Hypothesis

A Proposal for Cross-Modal Correlations Between Corpus and Image Data on Exploring Embodiment of Chinese Color Metaphor

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Abstract

The research aims to investigate a salient phenomenon in cognitive linguistics, color-based metaphorization, to explore the cross-modal correlation between linguistic and image representations of meaning using an empirical, data-driven approach. Color terms (CTs) are used to refer to emotional states, political stances, and other non-visual notions beyond their literal meanings. Although numerous studies have discussed the metaphorical senses of CTs in different languages, there are some fundamental issues that need to be re-examined: (1) What is an empirically convincing and theoretically valid framework to account for the cognitive mechanisms motivating color-based metaphorical extensions? (2) In what ways and for what reasons do basic CTs differ in their usage patterns of metaphorical mappings? (3) In what ways and to what extent are the linguistic meanings correlated with non-linguistic visual representations? The proposed research focuses on the five basic CTs in Chinese and adopts the Behavior Profiles approach to explore the cognitive motivations of their metaphorical extensions and employs the Visual Analysis approach to examine their cross-modal associations. Given the cross-modal empirical paradigm, results from the studies will shed new light on the sensory vs. affective bases of sense extension and offer unprecedented evidence for the interaction of linguistic metaphor and image portrayal. The research demonstrates a pioneering effort to utilize a cross-disciplinary framework to extend the frontiers of usage-based lexical semantics and cognitive linguistics.

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1. Introduction

The research demonstrates an integrated empirical paradigm to investigate a linguistic phenomenon called *color metaphor*, one of the most discussed issues in conceptual metaphor. It proposes to conduct two sets of studies with corpus-based (Behavioral Profiles: Gries 2006) and image-based approaches (Visual Analysis: Guilbeault et al. 2020), in order to resolve the unsettled issues on the embodiment of color metaphor.

Color metaphor has been frequently and widely investigated in Indo-European languages such as English and German, as well as in other major language families such as Sino-Tibetan languages. Given the diverse metaphorical extensions of CTs, this study expands the current scope of research to include empirical analysis based on linguistic corpus and image data in favor of the five Chinese basic CTs, which is bound to provide a more diverse and convincing range of evidence for embodied cognition theories and applications. The new, empirical findings in color metaphor will lead to cross-linguistic and cross-disciplinary breakthroughs in furthering the understanding of how abstract concepts are understood with embodied, concrete concepts in human perceptual system.

Color metaphor in general has been questioned by some Chinese scholars. Although a few studies have discussed the topic with analytical and example-based qualitative methods, empirically verifiable research in Mandarin is not adequate to draw insightful conclusions or to capture the characteristics of cognitive motivations that underly these metaphorical extensions. As a remedy, two

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empirical studies, focusing on linguistic (corpus) and non-linguistic (image) data, have been designed using sophisticated statistical techniques to test, validate, and possibly revise theoretical premises based on purely analytical findings about the embodiment of color metaphor.

The reason why abstract concepts in different semantic domains can be understood with a specific color concept is still unknown. Although some previous studies have discussed the conceptual mapping relations between literal and metaphorical meanings of CTs from the perspective of conceptual metaphor theory, most focused only on identifying and comparing the possible metaphorical meanings of CTs in different languages but largely ignored the underlying cognitive motivations of these metaphorical senses denoted by a color term. The current project aims to help resolve the issue by conducting corpus-based Behavioral Profiles analysis on the contextual variations of CTs in natural corpora. In this way, we can empirically explore the (dis)similarities of cognitive mechanisms that motivate their metaphorical extensions. This issue of color metaphor is crucial and central to explaining how different abstract concepts are associated with a certain color.

It has been demonstrated that both the sensory-motor perceptual experiences and introspective emotional experiences play substantial roles in constructing conceptual metaphors regarding the theories of embodied cognition. However, it remain unclear about the role of emotional experiences in constructing conceptual metaphors. The proposed research aims to investigate this issue by focusing on the conceptual mapping relations between the literal and metaphorical meanings of Chinese CTs. Visual information extracted from online images is used to provide non-linguistic findings with statistical methods, which is a novel approach that can synthesize metaphor-based and affect-based accounts of embodied semantics.

