https://doi.org/10.1016/j.lingua.2019.102744

Directionality of linguistic synesthesia in Mandarin: A corpus-based study

Qingqing Zhao[1*], Chu-Ren Huang[2], Kathleen Ahrens[3]

[1] Institute of Linguistics, Chinese Academy of Social Sciences, Beijing, China

* Corresponding author

Email: zhaoqingqing0611@163.com

[2] Department of Chinese and Bilingual Studies, The Hong Kong Polytechnic University, Hong Kong, China

Email: churen.huang@polyu.edu.hk

[3] Department of English, The Hong Kong Polytechnic University, Hong Kong, China

Email: kathleen.ahrens@polyu.edu.hk

Abstract

This paper examines the mapping directionality tendencies of linguistic synesthesia in Mandarin using a corpus-based approach. Based on this set of less-studied data, we find that Mandarin synesthesia does not share the same directionality tendencies with linguistic synesthesia in Indo-European languages, which challenges the assumed cross-linguistic universality of these transfer patterns. Based on the corpus data, we demonstrate that there are three types of directional tendencies for Mandarin synesthesia: unidirectional, biased-directional, and bidirectional. Unidirectional synesthesia is rule-based, while synesthesia that is biased in one direction is frequency-based. In contrast, bidirectional synesthesia shows no directional preference. Thus, the directionality of linguistic synesthesia cannot be interpreted as rule-based or frequency-based exclusively. In addition, this study finds that linguistic synesthesia shows language-specific variations for directionality tendencies grounded in both

embodiment and neural mechanisms, which challenges the theory that linguistic synesthesia is a bio-neurologically based linguistic realization. Lastly, the fact that linguistic synesthesia involves both rule-based and frequency-based transfer directionalities suggests that the relationship between linguistic synesthesia and metaphor merits further exploration.

Keywords:

Linguistic synesthesia, transfer directionality, variations, Mandarin Chinese, sensory lexicon

1. Introduction

Linguistic synesthesia is employed across different genres, time periods, and language families (Ullmann, 1957,1963/1966; Williams, 1976; Shen, 1997; Strik Lievers, 2015, 2017; Zhao, 2018) and describes one sensory modality in terms of another. For example, the English expression *"loud color"* uses an auditory concept to describe a concept that is viewed visually, and the Mandarin phrase 脆響 *cuì xiǎng "crisp sound"* employs a tactile adjective to describe a type of auditory perception.

The transfer patterns of linguistic synesthesia have been mainly analyzed in Indo-European languages, as noted by Zhao et al. (2018). Studies include synchronic research, such as Ullmann (1957) for poetic English, French, and Hungarian, and Strik Lievers (2015) for non-poetic English and Italian, and diachronic research, such as Williams (1976) for non-poetic English, and Strik Lievers and De Felice (2019) for non-poetic Italian. In general, these studies examine either type or token frequencies of lexical items involved in linguistic synesthesia within a pair of sensory modalities to determine the directional tendencies of synesthetic mappings. These directional tendencies are the general transfer patterns found in instances of linguistic synesthesia. There are two basic models that have been generalized for linguistic synesthesia in Indo-European languages in the literature, in which a directionality tendency for

linguistic synesthesia is attested. For example, Ullmann's (1957) model in Figure 1 describes a simple linear model for linguistic synesthesia.

Touch → Taste → Smell → Hearing → Vision

Figure 1: A linear model for linguistic synesthesia (summarized based on Ullmann,1957)

Another example is Williams' (1976) model in Figure 2, which shows a combined linear-hierarchical model.[1]

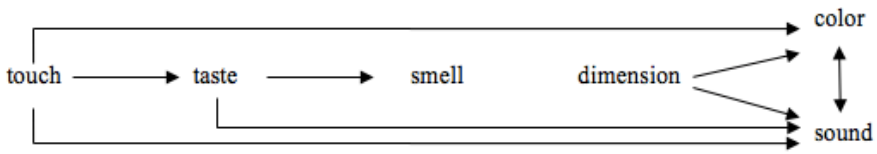


Figure 2: A transfer hierarchy for linguistic synesthesia (Williams, 1976: 463)

[1] VISION is divided into color and dimension in Williams' (1976) model, as shown in Figure 2. Although undefined, the color category includes English adjectives describing visual brightness of light (e.g., "bright" and "dark"), and the dimension category includes adjectives conceptualizing three-dimensional properties of objects, such as size (e.g., "big" and "small"), height (e.g., "high" and "low"), shape ("acute" and "flat"), and so forth (Williams, 1976: 476).

The arrangement of the five senses (i.e., TOUCH, TASTE, SMELL, HEARING, and VISION) in the two directionality models of linguistic synesthesia are relatively similar.[2, 3] In addition to his model, Williams (1976) also proposed a cross-linguistic universality claim for transfer tendencies of linguistic synesthesia in human languages.

This proposal was supported by Shen and colleagues' work (Shen, 1997; Shen and Cohen, 1998; Shen and Eisenman, 2008; Shen and Gil, 2008), which found that linguistic synesthesia in Hebrew and Indonesian also followed the linear transfer model for linguistic synesthesia in Indo-European languages (i.e., Figure 1). Nevertheless, the studies are generally based on small data samples, such as Shen's (1997) work on 130 synesthetic instances of poetic Hebrew and Shen and Gil's (2008) research on 125 synesthetic examples in non-poetic Indonesian. Zhao et al. (2018) employed a corpus-based approach to investigate linguistic synesthesia of gustatory adjectives in Mandarin Chinese from the Sinica Corpus and in English from BNC. The study found that linguistic synesthesia of Mandarin gustatory adjectives did not share the same transfer tendencies with that of English gustatory adjectives, thus posing a challenge to the cross-linguistic universality of the transfer patterns of linguistic synesthesia proposed by Williams (1976).

Another issue in the debate concerning the transfer tendencies of linguistic synesthesia is the interpretation of directionality. Williams (1976) argued for a rule-based interpretation of

[2] For a discussion about the similarities and differences between the two models for linguistic synesthesia in Indo-European languages, please see Zhao et al. (2018). In addition, it should be noted that these two models are not contradictory (Zhao et al., 2018), but instead that the linear model (i.e., Figure 1) could be included in the hierarchy model (i.e., Figure 2), as the hierarchy model makes "much stronger" and "more falsifiable" predictions (Winter, 2016a: 144).

[3] Note that the use of small capitals is meant to indicate that we consider these sensory domains to be conceptual domains, in that they are coherently organized domains of human experiences.

the directional tendencies of linguistic synesthesia. He claimed that the transfer hierarchy of linguistic synesthesia in Figure 2 was "a description of a rule-governed semantic change" that "qualifies for lawhood" (Williams, 1976: 473). In contrast, Strik Lievers (2015: 83), following Ullmann (1957), suggested that the directionality of linguistic synesthesia should be interpreted as a "frequency-based" tendency, rather than a "unidirectional" rule. This assumes that while most transfers of linguistic synesthesia between two sensory domains would show a frequency-based preference on a certain transfer direction, transfers in both directions could be possible.

2. Research questions

The literature review shows that there are two research debates on directionality of linguistic synesthesia. One is whether linguistic synesthesia obeys cross-linguistic universal directionality tendencies, and the other is whether directionality of linguistic synesthesia is rule-based or frequency-based. Mandarin Chinese as a Sino-Tibetan language is a good candidate to answer these questions by testing whether linguistic synesthesia in a non-Indo-European language follows a similar pattern to linguistic synesthesia in Indo-European languages, and whether linguistic synesthesia in Mandarin Chinese shows a rule-based or frequency-based directionality. However, most of the previous studies on Mandarin synesthesia only explored either specific synesthetic uses (e.g., Qian, 1985; Li, 1996; Wang and Xu, 2002; Yu, 2003; Yang and Zhang, 2007; Peng and Bai, 2008; Wang, 2008; Xiong and Huang, 2015; Huang and Xiong, 2019) or synesthetic usages for specific sensory modalities (e.g., Zhao and Huang, 2015; Zhao et al., 2015; Zhao et al., 2018). Though Zhao and Huang (2018) figured out the general transfer pattern for Mandarin synesthesia, the study was mainly based on limited data, i.e., synesthetic uses from a dictionary. In contrast with Zhao and Huang (2018), Zhao (2018) employed more comprehensive data to examine the general tendencies of Mandarin synesthesia from a corpus-based approach. However, the study did not focus on

systematic comparisons on the directionality between Mandarin synesthesia and linguistic synesthesia of Indo-European languages.

