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

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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)

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Touch → Taste → Smell → Hearing → Vision

Fig. 1. A linear model for linguistic synesthesia (summarized based on Ullmann, 1957).

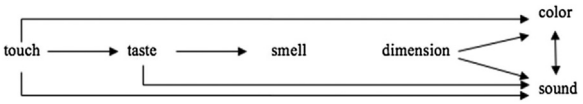

Fig. 2. A transfer hierarchy for linguistic synesthesia (Williams, 1976: 463).

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 Fig. 1 describes a simple linear model for linguistic synesthesia.

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

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., Fig. 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 the directional tendencies of linguistic synesthesia. He claimed that the transfer hierarchy of linguistic synesthesia in Fig. 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

[1] VISION is divided into color and dimension in Williams' (1976) model, as shown in Fig. 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).

[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., Fig. 1) could be included in the hierarchy model (i.e., Fig. 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.

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

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

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

1) Do mappings of linguistic synesthesia show general transfer patterns in Mandarin, as found in Indo-European languages?
2) If yes, is the directionality of Mandarin synesthesia rule-based or frequency-based?
3) Does Mandarin synesthesia demonstrate similar directional tendencies as linguistic synesthesia in Indo-European languages?

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

[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/.

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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.

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 adjective 肥 *féi* with the paraphrase as ''much fat'' in 說文解字 *Shuōwén Jiězì* demonstrates a close relation with the adjective 胖 *pàng* both in terms of its meaning in Mandarin (i.e., near synonymy) and the orthography (i.e., with the radical 月 conceptualizing meat, see Xu, 1963). As 胖 *pàng* is paraphrased in 說文解字 *Shuōwén Jiězì* as ''half of animals' meat for sacrifice'' which is related to the visual size, the visual meaning is also the most likely to be the original sensory meaning for the adjective 肥 *féi* describing a big size of humans' figure and other objects in Mandarin.[6]

3. Extracting the usages of Mandarin sensory adjectives from the Sinica Corpus and manually checking whether these adjectives were used for sensory modalities other than their original sensory domains:[7]

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

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

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

Source domains	Lexical types	Lexical tokens	Examples
VISION	99 **(49.7%)**	3034 **(37.5%)**	雜音 *zá yīn* ''*the* ***varicolored*** *sound* (noise)''
TOUCH	73 **(36.7%)**	2695 **(33.3%)**	暖色 *nuǎn sè* ''*the* ***warm*** *color*''
TASTE	21 (10.6%)	2291 (28.4%)	甜香 *tián xiāng* ''*the* ***sweet*** *fragrance*''
HEARING	4 (2.0%)	30 (0.4%)	喧鬧的色彩 *xuānnào de sècǎi* ''*the* ***loud*** *color*''
SMELL	2 (1.0%)	32 (0.4%)	臭臉 *chòu liǎn* ''*the* ***smelly*** *face* (the unpleasant facial expression)''
TOTAL	199 (100%)	8082 (100%)	–

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 8082 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.

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

4. Directionality of mandarin synesthesia

4.1. Unidirectional, biased-directional, and bidirectional transfers

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

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Table 2
Transfers between senses of Mandarin synesthesia.

Source domains	Target domains				
	TOUCH	TASTE	SMELL	VISION	HEARING
TOUCH		✓	✓	✓	✓
TASTE	✓		✓	✓	✓
SMELL	X	✓		✓	X
VISION	✓	✓	✓		✓
HEARING	X	X	X	✓	

The cross "X" represents no instances of synesthetic transfers found.

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.[8] 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 ten 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 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.

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

[8] 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.

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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***."

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

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.

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

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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)"
		VISION→HEARING	

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).[9] 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 Figs. 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 average token frequency per type of mapping is similar in both directions. Since neither direction can be shown to be dominant by any measurement, we conclude that the Mandarin synesthetic mapping between TOUCH and TASTE is bidirectional.