In sum, the proposal presents a pioneering empirical paradigm which integrates corpus-based and image-based approaches to probe into the puzzling issues of color metaphor in order to understand how CT-related abstract concepts are understood based on embodied, perceptual experiences. By exploring the cognitive mechanisms of color metaphor and the perceptual congruity between color concepts and their corresponding abstract concepts, the research may shed new light on multi-disciplinary ventures in Natural Language Processing tasks, e.g., semantic modeling with multimodal distributional information (text and image), in the long run.

2. Research Background

2.1. The Embodied View for Abstract Concepts

Under the framework of embodied cognition, concepts are fundamentally grounded and anchored in simulations of actual perceptual experiences (Barsalou, 1999 & 2008; Glenberg, 1997; Gibbs, 2005). Previous studies have provided substantial evidence for the embodied view of language comprehension in favor of associations between human sensory-motor system and concrete non-human concepts, such as properties of physical objects and movements (Zwaan & Pecher, 2012, Andres, 2015). However, abstract concepts are more difficult to understand from the embodied perspective (e.g., Borghi et al., 2017), as they cannot be perceived with human senses and lack direct connection with human sensory-motor system. Regarding the fundamental source for abstract concepts, there are two different views on the pivotal role of sensory-motor versus affective experiences in conceptual simulation, which is relevant to the current proposal on color-based metaphorical polysemy.

The conceptual metaphor theory (CMT) argues that abstract concepts can be understood through metaphorical mappings with concrete domains of daily experiences, which are perceptually grounded and embodied (Lakoff & Johnson, 1980; Lakoff, 1993; Gibbs et al., 1994). Strong linguistic support for the embodiment of metaphorical transfer can be found in previous studies on action metaphors (Raposo et al., 2009), texture metaphors (Lacey et al., 2012), taste metaphors (Citron & Goldberg, 2014), and temporal metaphors (Lai & Desai, 2016). In addition, CMT suggests that the relationship between abstract concepts and embodied concrete notions is not only at the linguistic level, but at the conceptual level. It has been explored by many behavioral studies focusing on the

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congruity between abstract concepts and embodied daily experience, e.g., space-valence mappings (Meier et al., 2004), importance and weight (Jostmann et al., 2009), time and motion (Miles et al., 2010), and humor and bodily actions (Xu et al., 2022), and some neuroimaging studies, e.g., valence and spatial locations (Quadflieg et al., 2011), and power perception and vertical space (Zanolie et al., 2012). It is claimed that early-age bodily experiences are the major source for understanding abstract notions.

Emotion is suggested in other studies to be the essential factor that explains how simulations of abstract concepts are directly constructed with the multimodality of human perception system. Specifically, Barsalou (1999: 600) proposed that introspective symbols are central to the representation of abstract concepts regarding the multimodal perceptual symbols, while emotional states (or content) are defined as one type of introspective perceptual experience. It is further indicated that emotional valence, as one dimension of emotions (Russell 1980), plays a crucial role in representing the semantics of abstract words, as discussed in Vigliocco et al. (2009) and Kousta et al. (2011). It is demonstrated that abstract words are more emotionally charged than concrete words (Vigliocco et al. 2014), and emotional valence can support the acquisition of abstract concepts (Ponari et al. 2020).

In sum, it is debatable whether sensory-motor or emotional-affect experiences are the key for conceptual transfers to abstract notions. To author best knowledge, only Dou et al. (2025) preliminarily showed that the color-sourced sensorimotor experiences present better performance than emotional experiences when capturing semantic relations among 20 *hēi*- and *bái*-related abstract concepts with image-based approach.

2.2. Previous Works on the Associations Between Color Concepts and Abstract Concepts

Since color is perceptually grounded (Barsalou 1999; Lakoff & Johnson 1980), a number of previous studies have explored the salience of color perception in human cognition from different perspectives, with a focus on psycholinguistics or lexical semantic issues.

Metaphorical associations of color brightness and valence with congruency effect have been demonstrated by several experimental studies based on the judgment speed of word valence (positive versus negative) with white or black font color (Meier et al., 2004) or the speed of color naming for words referring to morality or immorality in white or black fonts (Sherman & Clore, 2009). Furthermore, Davidoff (1991) proposed the one-to-many mapping relations between color concepts and emotions, as one single color may evoke multiple emotions, which has been investigated by participant-involved experiments, such as color-emotion matching tasks (Zentner, 2001) and categorization tasks matching emotion-related words with different colors (Winskel et al., 2021). The multiple color-emotion mappings reveal the polysemous nature of color concepts, which is reinforced by the metaphorical uses of CTs in languages.