Thus, the current study will follow Zhao (2018) by examining the general tendencies of Mandarin synesthesia using the Sinica Corpus (Chen et al, 1996).[4] However, we will focus on the similarities or differences of Mandarin synesthesia with attested patterns of linguistic synesthesia in Indo-European languages. In addition, we will adopt a corpus-based procedure for identification of linguistic synesthesia proposed by Zhao et al. (2019b) to collect data in this study. Furthermore, instead of focusing exclusively on the types of synesthetic transfers like Zhao and Huang (2018) or on synesthetic tokens like Strik Lievers (2015), we will consider both the type and the token (i.e., the frequency) of synesthetic transfers between sensory modalities for Mandarin synesthesia.

It is important to note that there is no uniformly agreed upon model of sensory classification (Miller and Johnson-Laird, 1976; Cacciari, 2008; Zhao et al., 2018). In this study, we decide, following several similar studies in linguistic synesthesia (e.g., Shen, 1997; Strik Lievers, 2015; Zhao, 2018; Zhao et al., 2018), to adopt the classical five sense modalities model. In this widely-adopted classification, VISION is characterized by the eyes, HEARING by the ears, TASTE by the tongue, SMELL by the nose, and TOUCH by the hand, the skin, and the muscle. However, there are several other important models available for consideration. For instance, Purves et al. (2000/2001) classified human senses into five categories: (1) somatic sensation, which includes perceptions experienced from mechanical stimuli (e.g., light touch, pressure, cutaneous tension), painful stimuli, and temperature; (2) vision; (3) audition; (4) vestibular sensation; and (5) chemical sensation, which is associated with the nose and mouth. In addition,

[4] The Sinica Corpus (Academia Sinica Balanced Corpus of Modern Chinese, 4th edition), is a well-established annotated corpus for Mandarin Chinese with about ten million word tokens, which can be accessed at http://lingcorpus.iis.sinica.edu.tw/modern/.

128 many linguistic studies treat either TOUCH (temperature, textual, pain, etc.) or VISION (shape,
129 size, color, distance, etc.) as a cover term for multiple sense modalities. Thus, it is worth
130 investigating which alternative model best predicts synesthetic mappings and directionality
131 constraints.

132 Second, neurological and psychological findings on multisensory integrations should be
133 considered as another possible source of linguistic synesthesia. For example, Spence (2016)
134 has found that not only chemical senses (i.e., TASTE and SMELL), but also non-chemical senses
135 (e.g., VISION and HEARING) play a role in flavor perception. Winter (2016b) demonstrated that
136 the integrations of TASTE with emotion and SMELL with emotion found in the brain and
137 behavior could also be attested by linguistic data. For instance, gustatory and olfactory words
138 are found to be more frequent for "emotionally valenced nouns" (e.g., *"fragrant kiss"*) than
139 visual words (Winter, 2016b: 975). We believe that our work based on the classical five sense
140 modalities model would build a solid foundation for further studies of linguistic synesthesia
141 based on these sophisticated models of sensory modalities.

142 In short, there are three research issues this study will address:

143 (1) Do mappings of linguistic synesthesia show general transfer patterns in Mandarin, as
144 found in Indo-European languages?

145 (2) If yes, is the directionality of Mandarin synesthesia rule-based or frequency-based?

146 (3) Does Mandarin synesthesia demonstrate similar directional tendencies as linguistic
147 synesthesia in Indo-European languages?

148 In what follows, the methodology for data collection and analysis will be presented in
149 Section 3. We will answer questions (1) and (2) in Section 4 by figuring out the general patterns
150 of Mandarin synesthesia, and question (3) in Section 5 by conducting systematic comparisons
151 between the tendencies of Mandarin synesthesia and the patterns of linguistic synesthesia in

Indo-European languages. In the last section, we will conclude with a discussion of our findings and the implications for future research.

3. Methodology

3.1. A corpus-based approach for data collection

This study adopts the linguistic synesthesia identification procedure designed by Zhao et al. (2019b) to collect data for Mandarin synesthesia.[5] We only focus on sensory adjectives in the study, as linguistic synesthesia was found to be involved overwhelmingly in sensory adjective usages in both Indo-European languages such as English and Italian (see Strik Lievers, 2015; Winter, 2019a) and non-Indo-European languages such as Mandarin (see Zhao, 2018). Therefore, we presume that the synesthetic tendencies of sensory adjectives in a specific language would be approximate to general patterns of linguistic synesthesia. Specifically, we take the following steps to collect synesthetic usages of Mandarin sensory adjectives in the Sinica Corpus.

1. Extracting Mandarin sensory adjectives:

   Mandarin sensory adjectives are extracted from two comprehensive electronic Chinese lexical thesauri, i.e., 哈工大信息檢索研究中心同義詞詞林擴展版 HIT-CIR Tongyici Cilin (Extended) (Che et al., 2010) and 知網 HowNet (Dong and Dong, 2003), similar to Strik Lievers et al.'s (2013) and Strik Lievers and Huang's (2016) methods for automatic extraction of perception-related items in English, Italian, and Mandarin Chinese. Specifically, we extracted all adjectives in categories with perception-related labels (i.e., hardness, taste, odor, color, sound quality, etc.) from the above two thesauri.

[5] The methodology reported in this section was supported by the Hong Kong Polytechnic University CRG grant (No. YBGM).

2. The extracted Mandarin sensory adjectives are classified in accordance with the original sensory meanings of these adjectives, where the original sensory meanings are determined in two ways:

(i) First, the etymology of the adjectives is considered, by examining the etymological origins of the adjectives paraphrased in the well-established Chinese etymology dictionaries including 說文解字 *Shuōwén Jiězì* "Explaining Graphs and Analyzing Characters" (Xu, 1963), 說文解字注 *Shuōwén Jiězì Zhù* "Annotation on Shuowen Jiezi" (Duan, 2007), and 漢語大字典 *Hànyǔ Dà Zìdiǎn* "Great Compendium of Chinese Characters" (Xu, 1986/2010). In addition, we refer to the earlier usages of the adjectives in Classic Chinese texts (particularly in pre-Qin texts), and the orthographical composition of the Chinese characters of these adjectives for their original meanings (see Wang, 1996; Huang and Hsieh, 2015 for the conceptual convention of radicals of Chinese characters).

For example, the adjective 臭 *chòu* was paraphrased as "Dogs can trace the birds which left through smelling." in 說文解字 *Shuōwén Jiězì*, with the usage in the pre-Qin text such as 鼻慾綦臭 *bí yù qí chòu* "the nose with the desire to smell" in 荀子 Xúnzǐ (book) (around the 3rd century BC). With respect to the orthographical composition of the adjective 臭 *chòu*, it is composed of 自 and 犬, where the former glyph conceptualizes the olfactory organ (i.e., nose) and the latter means "dog" (Xu, 1963). Therefore, the paraphrase, the earlier usage, and the orthography of the adjective demonstrate that the olfactory meaning is the original sensory meaning for the adjective 臭 *chòu*.

(ii) Second, a comparative analysis is utilized for the adjectives without the explicit philological evidence showing the original sensory meanings. For example, the

198 adjective 肥 *féi* with the paraphrase as "much fat" in 說文解字 *Shuōwén Jiězì*
199 demonstrates a close relation with the adjective 胖 *pàng* both in terms of its meaning
200 in Mandarin (i.e., near synonymy) and the orthography (i.e., with the radical 月
201 conceptualizing meat, see Xu, 1963). As 胖 *pàng* is paraphrased in 說文解字 *Shuōwén*
202 *Jiězì* as "half of animals' meat for sacrifice" which is related to the visual size, the
203 visual meaning is also the most likely to be the original sensory meaning for the
204 adjective 肥 *féi* describing a big size of humans' figure and other objects in Mandarin.[6]
205 3. Extracting the usages of Mandarin sensory adjectives from the Sinica Corpus and
206 manually checking whether these adjectives were used for sensory modalities other than their
207 original sensory domains: [7]

[6] As found by Wang et al. (2019), constituents of compounds and internal morpho-lexical structures between constituents play a role in the lexical semantics of Mandarin compounds. In line with this finding, Zhao (2018) and Zhao and Huang (2018) have observed that there are differences in synesthetic usages between Mandarin compound adjectives composed of morphemes from the same original sensory domains (e.g., 明朗 *mínglǎng* "bright" with both morphemes originally from VISION) and adjectives compounded by morphemes from different original sensory domains (e.g., 鮮亮 *xiānliàng* "bright" with the first morpheme originally from TASTE and the second from VISION). However, as the adjectives composed of morphemes from different original sensory domains are in a small number and do not affect the general transfer patterns of Mandarin synesthesia (see Zhao, 2018; Zhao and Huang, 2018), this paper leaves these adjectives for future research. For more information about tendencies and psychological reality of linguistic synesthesia of Mandarin compound adjectives composed of morphemes from different senses, please see Zhao (2018), Zhao and Huang (2018), and Chen et al (2019).

