How do non-tastes taste?

A corpus-based study on Chinese people's perception of spicy and numbing food

Sicong Dong
The Hong Kong Polytechnic University - Peking University Research Centre on Chinese Linguistics
szechungtung@gmail.com

Yin Zhong
Department of Chinese and Bilingual Studies
The Hong Kong Polytechnic University
beth.zhong@connect.polyu.hk

Chu-Ren Huang
Department of Chinese and Bilingual Studies
The Hong Kong Polytechnic University
churen.huang@polyu.edu.hk

Abstract

'Spicy' 辣 and 'Numbing' 麻 have long been known as tastes by Chinese people, though they are proved to be chemesthesis by neuroscientists. To examine the conceptualised perception of 'spicy' and 'numbing' among Chinese people, a corpus was compiled in the *Sketch Engine* which consists of comments on spicy and numbing food in *Dazhong Dianping*, the most popular food review website in China. After analysing 'spicy' and 'numbing' words and their collocations, we found evidence that they are indeed perceived as chemesthesis by Chinese people. First, these two senses are closely related to hurt and irritation which are among the properties of chemesthesis. Secondly, verbs that are semantically related to hurt and irritation collocate with 'spicy' and 'numbing', but not with the basic five taste properties. Thirdly, some collocations are found in accordance with the mechanisms of capsaicin in various aspects. In addition, semantic extension of the morphemes meaning 'spicy' and 'numbing' in Sinitic languages are mainly based on the meaning of irritation. Apart from that, according to the data, 'spicy' and 'numbing' interact with taste and smell sensations to some extent but have a loose relation with 'mouthfeel'. A synaesthetic account of transfer from taste to touch is provided for the divergence of 'spicy' and 'numbing' being deemed tastes while perceived as chemesthesis.

1 Introduction

The concept of 五味 *wuwei* 'five tastes' has been a long-held view on gustatory (taste) sense by Chinese people. As in the classic text *Lüshi Chunqiu* cited below, those five tastes are *sweet*, *sour*, *bitter*, *spicy* and *salty*. Due to the close relation of food and medicine in Chinese culture, 五味 *wuwei* also plays an important role in traditional Chinese medicine that those five tastes are believed to have different healing functions and are related to different internal organs.

五味三材... 调和之事，必以甘酸苦辛咸...
Among the five tastes and three materials... In the matter of blending [tastes], the sweet, the sour, the bitter, the spicy and the salty must be used. (吕氏春秋 *Lüshi Chunqiu*, 3rd century B.C.)

Therefore, 辛 *xin* or 辣 *la* (used more frequently in Modern Chinese), 'spicy', is one of the traditionally accepted tastes in China, as exemplified by a lexicalised term 酸甜苦辣 *suan-tian-ku-la* 'sour-sweet-bitter-spicy' in Modern Chinese, meaning all kinds of tastes, and also joys and sorrows of life metaphorically. Based on

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ShuoWenJieZi Zhu (Duan, 1815), 辛 *xin* has its most likely original meaning of serious punishment of cutting parts out of human body in ancient China. The severe pain caused by which was very likely to relate to the taste sense of 辛 *xin*, although most Chinese people might not realise this original meaning in later uses of 辛 *xin* and 辣 *la*.

Besides spicy food, Chinese people have a very long history of eating Sichuan (or Szechuan) Pepper (花椒 *huajiao*), which creates a numbing feeling (麻 *ma*), and is also considered as a taste sense by Chinese people. This can be supported by the following expressions when doing exact search in Google, where 麻 *ma* is frequently coordinated with *sour*, *sweet*, *bitter* and *spicy* (accessed 22 June 2018, with result numbers indicated in the brackets): '酸甜苦麻辣' (11300), '酸甜苦辣麻' (7730), '甜酸苦辣麻' (4170), '甜酸苦麻辣' (202). As a matter of fact, Sichuan pepper, the use of which can be traced in *Shijing* (11th - 7th century B.C.), was one of the main spices that ancient Chinese used to produce the 辛 *xin* 'spicy' flavour, while the use of chilli pepper came much later, with the first written record in the mid- and late Ming dynasty (1368 – 1644) (Zhao, 2006, p.346-350). Thus, 辛 *xin* might probably also denote the numbing feeling in Classical Chinese.