Color concepts are so primary that they can construe simulations of a specific color in its absence (Barsalou, 1999). CTs, as core and basic vocabulary, are used prevalently to describe diverse metaphorical meanings, demonstrating conceptual associations of colors with various abstract concepts in the target domains. For instance, *white* in English can refer to light/purity or cowardice/fear (Allan 2009), *vert* 'green' in French is associated with fear or anger (Hill 2008), *siah* 'black' in Persian refers to evil, dirty, or hopeless (Amouzadeh et al., 2011). In Chinese, as in other languages, CTs are used productively in metaphorical mappings. The five basic monolexemic CTs - *hēi* 黑 'black', *bái* 白 'white', *hóng* 红 'red', *huáng* 黄 'yellow', and *lǜ* 绿 'green' (Berlin & Kays, 1969; Wu, 2011) - are commonly found to refer to varied metaphorical meanings, some of which are Chinese-specific. The color *hóng* 'red' can refer to joy, blessing, or health (Wu, 1986), *bái* 'white' refers to both purity and funerals (Zhang, 1988), *huáng* 'yellow' can describe either royal glory or degrading pornography (Chen & Qin, 2003), and *hēi* 'black' is linked to anything evil or illegal (Xing, 2008). More recently, a series of studies have systemically investigated semantic relations and their underlying cognitive mechanisms among the Chinese color terms *hēi* 'black' and *bái* 'white' with both corpus-

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based Behavioral Profiles approach (e.g., Dou & Liu, 2023) and image-based visual analysis approach (e.g., Dou et al., 2023).

In short, the prevalent metaphorical uses of CTs indicate that sensory information from color perception plays an essential role in anchoring the semantics of non-visual concepts, both abstract and concrete, which is consistent with the theories of multimodal cognition (Barsalou 2003).

2.3. Critical Review: Unresolved Issues Related to Color Metaphor

CMT provides an effective framework to explain the mechanisms of multiple semantic extensions of CTs to different non-color meanings as conceptual transfer from the literal meanings of natural colors to non-visual senses. It complies with theories of lexical polysemy (Apresjan 1974; Jurafsky 1996), which assume that multiple related senses of a lexical item are systematically extended from its core meaning. However, there are some puzzling and unresolved issues that need to be further explored. **First,** the semantic interrelations among the metaphorical meanings of CTs have been largely ignored in previous studies, as the different senses of CTs are regarded as discrete primes and discussed from a purely analytical ground with isolated examples, e.g., Allan (2009), Hill (2008), and Li & Bai (2013). Less understood are the semantic (dis)similarities of the varied senses in relation to the cognitive motivations of the color-based metaphorical extensions. **Secondly**, apart from linguistic expressions, there is little non-linguistic evidence that can support previous proposals of the conceptual mappings between the literal and metaphorical senses of CTs. Therefore, there is a need to investigate the semantic interrelations of the extended concepts denoted by a color term to see if they trigger similar mental simulations at the conceptual level, especially when considering the potential role of emotional valence in understanding abstract concepts.

Given the above concerns, it is proposed to address the following questions about color-based metaphors: (1) What is the cognitive mechanisms responsible for the metaphorical extensions of basic color terms, and for what reasons the basic CTs differ in their scopes of metaphorical mappings? (2) Whether there is perceptual congruity between the CT-related sensory concepts and abstract concepts regarding their mental simulations in the human perceptual system, and to what extent can the linguistic findings correlate with non-linguistic representations of perceptual congruity?