[7] It is possible that some sensory adjectives should be considered as multimodal, as suggested by a reviewer. For such cases, we can rely on modality exclusivity norms, such as Lynott and Connell (2009) and Lynott and Connell (2013) for English, and Chen et al.'s (2019) for Chinese. For example, Mandarin adjective 麻 *má* "numbing" was given the rating scores of 4.77 and 4.75 for TOUCH and TASTE respectively on the range from 0 to 5 by native

If yes, the usages are marked as linguistic synesthesia. For example, the tactile adjective 輕柔 *qīngróu* "greatly soft" consisting of the tactile morphemes 輕 *qīng* "light (in weight)" and 柔 *róu* "soft", is considered a synesthetic use in the expression 輕柔歌聲 *qīngróu gēshēng "the soft singing"*, since the adjective was employed to describe an auditory perception instead of the tactile perception.

4. To ensure that correct and valid data of Mandarin synesthesia are identified, we follow Pragglejaz Group (2007) to add a discussion step to Zhao et al.'s (2019b) linguistic synesthesia identification procedure. That is, each of the three steps mentioned above is checked by no less than two annotators, and controversial synesthetic instances are discussed to reach consensus among different annotators.

3.2. Overview of collected data

Table 1 shows the distribution of the collected synesthetic usages of Mandarin sensory adjectives. That is, 199 Mandarin sensory adjectives are identified with 8,082 synesthetic instances in the Sinica Corpus. The appendix shows the top ten adjectives with the most synesthetic tokens from visual, tactile, and gustatory domains, and all adjectives with synesthetic usages from auditory and olfactory senses.

Table 1. The distribution of synesthetic data for Mandarin sensory adjectives

Source domains	**Lexical types**	**Lexical tokens**	**Examples**
VISION	99 **(49.7%)**	3,034 (**37.5%)**	**雜**音 *zá yīn "the* ***varicolored*** *sound* (noise)*"*

Mandarin speakers (Chen et al., 2019). In addition, Zhao et al. (2019a) have found that synesthetic adjectives are more multimodal than non-synesthetic adjectives.

TOUCH	73	2,695	暖色 *nuǎn sè*
	(36.7%)	**(33.3%)**	*"the **warm** color"*
TASTE	21	2,291	甜香 *tián xiāng*
	(10.6%)	(28.4%)	*"the **sweet** fragrance"*
HEARING	4	30	喧鬧的色彩 *xuānnào de*
	(2.0%)	(0.4%)	*sècǎi "the **loud** color"*
SMELL	2	32	臭臉 *chòu liǎn "the **smelly***
	(1.0%)	(0.4%)	*face* (the unpleasant facial expression)*"*
TOTAL	199	8,082	-
	(100%)	(100%)	

The data sample is much larger than those provided in previous work. For instance, it is about twice as large as that used by Zhao and Huang (2018) for the general tendencies of Mandarin synesthesia with respect to lexical types, and 16 times larger than those utilized by Strik Lievers (2015) for the general patterns of linguistic synesthesia in English and Italian in terms of lexical tokens.

Among the extracted data for Mandarin synesthesia, visual and tactile adjectives are the top two relating to both lexical types and lexical tokens, as demonstrated in Table 1. This finding is in line with the fact that VISION and TOUCH are the sensory domains with the most lexicalized adjectives in Mandarin as found in 哈工大信息檢索研究中心同義詞詞林擴展版 HIT-CIR Tongyici Cilin (Extended) and 知網 HowNet (Zhao, 2018). Though Zhao and Huang (2018) have also attested that visual and tactile adjectives are the top two with synesthetic usages in terms of lexical types, their study only identified 42 and 27 adjectives for VISION and TOUCH respectively. In addition, Zhao and Huang (2018) did not find Mandarin

241 olfactory adjectives with synesthetic usages, while the current study attests to two olfactory
242 adjectives used in linguistic synesthesia, as shown in Table 1. In Strik Lievers' (2015) study,
243 moreover, there are only about 500 synesthetic tokens collected for English and Italian
244 respectively. In addition, TOUCH and TASTE were found to be the top two linguistic synesthetic
245 usages for both languages in terms of lexical tokens, in contrast with this study, which finds
246 VISION and TOUCH to be the top two linguistic synesthetic usages in terms of lexical tokens.
247 This current study, therefore, employs a more comprehensive set of data for Mandarin
248 synesthesia as compared with both Zhao and Huang (2018) and Strik Lievers (2015), and thus
249 allows for a finer-grained examination of linguistic synesthesia.
250

251 4. Directionality of Mandarin synesthesia

252 4.1. Unidirectional, biased-directional, and bidirectional transfers

253 Based on the collected synesthetic data from the Sinica Corpus, this study finds that there are
254 15 transfer types between sensory modalities in Mandarin synesthesia, such as the transfers
255 from TOUCH to TASTE and from TOUCH to SMELL, as shown in Table 2, rather than all possible
256 20 transfer types among any two of five senses can be found.
257

258 **Table 2.** Transfers between senses of Mandarin synesthesia

Source domains	**Target domains**				
	TOUCH	TASTE	SMELL	VISION	HEARING
TOUCH		✓	✓	✓	✓
TASTE	✓		✓	✓	✓
SMELL	✕[8]	✓		✓	✕

[8] The cross "✕" represents no instances of synesthetic transfers found.

VISION	✓	✓	✓		✓
HEARING	✕	✕	✕	✓	

We follow Zhao et al. (2018) to calculate the synesthetic transferability of lexical types as the number of words in a sense showing a specific transfer divided by the whole number of words in the sense identified with synesthetic transfers. For example, among the identified 199 adjectives with synesthetic transfers in the Sinica Corpus, there are 73 Mandarin tactile adjectives identified with synesthetic usages (cf. Table 1), of which 41 adjectives are found to show the mapping from TOUCH to HEARING.[9] Hence, the mapping from TOUCH to HEARING has a synesthetic transferability of 56.2% (41/73). In addition, the frequency of lexical tokens is the number of instances identified to show a specific synesthetic transfer per million in the Sinica Corpus. For instance, there are 818 expressions attested with the synesthetic transfers from TOUCH to HEARING in the 10 million word Sinica Corpus. Thus, the frequency of lexical tokens of Mandarin synesthesia from TOUCH to HEARING is 81.8 per million based on the corpus size.

Based on the transferability and frequency of lexical types and tokens of Mandarin synesthesia data, we find that some mapping directions of linguistic synesthesia in Mandarin Chinese are indeed preferred (e.g., mapping from TOUCH to HEARING, but not from HEARING to TOUCH), analogous to Indo-European, Hebrew, and Indonesian languages (Williams, 1976; Shen, 1997; Shen and Cohen, 1998; Shen and Eisenman, 2008; Shen and Gil, 2008; Strik

[9] Please note that multiple transfers may occur in one adjective. For example, the tactile adjective 輕 *qīng* "light (in weight)" was found with transfers to TASTE, SMELL, VISION, and HEARING (see Appendix). Thus, the sum of numbers of tactile adjectives used for TASTE (i.e., seven), for SMELL (i.e., 15), for VISION (i.e., 62), and for HEARING (i.e., 41) is not equal to the whole number of tactile adjectives with synesthetic usages (i.e., 73). This also holds true for gustatory and visual adjectives in Mandarin.

Lievers, 2015). However, as to whether these directionalities are ruled-based (e.g. Williams 1976) or tendency-based (Strik Lievers 2015), we found mixed results that allow both types as well as a mixed type, which has not been reported by previous work. Specifically, the directionalities of linguistic synesthesia are as follows: (1) **Unidirectional**: synesthetic transfers occurring exclusively in one direction between two senses but not in reverse direction (e.g., mappings from TASTE to HEARING, but not from HEARING to TASTE). This is the type of directionality assumed by Williams (1976). (2) **Biased-directional**: synesthetic transfers are attested in both directions between the pair of senses but with a clearly dominant tendency (e.g., mappings from TOUCH to VISION have a much higher frequency than mappings from VISION to TOUCH). This is the type of transfer described by Strik Lievers (2015). (3) **Bidirectional**: transfers occurring in both directions for a pair of sense modalities without a clearly dominant direction (e.g., mappings from TOUCH to TASTE, and from TASTE to TOUCH). In addition, this tripartite classification supports our hypothesis that directionality of linguistic synesthesia is the result of competing tendencies: unidirectionality is the result of following a single rule, biased-directionality is the result of one (or more) frequency-based tendencies with the same direction, and bidirectionality is the result of several tendencies reaching rough equilibrium.