Chilli pepper is now widely used in China, but the regions that also consume Sichuan pepper, i.e. with a 麻辣 *mala* 'numbing-and-spicy' cuisine, are mainly in Sichuan Province and Chongqing City, which used to be part of Sichuan until 1997. Due to the heavy usage of chilli pepper and Sichuan pepper, the spicy and numbing flavours are more prominent in Sichuan cuisine than other regions in China (Zhao, 2003, p.46). According to Dunlop (2008), the strange, fizzing effect of Sichuan pepper, paired with the heat of chillies, is one of the hallmarks of modern Sichuanese cookery.

Although Chinese people treat spicy and numbing as tastes, modern science shows that they not belong to the gustatory sense, a sensory modality in which the basic taste qualities could be found in the taste buds on the tongue. Instead, they belong to 'common chemical sense', a kind of sense as distinct and well defined as smell or taste (Parker, 1912), or currently more often referred to as 'chemesthesis', a coined term indicating the chemical sensitivity of the skin and mucous membranes derives primarily from nerve fibres that belong to the sensory systems classically defined as touch, temperature, and pain (Green, 1996; 2016). In particular, capsaicin, the primary pungent compound in chilli pepper, is related to the pain and warming sensations; and sanshool, the primary pungent compound in Sichuan pepper, is responsible for the induced tactile and thermal sensitivity (Bryant & Mezine, 1999). Hagura *et al*. (2013) also found that the frequency-specific tactile channel is shared between Sichuan pepper and mechanical vibration, at around 50 Hz.

The spicy and numbing feelings caused by chilli pepper and Sichuan pepper, traditionally known as taste sense in China, shall belong to 'chemesthesis', which, together with taste, smell and mouthfeel, contributes to the integrated sensory impressions evoked in the oral cavity called *flavour* (Mouritsen & Styrbæk, 2014, p.5). Therefore, it will be interesting to address the following questions in this study:

a. How do Chinese people perceive 'spicy' and 'numbing' in the food? and,
b. Do Chinese people perceive them as 'taste sense' like what we call them, or as 'chemesthesis' as what they really are?

2 Methodology

First, 5 hot pot (火锅 *huoguo*) and 5 skewer hot pot (串串香 *chuanchuanxiang*) restaurants in Chongqing and Chengdu each, i.e. 20 in total, are chosen in the website *Dazhong Dianping* (大众点评)[1] according to the rates of positive comments. This is because Chongqing and Chengdu are the two biggest cities in the core region of Sichuan cuisine which are unique for their spicy and numbing flavour, and the two kinds of chosen food contain the most concentrated spicy and numbing flavour since other Sichuan cuisine restaurants would serve various dishes that are not spicy or numbing. Only the positive comments are chosen because the negative comments of the popular restaurants are much fewer than the positive ones. The categories selected in *Dazhong Dianping* for Chongqing restaurants include 'Chongqing hot pot' and 'skewer hot pot' under the category of 'hot pot'; while 'Sichuan hot pot/numbing-and-spicy hotpot' under the category of 'hot pot' and

[1] Accessed at http://www.dianping.com/

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'skewer hot pot' for Chengdu are chosen. In the refining stage of the selected restaurants, two of them were replaced by the succeeding two lower-ranking ones because their food does not match the criteria of this study.

Secondly, a third-party web crawler *Octoparse* (八爪鱼 *Bazhuayu*) is used to scrape the data from the website automatically. A tagged corpus is compiled in the *Sketch Engine*[2] (Kilgarriff *et al.*, 2014) (collected on 17 June 2018). A total of 9,141 comments have been collected, consisting of 1,255,649 Chinese characters, 723,502 words and 866,968 tokens.