2.4. Focus of the Research: The Five Basic Color Terms in Mandarin Chinese

The proposed research aims to provide empirical evidence of linguistic and non-linguistic correlations of color-based metaphorical polysemy in Mandarin Chinese to help address the unresolved issues. The five basic CTs in Mandarin, *hēi* 黑 'black', *bái* 白 'white', *hóng* 红 'red', *huáng* 黄 'yellow', and *lǜ* 绿 'green' (Berlin & Kays 1969; Wu 2011), have been selected as the research target, given that their meanings continue to be extended with various metaphorical extensions (Wu 1986; Zhang 1991; Zhang 1988; Chen and Qin 2003; Xing 2008; Li and Bai 2013; Lai & Chung 2018, etc.). Initial observations on *bái* 'white', one of the earliest-acquired Chinese basic CTs (Wu 2011), are provided below to show how flexible and intriguing the usage variations associated with the metaphorical senses of CTs are. The term *bái* 'white' can be used as either an adverb to modify the verb - *kàn* 'see', as in (1a), or an attributive modifier for the head noun - *xì* 'play', as in (1b), both of which pertain to the sense 'free of charge'. On the other hand, (1c) illustrates a different metaphorical meaning of *bái* 'in vain' occurring in the same linguistic manifestation as the adverbial use in (1a):

(1) a. 我白看了一场戏。 *wǒ bái kàn le yī-chǎng xì* 'I watched a play for free.'
b. 我看了一场白戏。 *wǒ kàn le yī-chǎng bái-xì* 'I watched a free play.'
c. 他白干了一年活。 *tā bái gān le yī-nián huó* 'He worked for a year without any return.'

3. Methodological Framework: An Integrated Empirical Paradigm

With reference to multimodal distributional semantics, the proposed research adopts a novel empirical paradigm by integrating the corpus-based BP approach (Gries 2006) and image-based VA approach (Guilbeault et al. 2020). Specifically, the BP approach helps to investigate semantic

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clustering relations among the high-frequency metaphorical meanings of CTs and to identify the prototypical contextual variations from a usage-based perspective. The BP approach consists of two key notions: 'ID tags' and 'behavioral profiles'. The former includes a set of linguistic parameters related to a particular word at different levels, e.g., morphosyntactic, semantic, and collocational features (Gries 2006), while the latter is defined as an "inventory of elements co-occurring with a word within the confines of a simple clause or sentence in actual speech and writing" (Gries & Divjak, 2009). Thus, the BP approach can incorporate lexical-grammatical behaviors associated with specific lexical meanings into a statistic model of feature analysis, which represents the probabilistic tendency of their occurrences in real contexts.

The VA approach stands as an automated method for multimodal content analysis, adept at discerning associations between words based on sensory information extracted from their Google Image search results. The VA approach hinges upon two pivotal concepts: 'JzAzBz color space' and 'color distribution'. First, the JzAzBz color space (Safdar et al. 2017) is a perceptually uniform color space that faithfully captures human color perception from the RGB color information in images. Second, color distribution refers to a computational representation of the targets in the JzAzBz color space based on their image search results. It takes the form of an eight-dimensional vector with each dimension corresponding to a distinct, evenly segmented region within the JzAzBz color space. This representation proves invaluable for a range of statistical analyses. Since color distributions can synthesize information from both metaphor and affective dimensions (Guilbeault et al. 2020), this approach will provide metaphor- and affect-based findings for the theoretical debate on embodied semantics. Dou and Zhang (2024) and Dou and Xue (2025) have demonstrated the high efficiency of the VA approach in capturing affective information embedded in the Chinese context.

By incorporating the corpus-based and image-based empirical approaches, the proposed research will be implemented under a cross-modal methodological framework to extend the research frontiers of usage-based lexical semantics and cognitive linguistics, as preliminarily discussed in Dou (2023).

3.1. Research Questions and Predictions

The pilot studies have shown the feasibility of the proposed empirical paradigm in dealing with the diverse metaphorical senses of CTs. The proposed research will then focus on the two research questions on the cognitive mechanisms for sense extensions, and the perceptual congruity between color perception and abstract concepts, as explicated below:

Q1: What are the cognitive mechanisms responsible for the metaphorical extensions of five basic CTs in Mandarin Chinese? And for what reasons the basic CTs differ in their scopes of metaphorical mappings?

Q2: Whether there is perceptual congruity between the CT-related sensory concepts and abstract concepts regarding their image-based visual representations? And to what extent can the linguistic findings correlate with non-linguistic representations of perceptual congruity?

Predictions: There are two hypothesized predictions corresponding to the research questions:

P1: The metaphorical extensions of difference CTs are motivated by their respect perceptual properties in the three dimensions of hue, brightness, and saturation. A comparison of the (dis)similarities among these color-specific cognitive mechanisms will help to explain why different colors possess different metaphorical extensions.