4.1.1. Unidirectional transfers

Table 3 presents the unidirectional transfers found for Mandarin synesthesia. These synesthetic transfers between two sensory modalities obey a rule-based unidirectionality, with no transfers in the reverse direction. As shown in Table 3, the synesthetic mappings from TOUCH to HEARING, from TOUCH to SMELL, and from TASTE to HEARING exhibit unidirectional transfers in Mandarin synesthesia, while the respective reverse transfer directions (i.e., from HEARING to TOUCH, from SMELL to TOUCH, and from HEARING to TASTE) are absent from the corpus.

Table 3. Unidirectional transfers of Mandarin synesthesia

Transfer Types	Transferability of lexical types	Frequency of lexical tokens	Examples
TOUCH→HEARING	56.2% (41/73)	81.8 (per million)	尖銳的笛音 *jiānruì de díyīn* *"the **sharp** sound of flute"*
TOUCH→SMELL	20.5% (15/73)	3 (per million)	乾燥的香味 *gānzào de xiāngwèi* *"the **dry** fragrance"*
TASTE→HEARING	52.4% (11/21)	14.2 (per million)	聲音甜美 *shēngyīn tiánměi* *"The voice is **sweet**."*

4.1.2. Biased-directional transfers

Table 4 shows the second type of transfer directionality of Mandarin synesthesia (i.e., a biased-directionality), which covers the most synesthetic transfers in Mandarin with respect to both lexical types and lexical tokens. As demonstrated in Table 4, biased-directional transfers are different from the unidirectional transfers, as biased-directional transfers have more than one direction attested. Moreover, the synesthetic transfers in two directions between senses presented in Table 4 are not equally possible, but rather show directional preferences. These preferences also differentiate biased-directional tendencies from bidirectional tendencies (discussed in 4.1.3 below) for Mandarin synesthesia. For instance, the transferability of lexical types for the mapping from TOUCH to VISION (i.e., 84.9% [62/73]) is about five times larger than the mapping from VISION to TOUCH (i.e., 18.2% [18/99]), and the frequency of lexical tokens for the mapping from TOUCH to VISION (i.e., 172.2 tokens per million) is approximately three times higher than that for the reversed direction mapping (i.e., 67.3 tokens per million).

Therefore, a biased-directionality can be attested for the transfer from TOUCH to VISION in Mandarin synesthesia. The synesthetic transfers from TASTE to VISION and from TASTE to SMELL are analogous to the transfer from TOUCH to VISION in Mandarin synesthesia. That is, transferabilities of lexical types and frequencies of lexical tokens for the mappings from TASTE to VISION and from TASTE to SMELL are both much larger than those of the mappings in the reverse directions (i.e., from VISION to TASTE and from SMELL to TASTE respectively). Hence, the synesthetic transfers between TASTE and VISION as well as between TASTE and SMELL also show a biased-directional tendency.

Table 4. Biased-directional transfers of Mandarin synesthesia

Transfer Types	**Transferability of lexical types**	**Frequency of lexical tokens**	**Examples**
TOUCH→VISION	84.9% (62/73)	172.2 (per million)	柔綠 *róu lǜ* *"**soft** green"*
VISION→TOUCH	18.2% (18/99)	67.3 (per million)	肉質細 *ròuzhì xì* *"The meat is **thin*** (The meat is tender)*."*
TOUCH－－→VISION			
TASTE→VISION	57.1% (12/21)	193.1 (per million)	顏色鮮美 *yánsè xiānměi "The color is **tasty*** (The color is bright and beautiful)*."*
VISION→TASTE	10.1% (10/99)	6.4 (per million)	厚味 *hòu wèi* *"**thick** taste* (*strong taste*)*"*
TASTE－－→VISION			

TASTE→SMELL	76.2% (16/21)	11.4 (per million)	淡香 *dàn xiāng "fragrance with a **mild taste*** (*light fragrance*)"
SMELL→TASTE	50% (1/2)	2.2 (per million)	香[…]滋味 *xiāng […]zīwèi "**fragrant** taste"*
TASTE- - →SMELL			
VISION→SMELL	13.1% (13/99)	6.3 (per million)	清香 *qīng xiāng "**limpid** fragrance* (*delicate fragrance*)"
SMELL→VISION	50% (1/2)	1 (per million)	臭臉 *chòu liǎn "the **smell** face* (the unpleasant facial expression)"
VISION- - →SMELL			
VISION→HEARING	87.9% (87/99)	**223.4** (per million)	聲音不大 *shēngyīn bú dà "The sound is not **big*** (The sound is not loud)."
HEARING→VISION	100% (4/4)	3 (per million)	色彩和諧 *sècǎi héxié "The color is **harmonious**."*
VISION- - →HEARING			

As elaborated above, the transferability of lexical types and the frequency of lexical tokens show consistent preferences in one direction for the transfers between TOUCH and VISION, between TASTE and VISION, and between TASTE and SMELL in Mandarin synesthesia. There is also a second type of biased-directional transfer, where lexical types and token frequencies show different biases. For example, as shown in Table 4, the transferability of lexical types from VISION to SMELL (i.e., 13.1% [13/99]) is lower than the transferability of lexical types from SMELL to VISION (i.e., 50% [1/2]). In contrast, the transferability of lexical tokens is higher from SMELL to VISION (with 6.3 tokens per million) than from VISION to SMELL (with

1 token per million).[10] Another example involves the transferability of lexical types for the mapping from VISION to HEARING (i.e., 87.9% [87/99]), which is smaller than that the transferability of lexical types from HEARING to VISION (i.e., 100% [4/4]). At the same time, the frequency of lexical tokens from VISION to HEARING is much higher (i.e., 223.4 tokens per million) than that from HEARING to VISION (i.e., three tokens per million).

4.1.3. Bidirectional transfers

Possible bidirectionality in synesthetic transfers can also be observed in Mandarin Chinese. That is, some pairs of sensory domains show no clear preference in terms of directions of synesthetic transfers. The most salient case involves TOUCH and TASTE. Although previous analyses predict that the mapping from TOUCH to TASTE will be preferred (see Figures 1 and 2 above), the prediction is not borne out in Mandarin data.

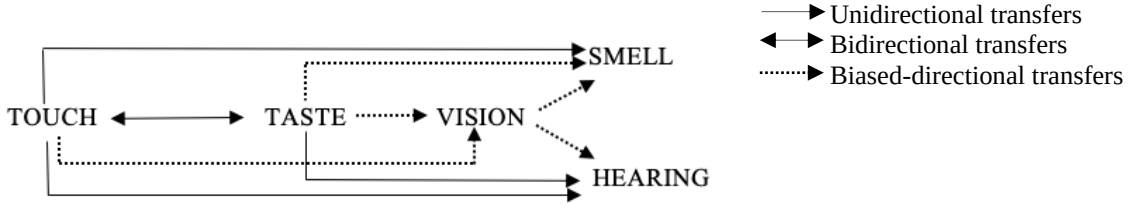
As demonstrated in Table 5, the synesthetic transferability of lexical types from TOUCH to TASTE (i.e., 9.6% [7/73]) is lower than that from TASTE to TOUCH (i.e., 23.8% [5/21]), contradicting predictions based on embodiment. On the other hand, the frequency of lexical tokens from TOUCH to TASTE is higher (i.e., 12.5 tokens per million) than that from TASTE to TOUCH (i.e., 10.4 tokens per million), which follow predictions based on embodiment. In contrast to the biased-directional transfers discussed above, in bidirectional transfers neither the type nor the token mapping preference is dominant, which contradicts previous predictions and is evidence against unidirectionality hypothesis. To confirm this bidirectionality we also check the mean lexical type frequency of mapping from TOUCH to TASTE and find that it is similar in both directions. TOUCH to TASTE is 1.8 [12.5/7] tokens per million and TASTE to TOUCH is 2.1 [10.4/5] tokens per million. Thus, in addition to type and token frequencies, the

[10] It is also important to note that SMELL is found to seldom map to other sensory domains in Mandarin synesthesia, with only two adjectives identified with synesthetic usages in the Sinica Corpus (cf. Table 1).