Thirdly, two major functions of the *Sketch Engine* were used in the study. One is 'Word Sketch', which is used to generate collocations. Results can be sorted by score or frequency. The scores of every item in the collocations will be provided throughout this paper and the scores are computed as follows:

$$14 + \log_2 \text{Dice}\left(\frac{||w_1, R, w_2||}{||w_1, R, *||}, \frac{||w_1, R, w_2||}{||*, R, w_2||}\right) = 14 + \log_2 \frac{2 \cdot ||w_1, R, w_2||}{||w_1, R, *|| + ||*, R, w_2||}$$

The other one is 'Keywords', which is used to identify individual words (tokens) which appear more frequently in the focus corpus than in the reference corpus, which is *Chinese Web 2011 (zhTenTen11, Stanford tagger)* in our study. The keyness score of a word is calculated according to the following formula:

$$\frac{fpm_{focus} + n}{fpm_{ref} + n}$$

3 Spicy and numbing are perceived as chemesthesis

Contrary to the common belief among Chinese people, the spicy and numbing flavours are perceived as chemesthesis but not tastes, as manifested by our data. This finding can be supported by the following arguments.

3.1 Collocations with 'hurt' and 'irritation'

In Table 1, the words for spicy and numbing are collocated with words meaning 'hurt' and 'irritation' which will make people feel uncomfortable or even painful, as presented in the first two rows. The words shown in the rest rows suggest that verbs meaning different kinds of hurt or irritation can go with various body parts and the spicy and numbing flavours. It indicates that Chinese people can realise spicy and numbing are associated with chemesthesis, and they can use language to describe such feelings explicitly.

辣味 **spicy taste**	冲 irritating 11.67, 烧心 burn heart 11.67
麻 **numbing**	刺激 irritation 9.41
伤 **hurt**	胃 stomach 11.19,嗓子 throat 10.82
烧 **burn**	胃 stomach 10.82,脸 face 10.14, 嘴 mouth 9.27, 肚子 belly 9.06
熏 **smoke**	辣油 chilli oil 12.68, 辣椒 chilli pepper 8.91
呛 **irritating**	嗓子 throat 12.29, 鼻子 nose 11.83
冲 **irritating**	鼻 nose 10.82
刺激 **irritation**	爽辣 refreshingly spicy 12.68, 辣度 spicy degree 9.75,麻 numbing 9.41, 辣 spicy 9.24, 麻辣 numbing and spicy 5.23

Table 1: Collocations with hurt and irritation

3.2 Collocations with verbs

Many verbs in our corpus as listed in Table 2, have meanings of reducing the degree of intense feelings such as 缓解 'to relieve' etc., the action or ability to tolerate negative experience such as 承受 'to bear' etc., the ability or courage to do something such as 敢 'dare' etc., to accommodate to unfamiliar things such as 惯 'get used to', to lead to negative results such as 导致 'to lead to', and negative actions such as 怕 'to fear', 哭 'to cry' and 死 'to die', etc. However, those verbs collocated with 'spicy' and 'numbing' in our corpus could not find association with 酸(味/度) 'sour (taste/degree)', 甜(味/度) 'sweet (taste/degree)', 苦(味/度) 'bitter (taste/degree)', 咸(味/度) 'salty (taste/degree)', 鲜(味/度) 'umami (taste/degree)' in the corpus *Chinese Web 2011 (zhTenTen11, Stanford tagger)* in the *Sketch Engine*. It further proves that spicy and numbing feelings have been perceived differently from those 'true' taste properties, and they are closely related to the irritation of chemesthesis. Thus, when spicy and numbing foods are served in certain quantities, intense feelings need to be relieved. Besides that, spicy and numbing feelings are hard to tolerate,

[2] Accessed at https://the.sketchengine.co.uk/

courage is required if people are not used to these feelings, and negative feelings like *fear*, *crying*, and *death* will be expressed.[3]

辣味 **spicy taste**	稍减 slightly reduce 9.19, 缓解 relieve 9.19, 解解 relieve 9.14, 接受 accept 9.1
辣 **spicy**	解 relieve 11.56, 怕 fear 9.71, 哭 cry 9.59, 死 die 9.22, 能吃 can eat 7.99, 解解 relieve 7.7, 死人 die human 7.66
辣度 **spicy degree**	缓冲 buffer 10.68, 承受 bear 10.68, 接受 accept 10.09, 减缓 slow down 9.41, 忍 endure 9.38, 挑战 challenge 9.27, 受得了 bear 8.81
麻 **numbing**	惯 get used to 10.51, 刺激 irritate 9.41, 不怕 not scare 9.16, 淌汗 sweat 8.93, 导致 lead to 8.82
辣椒 **chilli pepper**	敢 dare 8.43
花椒 **Sichuan pepper**	接受 accept 8.55
刺激 **irritation**	饱受 suffer 11.19