P2: The visual representations of abstract concepts denoted by the five CTs may exhibit a high degree of similarity with their corresponding color concepts in line with the theoretical premises of embodied metaphor (Xu et al. 2022; Quadflieg et al. 2011; Zanolie et al. 2012). The linguistic findings may correlate with the non-linguistic visual representation in terms of the valence dimension of emotional experience.

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3.2. Research Plan and Methodology

The two research questions and predictions are to be tested respectively with a corpus-based BP study and an image-based VA study, as summarized in Figure 5. Integrating linguistic and non-linguistic data will produce more convincing and decisive evidence to support the embodiment of color metaphors.

Study 1: Study 1 is dedicated to answering Question 1 and testing Prediction 1. Corpus-based BP studies with large datasets and fine-grained statistical techniques will be conducted on the distinct metaphorical meanings of the five basic CTs in Mandarin Chinese, as detailed below:

Identification of metaphorical meanings The metaphorical senses of the five basic CTs in Mandarin will be identified in two steps. First, the potential metaphorical meanings will be surveyed from previous works (e.g., Xing 2008; Li & Bai 2013; Lai & Chung 2018) and the *Contemporary Chinese Dictionary* (7th edition). These meanings will be then filtered based on their frequencies of occurrence in two corpora of Mandarin Chinese - Chinese Simplified Web 2017 Sample and Chinese Gigaword 2 Corpus (Mainland, simplified), providing a balanced coverage for the uses of CTs as the former consists of web texts and the latter of newswires. Each metaphorical meaning is described by two defining terms. A preliminary observation indicates that the number of metaphorical senses of a CT may range from 5 to 12.

Data collection 200 instances for each metaphorical meaning of the CTs will be collected randomly from the two Mandarin corpora. Instances matching the identified metaphorical meanings will be determined manually by three native speakers of Mandarin.

Identification of contextual features After creating the datasets of different senses, a set of contextual features, i.e., ID tags (Gries 2006), characterizing the local contexts of all the five target CTs will be identified in two steps. First, Word Sketches (Kilgarriff & Tugwell 2001) is used for preliminary observation on their lexical-collocation patterns and dependency relations, such as the collocation with Negation Marker and Aspectual Marker. Second, as done in previous studies (e.g., Gries 2006; Gries & Divjak 2009), the contextual features will be further enriched to cover other salient features pertaining to lexical semantics and discourse information, such as the semantic types of nouns collocated with a CT.

Data annotation Based on the identified ID tags, the sample sentences will be manually annotated by three linguistic experts in Chinese, double-blind, with disagreement resolved via a majority vote. Cohen's Kappa coefficient is used to measure the reliability and consistency among the three annotators. The annotation work is accepted for further analysis only if the coefficient exceeds the threshold value of 0.8 (Landis 1977).

Data analysis The cognitive mechanisms for the metaphorical senses of the five CTs will investigated with a two-step BP analysis, respectively. A hierarchical agglomerative clustering (HAC) analysis is first conducted to identify the clustering membership among the senses of a CT. Regarding the clustering hierarchy, the technique of multiple correspondence analysis (MCA) will be then used to explore the inter-cluster semantic (dis)similarities regarding the distinctive contextual features of each cluster, which will provide theoretical support for the cognitive mechanisms. Thus, there will be five sub-BP analyses corresponding to the five CTs. The statistical analysis is performed with *vcd*, *pvclust*, *cluster*, and *FactoMiner* packages in R.

Expected finding It is expected that the investigation will find distinct cognitive mechanisms among the five CTs based on the perceptual properties of colors, which can serve to explain their diverse metaphorical mappings with distinct abstract semantic domains.

Study 2: Study 2 is dedicated to answering Question 2 and testing Prediction 2. The image-based VA approach (Guilbeault et al. 2020) is adopted for the purpose, as detailed below:

Construction of search terms The search terms in the study fall into three semantic domains. Firstly, the CTs, *black*, *white*, *red*, *yellow*, and *green*, are selected as the target terms, referring to the literal meanings of the five basic CTs. Secondly, the terms identified in Study 1 for the metaphorical senses are used as the target terms to represent the metaphorical senses of these CTs. Third, a pair of

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terms (*positivity/morality* vs. *negativity/immorality*) is selected as referents to represent the positive and negative affective polarities in line with Meier et al. (2004).