359 average token frequency per type of mapping is similar in both directions. Since neither
360 direction can be shown to be dominant by any measurement, we conclude that the Mandarin
361 synesthetic mapping between TOUCH and TASTE is bidirectional.
362
363 **Table 5.** Bidirectional transfers of Mandarin synesthesia

Transfer Types	**Transferability of lexical types**	**Frequency of lexical tokens**	**Examples**
TOUCH→TASTE	9.6% (7/73)	12.5 (per million)	烈酒 *liè jiǔ* *"**scorching** wine (strong wine)"*
TASTE→TOUCH	23.8% (5/21)	10.4 (per million)	腰酸 *yāo suān "The waist is **sour*** (It feels sore in the waist)*"*
TOUCH↔TASTE			

364
365 **4.1.4 Summary**
366 To summarize, Mandarin synesthesia exhibits three types of transfer directionality, including
367 unidirectionality, biased-directionality, and bidirectionality. Except for the transfers between
368 TOUCH and TASTE which show bidirectionality, all other mappings of Mandarin synesthesia
369 are found to show a preference for transfer directions with the transfers from TOUCH to
370 HEARING, TOUCH to SMELL, and TASTE to HEARING obeying a rule-based unidirectionality,
371 and all other transfers following a frequency-based biased-directionality. The general transfer
372 directionality of Mandarin synesthesia can thus be diagrammed as in Figure 3.
373



374
375 **Figure 3:** Transfer directionality of Mandarin synesthesia

We will return to the comparison of directionality between Mandarin synesthesia and linguistic synesthesia in Indo-European languages in Section 5, after the underlying mechanisms of Mandarin synesthesia are discussed.

4.2. Mechanisms underlying transfers of Mandarin synesthesia

Previous studies proposed two kinds of mechanisms to account for mapping of linguistic synesthesia. On one hand, Shen (1997), Popova (2003, 2005), and Yu (2003) argued that linguistic synesthesia is grounded in our bodily experiences, where perceived similarity on the intensity and subjective evaluation provides the cognitive basis for transfers between senses. On the other hand, Williams (1976) and Rakova (2003) assumed that neural connections in the physiological ground of synesthetic mappings. Although these two hypotheses seem to be similar, they differ crucially in that the embodiment-grounded approach is soft-wired, relying on (linguistic) conceptualization, while the neurologically-grounded approach is hard-wired, relying on the physiological composition of the brain. Hence strong universality without exception is predicted by the neurological hypothesis, while some language-specific variations are allowed by the embodiment hypothesis. Yet, both hypotheses assume a fixed hierarchy among the five sensory domains. Interestingly, Shibuya and Nozawa (2003: 406) and Shibuya et al. (2007) proposed a "Physiological = Psychological Model", which identifies both constraints on sensory experiences (including emotional experiences) and on brain structures underlying linguistic synesthesia across a variety of languages. In addition, one recent empirical study, Zhao et al. (2018), found that linguistic synesthesia of gustatory adjectives in Mandarin and English required both the embodiment and the neural basis to account for the full range of data. Our corpus-based analysis herein has allowed us to observe that both the embodiment and the neural bases are needed to explain and predict the transfer tendencies of Mandarin synesthesia. However, what still remains to be explicated is how embodiment and

neural mechanisms ground specific synesthetic transfers. In fact, in addition to similarities of perceptual intensity and subjective evaluation as embodied mechanisms attested by Zhao et al. (2018), we also discover that sensory integration can be another sub-type of embodiment mechanism to underpin Mandarin synesthesia in our current data set. In what follows, we will present four examples that demonstrate the specific embodied and neural mechanisms underlying transfers of Mandarin synesthesia: examples (1) through (3) can be predicted by the embodiment hypothesis, while example (4) can be predicted by the neurologically-grounded hypothesis.

In example (1), we note that 強 *qiáng* "strong" has an original meaning of "with strong strength" and 弱 *ruò* "weak" has an original meaning of "with weak strength." Thus, both are adjectives conceptualizing the intensities of tactile perceptions in Mandarin. The two adjectives are also used for HEARING based on the Sinica Corpus, as shown in (1), where 強 *qiáng* "strong" describes the auditory perception with a strong intensity, while 弱 *ruò* "weak" conceptualizes a weak intensity in HEARING.

(1) 蟬聲[…]時**強**[TOUCH→HEARING]時**弱**[TOUCH→HEARING]

*"The sound of cicadas […] is **strong** at times and **weak** at other times."*

Thus, the perceived similarity on the intensity can be observed for the two adjectives when used for TOUCH and HEARING, demonstrating the use of an embodied mechanism as suggested by Zhao et al. (2018).

In (2), 美 *měi* "tasty" and 甜 *tián* "sweet" originally denoted pleasant tastes, while 膩 *nì* "cloying" originally denoted an unpleasant taste. However, in the examples provided in (2a) and (2b) below, the sensory domain involves VISION, with 美 *měi* "tasty" and 甜 *tián* "sweet" utilized to provide a positive reading, while 膩 *nì* "cloying" used to provide a negative reading.

(2) a. 景色真**美**[TASTE→VISION]

*"The scenery is **tasty*** (The scenery is beautiful)*."*

b. 女裝[…]**甜**[TASTE→VISION]而不**膩**[TASTE→VISION]

*"This dress […] is **sweet** but not **cloying*** (This dress […] is attractive with good taste)*."*

These three synesthetic expressions preserve the affective evaluation of the gustatory adjectives when used for VISION. Thus, they demonstrate the embodiment mechanism of perceived similarity on subjective evaluation underlying transfers of Mandarin synesthesia.

Mandarin adjectives denoting unpleasant tastes (i.e., 苦 *kǔ* "bitter" and 酸 *suān* "sour") can be utilized for the pleasant odor (i.e., 香 *xiāng* "fragrance"), as shown in (3). Thus, the affective evaluation is not retained in these two synesthetic expressions, which were assumed to be inconsistent with the embodied mechanism of perceived similarity by Zhao et al. (2018).

(3) a. 微**苦**[TASTE→SMELL]氣香

"*the slightly **pungent** fragrance of air* (in the coffee or tea context)"

b. **酸**[TASTE→SMELL]香撲鼻

"*The **acidic** fragrance is strong* (in the vinegar context)."

Zhao et al. (2018) suggested that the linguistic expressions in (3) were triggered by specific contexts. A closer look at the synesthetic usages, however, would indicate that the contextually-triggered olfactory uses of the two gustatory adjectives are in line with the sensory integration between TASTE and SMELL experienced by humans. As argued by Winter (2016a, 2016b, 2019a), people generally rely on both TASTE and SMELL to determine the flavor of food. Thus, the bitter taste as an intrinsic perceptual property of coffee as well as tea and the sour taste as an intrinsic perceptual property of vinegar are integrated with the olfactory perceptions

of these objects for human beings, which thus motivates the conceptualization of the olfactory perceptions of coffee, tea, and vinegar in terms of the concepts of the gustatory perceptions of these objects. In other words, shared collocating sensory experiences can also lead to sensory integration and linguistic synesthesia, which are embodied as well.

Example (4) shows the neural mechanism underlying Mandarin synesthesia, where the adjective 麻 *ma2* "numbing" was utilized for a spicy taste.

(4) 乾煸牛肉絲**麻**[TOUCH→TASTE]而不辣

"The dry-fried sliced beef is ***numbing****, but not spicy."*

The usage exhibits a consistency with the physiological finding that the sensation induced on the tongue and lips by Szechuan pepper shares the same RA1 channel with mechanical vibration (Hagura et al., 2013). Thus, in addition to the gustatory usage of the English adjective "hot" and the tactile usage of the Mandarin gustatory adjective 辣 *là* "hot [in TASTE]" (see Rakova, 2003; Zhao et al., 2018), the Mandarin adjective 麻 *ma2* "numbing" used for TASTE is also in line with neuro-biological connectedness in human brains, suggesting the neural mechanism underlying transfers of linguistic synesthesia.

5. Directionality of linguistic synesthesia revisited

Based on Figure 3 for the directionality of Mandarin synesthesia and Figures 1 and 2 for the directionality of linguistic synesthesia in Indo-European languages, it can be observed that Mandarin synesthesia does not share the same directional tendencies with linguistic synesthesia of Indo-European languages. As noted by Winter (2016a) and Zhao et al. (2018), the directionality model in Figure 2 can include that in Figure 1, with more precise and finer-grained predictions for the directional tendencies of linguistic synesthesia in Indo-European

languages. Thus, we take the model in Figure 2 as the general directional patterns of linguistic synesthesia of Indo-European languages, and compare it with the directionality of Mandarin synesthesia.[11] A comparison between Figure 2 (re-named as Figure A) and Figure 3 (re-named as Figure B) is diagrammed as Figure 4 below.