4.1.4. Summary

To summarize, Mandarin synesthesia exhibits three types of transfer directionality, including unidirectionality, biased-directionality, and bidirectionality. Except for the transfers between TOUCH and TASTE which show bidirectionality, all other mappings of Mandarin synesthesia are found to show a preference for transfer directions with the transfers from TOUCH to HEARING, TOUCH to SMELL, and TASTE to HEARING obeying a rule-based unidirectionality, and all other transfers following a frequency-based biased-directionality. The general transfer directionality of Mandarin synesthesia can thus be diagrammed as in Fig. 3.

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

[9] 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).

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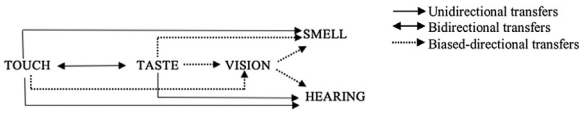

Fig. 3. Transfer directionality of Mandarin synesthesia.

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**$_{[\text{TOUCH}\rightarrow\text{HEARING}]}$時**弱**$_{[\text{TOUCH}\rightarrow\text{HEARING}]}$
''*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**$_{[\text{TASTE}\rightarrow\text{VISION}]}$
''*The scenery is* ***tasty*** (The scenery is beautiful).''
b. 女裝[. . .]**甜**$_{[\text{TASTE}\rightarrow\text{VISION}]}$而不**膩**$_{[\text{TASTE}\rightarrow\text{VISION}]}$
''*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**$_{[\text{TASTE}\rightarrow\text{SMELL}]}$氣香
''*the slightly* ***pungent*** *fragrance of air* (in the coffee or tea context)''
b. **酸**$_{[\text{TASTE}\rightarrow\text{SMELL}]}$香撲鼻
''*The* ***acidic*** *fragrance is strong* (in the vinegar context).''

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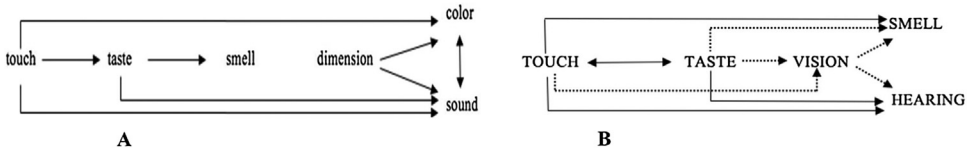

Fig. 4. Contrasting directionality of linguistic synesthesia.

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**$_{[\text{TOUCH}\rightarrow\text{TASTE}]}$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 Fig. 3 for the directionality of Mandarin synesthesia and Figs. 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 Fig. 2 can include that in Fig. 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 Fig. 2 as the general directional patterns of linguistic synesthesia of Indo-European languages, and compare it with the directionality of Mandarin synesthesia.[10] A comparison between Fig. 2 (re-named as Figure A) and Fig. 3 (re-named as Figure B) is diagrammed as Fig. 4 below.

It can be observed that there are similarities between Mandarin synesthesia and linguistic synesthesia in Indo-European languages, as shown in Fig. 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-European languages; and (2) there are transfers found in Mandarin synesthesia, but not in linguistic synesthesia of Indo-European languages, including the transfers from TOUCH to VISION, TASTE to VISION, and VISION to SMELL. Thus, the universal directionality patterns of linguistic synesthesia suggested by Williams (1976) cannot be supported.

[10] Please note that VISION is divided into color and dimension in Fig. 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.

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

It is also relevant to note that Xiong and Huang (2015, 2016) find that TASTE is quite versatile for linguistic synesthesia in non-poetic Mandarin and Chinese translations for Buddhist texts. For instance, 味 *wèi* ''taste'' can be used for all other four senses, including 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;

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Steffensen, 2009: 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.

Conflicts of interest

None.

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Appendix A

Table A1
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

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Table A1 (*Continued*)

Source domains	Target domains				
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* “tasty”	0	1	1222	23	1246
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* “loud”	0	0	0	1	1
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

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