Data collection Google's Python API will be used to obtain the images returned by a Google search for each term. Precisely, the first 200 images, shaped by the PageRank algorithm based on the population-level search activity in a region (Jing & Baluja 2008), are downloaded from Google Images in one shot for concepts described by one term. For concepts described by two terms, the first 100 images of each term are downloaded respectively from Google Images. In this way, several sub-datasets of 200 images for each concept are collected to form the visual image dataset. All images will be collected with a same HK IP address, which indicates that the searching results are generalized based on the search activity in HK.

Computing color distributions The collected images in the sub-dataset of each target concept will be transferred into an eight-dimensional perceptually grounded word embedding (color distributions) with the package *comp-syn* (Desikan et al. 2020) in Python.

Data analysis Based on the color distributions of metaphorical senses of the five CTs, two experiments will be conducted to investigate their image-based visual associations. First, five correspondence analysis (CA) biplots will be generated, respectively, to scrutinize the emotional valences of the literal and metaphorical senses of each CT. This is achieved by comparing their association strengths with the two referential terms of affective polarity. Like MCA, the differences in their association strengths were visualized as relative proximities within the CA biplots. Then, a CA biplot and a HAC dendrogram will be provided to explore the perceptual distinguishability among the literal and metaphorical senses of the five CTs. This examination was grounded in the mutual verification between their association strengths and hierarchical clustering structures.

Expected finding It is expected to find a significant perceptual congruity between the literal and metaphorical senses of the five CTs. Emotional valence is expected to provide reasonable explanations for the detected perceptual distinguishability.

General discussion on the BP and VA findings After completing the two studies, a comprehensive discussion will be conducted to explicate the potential interrelations between the corpus-based BP findings and the image-based CA findings. Since the two studies focus on two distinct and important facets of color metaphors in Mandarin Chinese, it is expected that their findings will provide a comprehensive picture for embodiment of color metaphors

4. Impact Statement

The research addresses both theoretical and empirical issues pertaining to one of the most fundamental and intriguing topics in linguistics and cognitive science: embodied metaphor. Embodied metaphor (Lakoff & Johnson 1980, 1999; Gibbs et al. 1994) claims that abstract concepts are embodied through metaphorical mappings from concrete concepts that are highly grounded in sensory-motor perceptual experience. This is one of the most impactful mechanisms in explaining the mental representation of abstract concepts under the framework of embodied cognition. Focusing on color metaphors in Chinese, we argue that the conceptual mapping between abstract concepts and embodied color concepts is realized not only at the linguistic level (metaphorical uses of CTs) but also at the conceptual level (congruity between mental stimulations of colors and abstract concepts). To our best knowledge, there is still no empirical study that investigates such metaphorical relations between color perception and abstract concepts based on linguistic as well as non-linguistic data. With the clear objectives stated above, the contribution of the proposed study is threefold: (1) methodologically, it provides an appliable empirical paradigm for integrating the corpus-based Behavioral Profiles (BP) approach and the image-based Visual Analysis (VA) approach to enhance linguistic research on metaphorical polysemy and other issues of lexical semantics and cognitive linguistics; (2) theoretically, it sheds new light on an unsettled theoretical agenda related to embodied cognition - the debate on the pivotal role of sensory-motor and emotional experience in simulating abstract concepts. It advances our understanding on how diverse metaphorical extensions of a term are realized with detectable effects of contextual variables; (3) application-wise, it facilitates

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knowledge transfer to improve semantic modeling and metaphor identification in NLP tasks for AI applications. It also facilitates industrial applications in color-related designs and initiatives. The three contributions will be realized step by step to render short-term, medium-term, and long-term impacts, as detailed below:

Firstly, the research will render a short-term impact by providing a novel research paradigm to enhance computational linguistic studies addressing lexical semantics and cognitive linguistics. To answer the proposed questions, the corpus-based BP approach and image-based VA approach will be integrated to cross-reference the findings from linguistic and non-linguistic data. Multimodal distributional semantics (MDS: Bruni et al. 2014) provides a theoretical foundation for this research, which claims that the word meanings can be represented based on not only text-based distributional information but also other information, such as image-based visual information. The new research paradigm, on the one hand, allows us to explore the underlying cognitive mechanisms of CT-related metaphorical extensions with empirical evidence based on linguistic data. On the other hand, it provides a novel way to investigate the perceptual congruity between the literal and metaphorical meanings of CTs based on visual information extracted from images, which can synthesize sensory-based and affect-based information in the computational representations of these meanings. By investigating the correlations between the linguistic findings on the cognitive mechanisms of color metaphors and the non-linguistic perceptual distinguishability, the proposed research will show how empirically validated evidence can be utilized to settle lexical semantic issues based on multimodal information.