Table 2: Verbs closely related to 'spicy' and 'numbing'

3.3 Collocations in line with the mechanisms of capsaicin

When we glance over the comments, some findings seem quite interesting. (1) Many people think the degree or intensity of spicy and numbing is much higher at the later stage of dining. (2) Some non-local people are not used to the spicy and numbing flavours of hot pot and skewer hot pot. (3) Many diners tend to consume other sweet or cold food to relieve the intense feeling caused by spiciness. With the collocations and keyword lists, these observations are considered valid, and can all be supported by the previous research on the mechanisms of capsaicin, which bolsters the claim that spicy and numbing are perceived as chemesthesis.

The collocations in Table 3 show that the flavours of spicy and numbing are not so strong at the beginning (开始), but the more (越) you eat (吃), the heavier they get (变重), and subsequently (后面) they will slowly (慢慢) come out (出来), appear (显现) and release (释放). This is because compared to tastes, capsaicin has a slow onset and persists for prolonged periods, and successive capsaicin stimuli at short intervals will continue to produce increasing irritation in the burn intensity, which is a phenomenon known as 'sensitisation' (Prescott & Stevenson, 1995).

辣味 **spicy taste**	出来 come out 9.93, 后面 later 9.93, 慢慢 slowly 9.35, 显现 appear 9.12, 释放 release 9.04
辣 **spicy**	开始 beginning 7.92
辣度 **spicy degree**	显露 appear 8.81
麻味 **numbing taste**	变重 get heavier 12.68, 后面 later 9.27
麻 **numbing**	后面 later 8.01
吃 **eat**	越 more 11.08

Table 3: Collocations concerning the latency of onset and time course

According to the collocations shown in Table 4, non-local people are not used to the heavy spicy and numbing flavours, and have to choose the suitable spicy degree, frequently slightly spicy. This phenomenon may be due to 'desensitisation', which occurs when the interval of stimulation is relatively long and subsequent stimuli of capsaicin are perceived as less intense. Another possibility is that the greater range of sensation intensities experienced by frequent chilli users may make them judge capsaicin burn as less intense than infrequent users (Prescott & Stevenson, 1995).

外地 **non-local**	吃不得辣 cannot eat spicy 13.99, 辣度 spicy degree 10.91, 微辣 slightly spicy 8.91, 适合 suit 7.78
惯 **get used to**	(口味儿)重的 (flavour) heavy 11.67, 麻 numbing 10.51, 不 not 7.87

Table 4: Collocations concerning the discomfort of non-local people

[3] The verb 死 'to die' also appears in the collocations with taste words, but the scores are all under 1.0, much lower than its collocation with 辣 'spicy' (2.83 in *Chinese Web 2011* and 9.22 in our corpus). Besides, some of the verbs or similar verbs can also collocate with 苦 'bitter', such as 饱受 'to suffer' 9.25, 忍受 'to endure' 6.35, 缓解 'to relieve' 2.29, etc. However, in the corresponding contexts, 苦 'bitter' is used with the meaning of suffering of life but not one of the five tastes.

Lastly, as a corpus based on comments on spicy and numbing food, it seems unusual to have the following terms of sweet or cold food in the top 25 key single words and top 25 key multi-words (keyness scores attached): 冰粉 'icy jelly' 599.18, 糍粑 'glutinous rice cake' 475.95, 红糖糍粑 'brown sugar glutinous rice cake' 419.7, 银耳汤 'tremella soup' 145.01. These kinds of food are actually used to reduce the intensity of irritation. A somewhat funny thing is that people who go to eat spicy food are inclined to relieve the spiciness, as discussed in section 3.2, and what they use to achieve this is almost sweet or cold food, more examples can be found in the collocations of 解辣 'to relieve spiciness': 豆奶 'soy milk' 11.19, 凉爽 'cool' 11.09, 冰冰凉凉 'icy and cool' 10.75, 酸梅 'sour plum' 10.68, 甜 'sweet' 10.6, 汤圆 'glutinous rice ball' 9.64, 冰 'ice' 9.44, 红糖 'brown sugar' 9.32, 冰粉 'icy jelly' 9.19.[4] This phenomenon could be explained by the findings that the burning sensation produced by capsaicin can be reduced by lower temperatures and sweetness (Prescott & Stevenson, 1995; Mouritsen & Styrbæk, 2017, p.20).