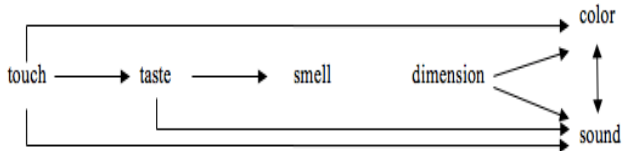


Figure A: Transfer directionality of linguistic synesthesia in Indo-European languages

Figure B: Transfer directionality of Mandarin synesthesia

Figure 4: Contrasting directionality of linguistic synesthesia

It can be observed that there are similarities between Mandarin synesthesia and linguistic synesthesia in Indo-European languages, as shown in Figure 4: (1) linguistic synesthesia in both Mandarin and Indo-European languages follows directional tendencies, rather than showing random transfers between senses; (2) TOUCH is the most frequent sensory domain in the hierarchies generally as the source of transfers for linguistic synesthesia in both Mandarin and Indo-European languages; and (3) SMELL occurs most frequently as the target domain instead of the source domain for linguistic synesthesia in both Mandarin and Indo-European languages. Crucially, Mandarin synesthesia, however, shows differences with linguistic synesthesia in Indo-European languages: (1) the transfers between TOUCH and TASTE is bidirectional in Mandarin synesthesia, but unidirectional in linguistic synesthesia of Indo-

[11] Please note that VISION is divided into color and dimension in Figure 2. We consider transfers both related to color and dimension as linguistic synesthesia of the visual sense for comparison with the directionality of Mandarin synesthesia.

494 European languages; and (2) there are transfers found in Mandarin synesthesia, but not in
495 linguistic synesthesia of Indo-European languages, including the transfers from TOUCH to
496 VISION, TASTE to VISION, and VISION to SMELL. Thus, the universal directionality patterns of
497 linguistic synesthesia suggested by Williams (1976) cannot be supported.

498 The differences of directionalities between Mandarin synesthesia and linguistic
499 synesthesia in Indo-European languages may be the result of the following two reasons. Firstly,
500 linguistic synesthesia is grounded in embodiment, which includes both perceived similarity
501 and sensory integration between experiences from different senses as demonstrated in the last
502 section. The embodiment, however, is culturally bounded, which is widely recognized to result
503 in language-specific variations of metaphors (see Lakoff and Johnson, 1980, 1999; Johnson,
504 1987; Ahrens and Huang, 2002; Gibbs, 2005; Lu and Ahrens, 2008; Hsiao and Su, 2010; de
505 Prado Salas, 2016; Wen and Yang, 2016; Jing-Schmidt and Peng, 2017). For instance, Zhou
506 and Zhang (2017) found that metaphorical usages of 面子 *miànzi* and 臉 *liǎn* in spoken Chinese
507 are different, although they are near synonyms with the meaning of "face," with 面子 *miànzi*
508 being more positive (e.g., 有面子 *yǒu miànzi* "[being shown] due respect to"), and 臉 *liǎn*
509 being more negative (e.g., 丟臉 *diū liǎn* "lose face/shameful"). They suggested that the
510 difference resulted from a unique system of value-constructs operating in Chinese culture (i.e.,
511 face), where 面子 *miànzi* is "other-oriented as a social self", while 臉 *liǎn* "self-oriented as a
512 personal self" (Zhou and Zhang, 2017: 152). However, similar metaphors have not been
513 reported in Western culture. Therefore, the variation on the directionality of linguistic
514 synesthesia across languages should not be seen as unusual.

515 It is also relevant to note that Xiong and Huang (2015, 2016) find that TASTE is quite
516 versatile for linguistic synesthesia in non-poetic Mandarin and Chinese translations for
517 Buddhist texts. For instance, 味 *wèi* "taste" can be used for all other four senses, including
518 TOUCH, SMELL, VISION, and HEARING in Chinese Buddhist texts (Xiong and Huang, 2016). In

line with the findings of Xiong and Huang (2015, 2016), TASTE is more versatile in Mandarin (i.e., with transfers to TOUCH) than in Indo-European languages found by this study. These may suggest that the gustatory experience is predominant in Chinese culture as suggested by Zhao and Huang (2018). Thus, it would make sense that TASTE is found to be used more frequently as the source domain for synesthetic mappings in Mandarin than Indo-European languages.

The other reason for the differences of directionalities between Mandarin synesthesia and linguistic synesthesia in Indo-European languages may lie in that our study is based on much larger data sample than those used for linguistic synesthesia in Indo-European languages (cf. Table 1).

With respect to the debate on whether the directionality of linguistic synesthesia is rule-based or frequency-based, this study finds that Mandarin synesthesia shows three different types of directionalities: unidirectionality, biased-directionality, and bidirectionality. The unidirectionality of Mandarin synesthesia is rule-based, while biased-directionality is frequency-based. Thus, the directionality of linguistic synesthesia cannot be interpreted as rule-based or frequency-based exclusively. Rather, the transfers of linguistic synesthesia are complex and involve different types, some of which may be rule-based and others frequency-based.

6. Conclusion

This study employs a corpus-based approach to examine the transfer tendencies of linguistic synesthesia in Mandarin Chinese. We find that Mandarin synesthesia does not share the same transfer patterns with linguistic synesthesia in Indo-European languages. Thus, the cross-linguistic universality of transfer tendencies of linguistic synesthesia proposed by Williams (1976) cannot be supported. In addition, this study attests that Mandarin synesthesia shows

three different types of directionalities, i.e., unidirectionality, biased-directionality, and bidirectionality. The unidirectionality of Mandarin synesthesia is rule-based, as transfers in reverse directions cannot be found. In contrast, the biased-directionality of Mandarin synesthesia is frequency-based, where transfers between senses in two directions can be attested, but exhibit preferences in one direction. Therefore, directionality of linguistic synesthesia is neither rule-based nor frequency-based exclusively. Rather, both are at work and either complement or compete with each other to establish directionality in linguistic synesthesia.

The directionality of linguistic synesthesia in Mandarin Chinese reported in this study may also shed light on the nature of linguistic synesthesia. At least three different accounts have been given in the past literature on the nature of linguistic synesthesia. That is, linguistic synaesthesia is considered to be: either (1) metaphorical (e.g., Shen, 1997; Strik Lievers, 2017); or (2) neurological (e.g., Rakova, 2003; Ronga et al., 2012); or (3) literal (e.g., Winter, 2019a, 2019b). Our current study shows that linguistic synesthesia allows language-specific variations in the directionality, which is inconsistent with the neurological hypothesis based on the hard-wiring of the human brain that predicts universality.

On the other hand, the literal account of linguistic synesthesia focuses on the degree and evaluative interpretation of linguistic synesthesia, such as *"big voice"* and *"sweet smell"*, arguing that degree/evaluative readings are among the literal senses of these words (Winter, 2019a, 2019b). However, since similar meaning extensions are also attested in metaphor, this account does not rule out a metaphor account. Furthermore, linguistic synesthesia has also been attested to involve rule-based directional transfers, hence showing similarity with metaphor (Lakoff and Johnson, 1980; Johnson, 1987; Gibbs, 2005). In addition, it is also consistent with the observation that linguistic synesthesia and metaphor are both used in "interpersonal" communication activities grounded in perceptual and social bases (Gahrn-Andersen, 2019;

Steffensen, 2008: 677; Ursini and Acquaviva, 2019). However, one challenge to the metaphorical account is the fact that current theories of metaphor do not account for frequency-based directionality tendencies typical of linguistic synesthesia. Thus, an intriguing issue to be explored further is the relationship between linguistic synesthesia and metaphor. Whether linguistic synesthesia is a special sub-type of metaphor or a complex linguistic device incorporating metaphorical mapping mechanisms (Ahrens, 2010) are two possibilities.

An additional area to be explored involves modality exclusivity norms. Linguistic synesthesia involves mainly lexemes based on the sensory lexicon. Recently released modality exclusivity norms of sensory lexicon (Lynott and Connell 2009, 2013; Chen et al., 2019) in both English and Chinese show that a sensory word can express range widely in terms of modality exclusivity, which has to do with when a sensory word may occur almost exclusively in a single sense modality or in two or more modalities with varying degrees of exclusivity. It is also important to note that the most dominant modality, the modality with the highest exclusivity, does not necessarily entail the original sense modality of that word. The three types of directionality from unidirectional to biased-directional to bidirectional discussed herein match well with the wide range of variability of exclusivity of sensory modalities. As Chen et al.'s (2019) study already showed a degree of correlation between modality exclusivity and linguistic synesthesia, this current study provides additional data for future studies of possible relations between modality exclusivity and mapping directionality of linguistic synesthesia.

