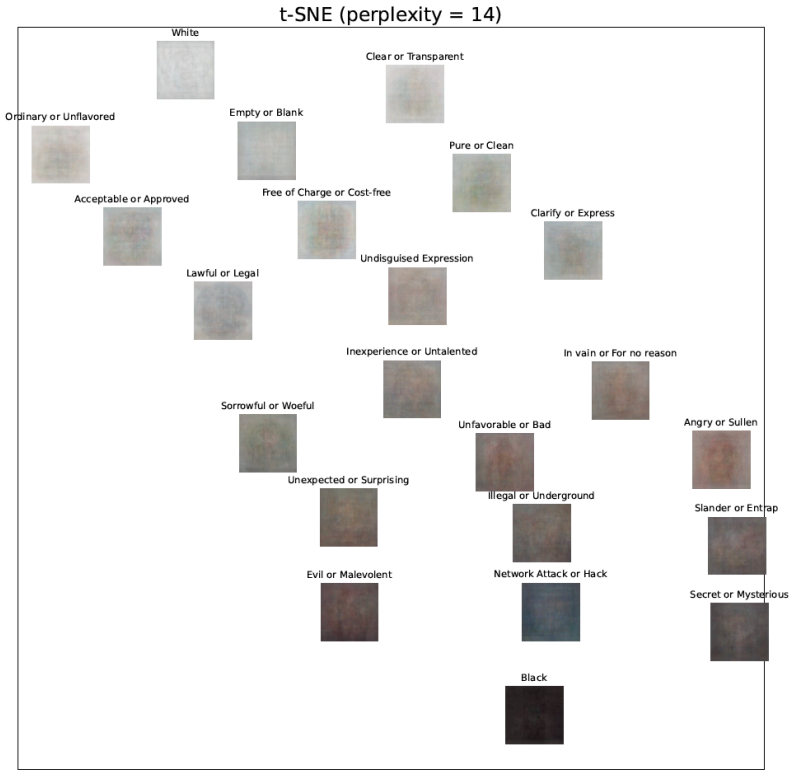


Fig. 1: t-SNE plots for color distribution data of the literal and metaphorical meanings of hēi and bái. Technically, meanings with similar color distributions would be neighbors with each other in this plot. The desired number of neighbors for each data point, perplexity, is set to 14 to get an ideal visualization of the t-SNE results. The data points were labeled with their corresponding search terms and colorgrams, defined as "a composite image produced by averaging the color value for each pixel across all images in a search term's image set" (Guilbeault et al. 2020: 5).

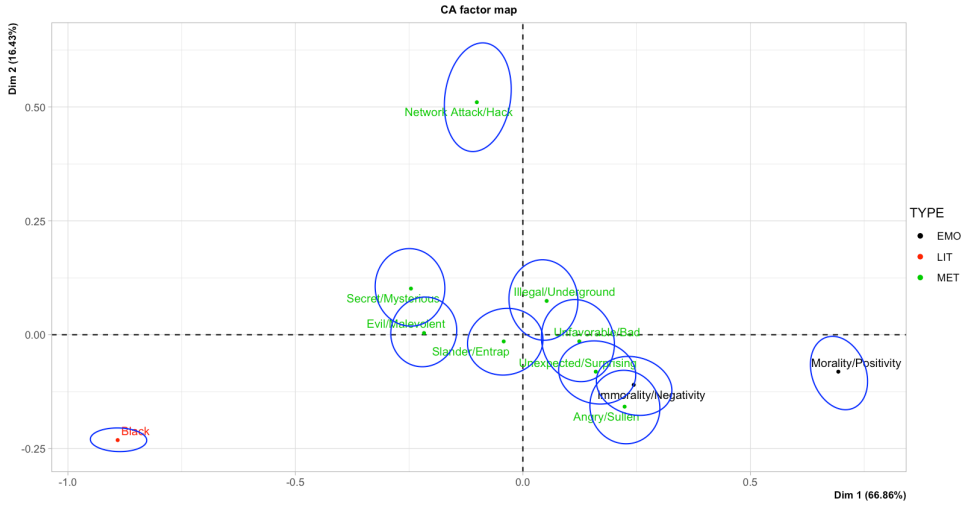


Fig. 2: Correspondence analysis (CA) biplot for the color distribution data of terms referring to the literal and metaphorical meanings of hēi, as well as the affective polarity. The positions of data points were predicated with 95% confidence ellipses. In a CA biplot, the smaller the proximity between two data points is, the stronger their association. A concept is regarded to be emotionally more positive if its corresponding data point has closer proximity with 'Morality/Positivity', while closer proximity with 'Immorality/Negativity' indicates negative valence.