Secondly, the research will render an impact on theoretical linguistics and Chinese linguistics. By delivering a corpus-based BP study with Mandarin data to address the unsettled issues of color metaphor, the research is bound to offer new findings and insight to the linguistic accounts of the cognitive mechanisms that motivate the diverse metaphorical extensions of CTs. As it proposes to focus on exploring the contextual variations of CTs with different metaphorical senses in Mandarin, it presents a serious and pioneering effort in answering the theoretical questions of conceptual mapping relations between the CT-related concepts that may concern theoretical linguists, psycholinguists, and computational linguists in general. Specifically, it helps to identify whether there are accountable conceptual mappings between the abstract concepts and the perceptual properties of colors, which provide explanations for how the literal meanings of CTs are extended to various metaphorical meanings in different semantic domains. Through analytically valuable and methodologically valid experiments, this research will provide convincing evidence from Mandarin to advance our knowledge on the systemic semantic relationships between different senses of polysemous words. The Chinese-specific findings offered by this research will also have an impact on the development of Chinese linguistics regarding the Chinese-specific patterns of metaphorical extensions across different CTs. In addition, exploring the perceptual congruity between CT-related concrete and abstract concepts may also help to answer the arising debate on the essential role of sensory-motor perceptual experience and emotional experience in stimulating abstract concepts.

Finally, as a long-term impact, the findings of the research may practically benefit semantic modeling in NLP to bring real-world impact beyond linguistic pursuits. Due to the existence of various metaphorical polysemy, one CT can refer to different non-literal meanings depending on its local context. This poses serious challenges in Natural Language Understanding (NLU) to correctly identify the intended meaning in the development of AI systems related to language processing. It requires a more sophisticated semantic model that can integrate lexical semantics, contextual information, as well as world knowledge. The enriched metaphorical extensions of a word may add burden to deep annotation of linguistic information in machine learning models or vector value in deep learning to retrieve relevant information for correct processing. Thus, finding appropriate contextual features to enhance the quality of semantic representation has been a critical task in AI applications. It is expected that practical solutions may be inferred from the empirical findings offered by this research. First, this research may facilitate the detection of possible linguistic contextual features that can efficiently distinguish different senses of a color polyseme. Furthermore, it is

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expected that the cross-modal findings can facilitate the design of new semantic models with multimodal distributional information, including image-based visual information and text-based linguistic information, as preliminarily discussed in Bruni et al. (2011) and Bruni et al. (2014). It will substantially improve the performance of various AI applications with respect to semantic understanding, e.g., dialogue system and machine translation. It will also facilitate industrial applications of color-related designs by understanding color-triggered implications. It may bring foreseeable advantages for occupational groups, such as AI technicians, industrial designers, and translators.

In sum, this research demonstrates a new paradigm by linking corpus-based and image-based findings of color metaphors in the initial stage. It will have lasting impacts on advancing theoretical accounts in cognitive linguistic research in the next stage and eventually facilitate multi-modal application in the AI and design industries beyond academia in the long term.

5. Summary

As a salient perceptual experience, color perception provides a basic source domain for understanding different non-color concepts through metaphorical extensions. By investigating the semantic clustering patterns and perceptual-affective congruity among the metaphorical meanings of the five Chinese basic CTs, the proposed research is contributive in teasing out the cognitive motivations and cross-modal associations with different metaphorical concepts in the target domains as a systemic operation of human cognition. As a pioneering effort to correlate linguistic and visual representations of meanings, the study is also significant in enhancing the quality and applicability of semantic modeling with an empirical, multimodal paradigm in integrating distinctive linguistic features and visual image data for the advancement of corpus-based cognitive linguistics.

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