References

Ahrens, K. (2010). Mapping Principles for Conceptual Metaphors. In L. Cameron, A. Deignan, G. Low, & Z. Todd. (Eds.), Researching and applying metaphor in the real world. (pp. 185-207). Amsterdam: John Benjamins Publishing Company.

Ahrens, K., & Huang, C. R. (2002). Time passing is motion. *Language & Linguistics*, *3*(3), 491-519.

Cacciari, C. (2008). Crossing the senses in metaphorical language. In R. W. Gibbs Jr (Ed.), *The Cambridge Handbook of Metaphor and Thought* (pp. 425-443). New York: Cambridge University Press.

Che, W., Li, Z., & Liu, T. (2010). LTP: A Chinese language technology platform. In *Proceedings of the 23rd International Conference on Computational Linguistics: Demonstrations*, 13-16.

Chen, K.-J., Huang, C.-R., Chang L.-P., & Hsu H.-L. (1996). Sinica corpus: Design methodology for balanced corpora. In *Proceedings of the 11th Pacific Asia Conference on Language, Information and Computation (PACLIC 11),*167-176.

Chen, I., Zhao, Q., Long, Y., Lu, Q., & Huang, C.-R., (2019). Mandarin Chinese Modality Exclusivity Norms. *PLOS ONE, 14*(2): e0211336.

de Prado Salas, J. G. (2016). Metaphor and engaged coordination. *Language Sciences, 53*, 75-85.

Dong, Z., & Dong, Q. (2003). HowNet - A hybrid language and knowledge resource. In *Proceedings of Natural Language Processing and Knowledge Engineering*, 820-824.

Duan, Y. (2007 [1735-1815]). *Commentary on explaining graphs and analyzing characters* [*Shuowen Jiezi Zhu*]. Nanjing: Phoenix Press.

Gahrn-Andersen, R. (2019). Biological simplexity and cognitive heteronomy. *Language Sciences, 71*, 38-48.

Gibbs, J. R. W. (2005). *Embodiment and cognitive science*. New York: Cambridge University Press.

Hagura, N., Barber, H., & Haggard, P. (2013). Food vibrations: Asian spice sets lips trembling. In *Proceedings of the Royal Society of London B: Biological Sciences*, *280*, 1-6.

Hsiao, C.-H., & Su, L.I. (2010). Metaphor and hyperbolic expressions of emotion in Mandarin Chinese conversation. *Journal of pragmatics, 42*(5), 1380-1396.

Huang, C.-R., & Hsieh, S.-K. (2015). Chinese lexical semantics: From radicals to event structure. In W. S.-Y. Wang & C.-F. Sun (Eds.), *The Oxford Handbook of Chinese linguistics* (pp. 290-305). New York: Oxford University Press.

Huang, C.-R., & Xiong, J. (2019). Linguistic Synaesthesia in Chinese. In C.-R. Huang et al. (Eds.), *Routledge Handbook on Chinese Applied Linguistics*. London: Routledge.

Jing-Schmidt, Z., & Peng, X. (2017). Winds and tigers: metaphor choice in China's anti-corruption discourse. *Lingua Sinica, 3*(1), 2.

Johnson, M. (1987). *The body in the mind: The bodily basis of meaning, imagination, and reason*. Chicago and London: The University of Chicago Press.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: The University of Chicago Press.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodied mind and its challenge to Western thought.* New York: Basic Books.

Li, G. 1996. The physiological commonality of synaesthesia [Lun Tonggan de Renlei shenglixue gongxing]. *Journal of Foreign Languages*, *3*, 34-40.

Lu, L., & Ahrens, K. (2008). Ideological influences on BUILDING metaphors in Taiwanese presidential speeches. *Discourse and Society, 19(3)*, 383-408.

Lynott, D., & Connell, L. (2009). Modality exclusivity norms for 423 object properties. *Behavior research methods, 41*(2), 558-564.

Lynott, D., & Connell, L. (2013). Modality exclusivity norms for 400 nouns: The relationship between perceptual experience and surface word form. *Behavior research methods, 45*(2), 516-526.

Miller, G., & Johnson-Laird, P. (1976). *Language and perception*. Cambridge, London & Melbourne: Cambridge University Press.

Peng, Y., & Bai, J. (2008). A new perspective to the synaesthetic metaphor [Tonggan Renzhi Xinlun]. *Foreign Languages and Their Teaching, 1*(1), 14-17.

Pragglejaz Group (2007). MIP: A method for identifying metaphorically used words in discourse. *Metaphor and Symbol, 22*(1), 1-39.

Purves, D., Augustine, G. J., Fitzpatrick, D., Katz, L. C., LaMantia, A.-S., McNamara, J. O., & Williams, S. M. (Eds.) (2000/2001). *Neuroscience*, 2nd edn. Massachusetts: Sinauer Associates, Inc.

Qian, Z. (1985). Synaesthesia [Tonggan]. *Seven pieces patched together [*Qizhui Ji*]* (pp. 54-66). Shanghai: Shanghai Classics Publishing House.

Rakova, M. (2003). *The extent of the literal: Metaphor, polysemy and theories of concepts*. New York: Palgrave Macmillan.

Ronga, I., Bazzanella, C., Rossi, F., & Iannetti, G. (2012). Linguistic synesthesia, perceptual synesthesia, and the interaction between multiple sensory modalities. *Pragmatics & Cognition, 20*(1), 135-167.

Shen, Y. (1997). Cognitive constraints on poetic figures. *Cognitive Linguistics, 8*(1), 33-71.

Shen, Y., & Cohen, M. (1998). How come silence is sweet but sweetness is not silent: A cognitive account of directionality in poetic synaesthesia. *Language and Literature, 7*(2), 123-140.

Shen, Y., & Eisenman, R. (2008). "Heard melodies are sweet, but those unheard are sweeter": Synaesthetic metaphors and cognition. *Language and Literature, 17*(2), 107-121.

Shen, Y., & Gil, D. (2008). Sweet fragrances from Indonesia: A universal principle governing directionality in synaesthetic metaphors. In J. Auracher & W. v. Peer (Eds.), *New beginnings in literary studies* (pp. 49-71). Newcastle: Cambridge Scholars Publishing.

Shibuya, Y., & Nozawa, H. (2003). Constraints on synaesthesia. In *Proceedings of the Annual Meeting of the Berkeley Linguistics Society* (Vol. 29, No. 1, pp. 403–414). Berkeley: Berkeley Linguistics Society.

Shibuya, Y., Nozawa, H., & Kanamaru, T. (2007). Understanding synesthetic expressions: Vision and olfaction with the physiological = psychological model. In M. Plümacher, & P. Holz (Eds.), *Speaking of colors and odors* (pp. 203-226). Amsterdam: John Benjamins.

Spence, C. (2016). Multisensory flavour perception. In E. Guichard, C. Salles, M. Morzel, & A. Le Bon (Eds.), *Flavour: From food to perception* (pp. 373-394). Chichester: John Wiley & Sons.

Steffensen, S. V. (2009). Language, languaging, and the extended mind hypothesis. *Pragmatics & Cognition, 17*(3), 677-697.

Strik Lievers, F. (2015). Synaesthesia: A corpus-based study of cross-modal directionality. *Functions of Language, 22*(1), 69-95.

Strik Lievers, F. (2017). Figures and the senses. *Review of Cognitive Linguistics, 15*(1), 83-101.

Strik Lievers, F., & De Felice, I. (2019). Metaphors and perception in the lexicon. In L. J. Speed, C. O'Meara, L. San Roque, & A. Majid (Eds.), *Perception Metaphors* (pp. 85-104). Amsterdam: John Benjamins.