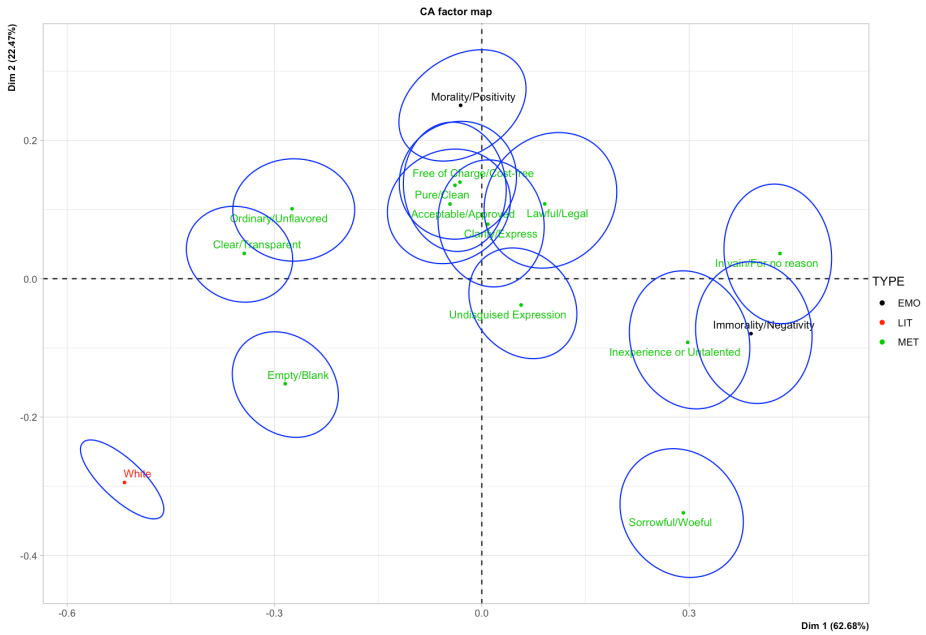
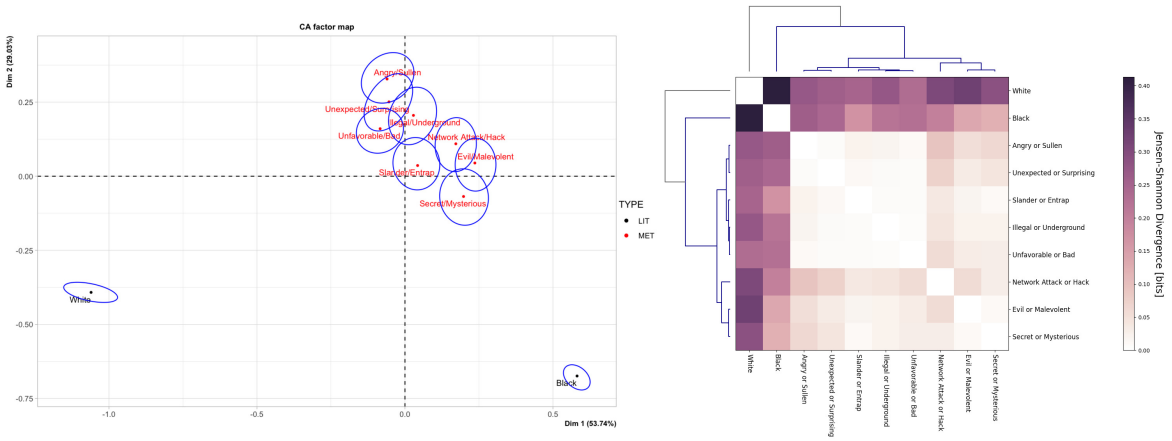
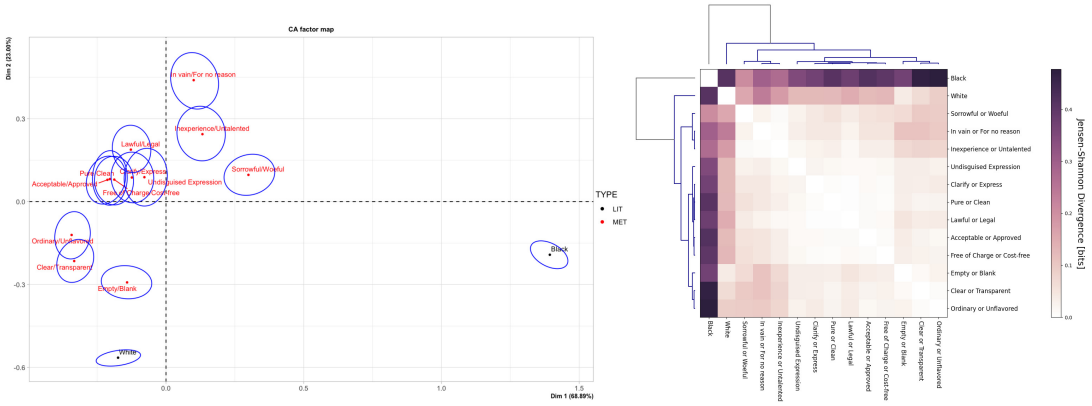


Fig. 3: Correspondence analysis biplot for the color distribution data of terms referring to the literal and metaphorical meanings of bái, as well as the affective polarity.



A **B**

Fig. 4: Correspondence analysis biplot (A) and clustering dendrogram (B) for the eight metaphorical meanings of hēi and the two literal meanings of hēi and bái. For (A), terms referring to literal meanings were colored in Black, while metaphorical meanings were Red. For (B), the clustering results were calculated with the ward method based on the distance matrix that consists of the Jensen-Shannon (JS: Guilbeault et al., 2020) divergency values between pairs of terms' color distributions. The clustering results were visualized as a dendrogram, and JS divergency values were represented as a heatmap. Lower JS values correspond to more similar color distributions in the perceptually uniform colorspace.



A **B**

Fig. 5: Correspondence analysis biplot (A) and clustering dendrogram (B) for the twelve metaphorical meanings of bái and the two literal meanings of hēi and bái

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