3.4 Evidence from the Sinitic languages

Rakova (2003, pp.39-40) investigates 8 European languages together with English, to see what words they use to refer to the spicy flavour. She suggests that the words can mainly be divided into two groups, spicy = hot, and spicy = sharp. It means that words for the spicy flavour are also words for sensations caused by either noxious thermal or mechanical stimuli. To make a comparison, we investigate Mandarin Chinese and 42 Sinitic languages or Chinese dialects using dictionaries[5]. The basic meaning of 辣 *la* 'spicy' is the irritating flavour, and 麻 *ma* 'numbing' refers to the numb feeling in the tongue/mouth or other parts of human body, and the semantic extension of the morphemes 辣 *la* and 麻 *ma* also display relations with the properties of irritating chemesthesis.

First, meanings of 辣 *la* and 麻 *ma* are all negative or neutral, except only one positive meaning 能干'competent' in Nanchang dialect. 辣 *la* in 44.2% of the languages means 辣味刺激 'to irritate by the spicy flavour', also in 44.2% of the languages means 狠毒 'vicious', which are based on the offensive pain-causing properties of spicy. 麻 *ma* in some languages has meanings like 办事迟缓, 拖拉 'tardy' (Haikou), 微醉 'drunk' (Chengdu), 不沉着, 显得忙乱 'flustered' (Suzhou), 狂妄自大 'arrogant' (Yangzhou) and 哄骗 'to deceive' (Chengdu and Guiyang), all of which relate to the numbness in the process of moving or thinking.

Secondly, 辣 *la* is related to pain or warming in compound words or phrases, such as 火辣辣 'hot or painful' (Mandarin), 热辣辣 'hot' (Guangzhou), 辣火 'chilli pepper' (Suzhou), 辣化化 'burning and prickling' (Hangzhou), 麻辣火烧 'burning pain' (Changsha).

Thirdly, some compound words use 麻 *ma* to demonstrate the vibration property of numbing, as in 麻苏苏 'spasm feeling caused by fear' (Lanzhou). In addition, some cases using 辣 *la* can have meanings like 泼辣 'termagant' (Mandarin) or 辣手 'tricky' (Yinchuan, etc.), which are also derived from the offensive pain-causing properties of spicy as chemesthesis.

4 Interaction with other senses

When eating and enjoying food, it is the integration of the combined senses that produces what we think of as *flavour* (Mouritsen & Styrbæk, 2017, p.23). Although spicy and numbing are not tastes, they do interplay with tastes, as well as with some other senses.

4.1 Hurt and irritation to sensory organs

The first kind of interaction is not in the least peaceful: Spiciness and numbness hurt all kinds of sensory organs. In the collocations of different sensory organs, shown in Table 5, we can find that except for the burning and numbing irritation, hot pots may also make diners' mouths malfunctioning or swelling, or even cause problems in their ears and eyes.

[4] 豆奶 'soy milk', 酸梅(汤) 'sour plum (juice)' and 汤圆 'glutinous rice ball' are almost always served with sugar in Chongqing and Chengdu.

[5] The data of the 42 languages are almost based on *Xiandai Hanyu Fangyan Da Cidian* [Great Dictionary of Modern Chinese Dialects] edited by Rong Li, with one exception of *Lanzhou Fangyan Cidian* [Dictionary of Lanzhou Dialect] written by Wenxuan Zhang and Chao Mo. The detailed list is not provided here due to limited space.