675 Strik Lievers, F., & Huang C.-R. (2016). A lexicon of perception for the identification of linguistic
676 synaesthesia in corpora. In *Proceedings of the 10th Language Resources and Evaluation*
677 *Conference (LREC 2016)*, 4032-4036.
678 Strik Lievers, F., Xu G., & Xu, H. (2013). A methodology for the extraction of lexicalized synaesthesia
679 from corpora. Paper presented at the 19th International Congress of Linguists. Université de
680 Genève, 21-27 July.
681 Ullmann, S. (1957). *The principles of semantics*. Oxford: Basil Blackwell.
682 Ullmann, S. (1963/1966). Semantic universals. In J. Greenberg (Ed.), *Universals of language*.
683 Cambridge; London: The MIT Press.
684 Ursini, F. A., & Acquaviva, P. (2019). Nouns for visual objects: A hypothesis of the vision-language
685 interface. *Language Sciences, 72*, 50-70.
686 Wang, N. (1996). *The principle in etymological studies on Chinese* [Xunguxue Yuanli]. Beijing: China
687 International Radio Press.
688 Wang, Y. (2008). The cognitive foundation and philosophical implication of synaesthetic metaphors
689 [Tonggan Yinyu de Renzhi Jichu he Zhexue yiyi]. *Foreign Language and Their Teaching, 4*(1),
690 13-16.
691 Wang, S., & Xu, J. (2002). Synaesthesia and conceptual metaphor [Tonggan yu Gailian Yinyu]. *Foreign*
692 *Language Research, 3*, 91-94.
693 Wang, S., Huang, C. R., Yao, Y., & Chan, A. (2019). The effect of morphological structure on semantic
694 transparency ratings. *Language and Linguistics, 20*(2), 225-255.
695 Wen, X., & Yang, K. (2016). Systematicity and complexity of IDEA metaphors in Chinese. *Metaphor*
696 *and Symbol, 31*(4), 230-249.
697 Williams, J. M. (1976). Synaesthetic adjectives: A possible law of semantic change. *Language, 52*(2),
698 461-478.
699 Winter, B. (2016a). *The sensory structure of the English lexicon.* (Doctor of Philosophy), University of
700 California, Merced, CA: Merced.
701 Winter, B. (2016b). Taste and smell words form an affectively loaded and emotionally flexible part of
702 the English lexicon. *Language, Cognition and Neuroscience, 31*(8), 975-988.

Winter, B. (2019a). *Sensory Linguistics: Language, perception and metaphor*. Amsterdam: John Benjamins Publishing Company.

Winter, B. (2019b). Synesthetic metaphors are neither synesthetic nor metaphorical. In L. J. Speed, C. O'Meara, L. San Roque, & A. Majid (Eds.), *Perception metaphors* (pp. 105-126). Amsterdam & Philadelphia: John Benjamins Publishing Company.

Xiong, J., & Huang, C.-R. (2015). Being assiduous: Do we have BITTERNESS or PAIN? The synaesthetic and conceptual metaphors of BITTERNESS and PAIN in Chinese and English. In Q. Lu & H. H. Gao (Eds.), *Chinese lexical semantics* (LNAI 9332, pp. 15-23). Gewerbestrasse: Springer International Publishing.

Xiong, J., & Huang, C.-R. (2016). The synaesthetic and metaphorical uses of *wei* 'taste' in Chinese Buddhist texts. In *Proceedings of 30th Pacific Asia Conference on Language, Information and Computation (PACLIC 30)*, 485-492.

Xu, S. (1963 [156]). *Explaining graphs and analyzing characters [Shuowen Jiezi]*. Beijing: Zhonghua Book Company.

Xu, Z. (1986/2010). *Great compendium of Chinese characters [Hanyu Da Zidian]*, 2nd edn. Chengdu & Wuhan: Sichuan Dictionary Publishing Company & Hubei Dictionary Publishing Company.

Yang, B., & Zhang, H. (2007). Cross-modal perception and synaesthetic adjectives [Kua Ganguan Ganzhi yu Tonggan Xingrongci Yanjiu]. *Foreign Language Education, 28*(1), 16-21.

Yu, N. (2003). Synesthetic metaphor: A cognitive perspective. *Journal of Literary Semantics, 32*(1), 19-34.

Zhao, Q. (2018). *Synaesthesia, metaphor, and cognition: A corpus-based study on synaesthetic adjectives in Mandarin Chinese*. (Doctor of Philosophy), The Hong Kong Polytechnic University, Hong Kong.

Zhao, Q., & Huang, C.-R. (2015). A corpus-based study on synaesthetic adjectives in Modern Chinese. In Q. Lu & H. H. Gao (Eds.), *Chinese lexical semantics* (LNAI 9332, pp. 535-542). Gewerbestrasse: Springer International Publishing.

Zhao, Q., & Huang, C.-R. (2018). Mapping models and underlying mechanisms of synaesthetic metaphors in Mandarin [Xiandai Hanyu Tonggan Yinyu de Yingshe Moxing yu Zhiyue Jizhi]. *Language Teaching and Linguistic Studies, 1*, 44-55.

Zhao, Q., Huang, C.-R., & Long, Y. (2018). Synaesthesia in Chinese: A corpus-based study on gustatory adjectives in Mandarin. *Linguistics, 56*(5), 1167-1194.

Zhao, Q., Huang, C.-R. & Xu, H. (2015). Auditory synaesthesia and near synonyms: A corpus-based analysis of sheng1 and yin1 in Mandarin Chinese. In *proceedings of the 29th Pacific Asia Conference on Language, Information and Computation (PACLIC-29)*, 315-322.

Zhao, Q., Long, Y., & Huang, C.-R. (2019a). Linguistic synaesthesia of Mandarin sensory adjectives: Based on both corpus and experimental data. Paper presented at the 20th Chinese Lexical Semantics Workshop. Beijing: 27-20, June.

Zhao, Q., Xiong, J. & Huang, C.-R. (2019b). Linguistic synaesthesia, metaphor, and cognition: The systematicity and significance of linguistic synaesthesia in Chinese [Tonggan, Yinyu yu Renzhi:Tonggan Xianxiang zai Hanyu zhong de Xitongxing Biaoxian yu Yuyanxue Jiazhi]. *Zhuoguoyuwen, 2*, 240-253.

Zhou, L., & Zhang, S. J. (2017). How face as a system of value-constructs operates through the interplay of mianzi and lian in Chinese: a corpus-based study. *Language Sciences, 64*, 152-166.

Appendix. Distributions of the top ten visual, tactile, and gustatory adjectives and all auditory and olfactory adjectives with synesthetic tokens

Source domains	**Target domains**				
VISION	TOUCH	TASTE	SMELL	HEARING	Total
大 *dà* “big”	0	9	1	1083	1084
緊 *jǐn* “tense (in VISION)”	409	0	0	2	411
高 *gāo* “high”	0	0	0	197	197
低 *dī* “low”	0	0	0	182	182
清 *qīng* “limpid”	21	26	38	31	116
鬆 *sōng* “shaggy”	116	0	0	0	116
小 *xiǎo* “small”	0	0	0	84	84
長 *cháng* “long”	0	0	0	77	77
沈 *chén* “deep”	6	0	1	67	74

清楚 *qīngchǔ* “clear”	0	0	1	62	63
TOUCH	TASTE	SMELL	VISION	HEARING	Total
乾 *gān* “dry”	0	0	459	9	468
輕 *qīng* “light (in weight)”	2	2	105	244	353
尖 *jiān* “sharp”	0	0	122	117	239
冷 *lěng* “cold”	0	1	49	117	167
粗 *cū* “rough”	0	0	133	7	140
爛 *làn* “tender”	0	0	117	0	117
熱烈 *rèliè* “scorching”	0	0	30	64	94
烈 *liè* “scorching”	78	0	13	0	91
重 *zhòng* “heavy”	17	7	21	40	85
溫柔 *wēnróu* “soft”	0	0	42	41	83
TASTE	TOUCH	SMELL	VISION	HEARING	Total
美 *měi*	0	1	1222	23	1246

“tasty”					
淡 *dàn* “of mild taste”	0	27	250	71	348
濃 *nóng* “of intense taste”	0	33	167	5	205
酸 *suān* “sour”	90	10	0	1	101
鮮 *xiān* “tasty”	0	0	83	0	83
辣 *là* “hot (in TASTE)”	2	0	78	0	80
苦 *kǔ* “bitter”	1	1	66	1	69
甜美 *tiánměi* “tasty”	0	1	30	26	57
甜 *tián* “sweet”	0	13	15	8	36
甜蜜 *tiánmì* “sweet”	0	3	10	3	16
HEARING	TOUCH	TASTE	SMELL	VISION	Total
和諧 *héxié* “harmonious”	0	0	0	26	26
喧鬧 *xuānnào* “noisy”	0	0	0	2	2
吵 *chǎo*	0	0	0	1	1

“loud”					
喧嘩 *xuānhuá* “noisy”	0	0	0	1	1
SMELL	TOUCH	TASTE	VISION	HEARING	Total
香 *xiāng* “fragrant”	0	22	0	0	22
臭 *chòu* “smelly”	0	0	10	0	10

759