嘴巴 **mouth**	冰块敷 ice compress 12.68, 失去 lose 11.61, (不)好使 (cannot) function well 10.82, 爆炸 explode 10.6, (吃不)消 cannot bear 10.3, 麻 numbing 9.83
嘴 **mouth**	肿肿 swell 10.41, 肿 swell 10.41, 烧 burn 9.27, 麻 numbing 8.71
嘴皮 **lip**	翻过来 turn over 13.41, 发麻 numbing 11.83
嘴唇 **lip**	不行 cannot stand 10
舌头 **tongue**	打结 knot 11.83, 发麻 numbing 11.09, 麻 numbing 9.02
鼻子 **nose**	呛 irritate 11.83
鼻 **nose**	冲 irritate 12.68
耳朵 **ear**	听(不见) (cannot) hear 10.09
眼睛 **eye**	熏 smoke 12.09, 熏到 smoke 11.41, 睁(不开) (cannot) open 11, 出汗 sweat 10.82

Table 5: Collocations concerning hurt and irritation to sensory organs

4.2 Interaction with taste sense

Except for the relieving effect of sweetness on the burning sensation produced by capsaicin as mentioned earlier, spicy and numbing can also affect tastes. Our data show that (1) the spicy and numbing flavours usually make it harder for diners to perceive other tastes, and (2) display a close relation with bitterness in the later stage of dining. Both can be supported by studies in neuroscience and pharmacology.

When we get the collocations of 味觉 'taste', the following words appear: 刺激 'to irritate' 13, 丧失 'to lose' 11.99, 失灵 'to malfunction' 11.83, 冲击 'to strike' 11.19, 失去 'to lose' 10.82, which suggests that the irritation of spicy and numbing will make diners cannot feel other tastes well. This is consistent with the finding that chilli pungency may reduce the taste intensity of foods into which it is incorporated (Prescott & Stevenson, 1995). In addition, according to Rong *et al*. (2016), Sichuan pepper contains the anaesthetic constituents, which can also reduce the taste intensity.

Collocations in Table 6 imply another effect of spiciness and numbness on tastes. The spicy and numbing hot pot is very likely to turn bitter after boiling for some time. Previous research in neuroscience may also provide an explanation. Green & Schullery (2003) claim that capsaicin is capable of stimulating a subset of taste neurons that respond to bitter substances, and when applied to small areas of the tongue, capsaicin can produce a bitter taste as well as sensory irritation. Actually, some people experience capsaicin as a moderately intense bitter taste (Mouritsen & Styrbæk, 2017, p.21).

苦 **bitter**	煮到(后期) boil to (later) 9.71, 吃到(后面) eat to (later) 8.05, (越)煮(越) (the more) boil 7.52, 时间 time 7.27
发苦 **turn bitter**	后面 later 9.31

Table 5: Collocations with bitter taste

4.3 Effect on smell

Spicy and numbing are not olfactory senses, but daily experience tells us that we can 'smell' them, especially the spicy flavour, which often irritates the nose and cause people to sneeze or cough. There is evidence in our data showing that spicy and numbing can influence smell - their fragrance (香味) can be 'smelt' (闻到), pervade (弥漫) in the air (空气), cover (掩盖) other smell, or cause irritation (刺激 and 呛) to olfactory organ (as shown in Table 6).

闻到 **smell**	就咳咳咳 then cough 11, 火锅味 hot pot aroma 10.09, 海椒 chilli pepper 9.91, 辣椒味 chilli pepper aroma 9.35, 香辣 fragrant and spicy 9.14, 辣味 spicy taste 8.33
气息 **odour**	花椒 Sichuan pepper 11.19
辣味 **spicy taste**	掩盖 cover 8.93, 闻到 smell 8.33, 香 fragrant 8.24
麻 **numbing**	香味 fragrance 8.24
辣椒 **chilli pepper**	气呛 irritating 8.98, 弥漫 pervade 8.46
花椒 **Sichuan pepper**	很香 very fragrant 10.27, 弥漫 pervade 10.14
呛 **irritate**	空气 air 10.91, 火锅味 hot pot aroma 10.41
刺激 **irritate**	闻到 smell 9.14

Table 6: Collocations concerning the effect of spicy and numbing on smell

4.4 Relation with mouthfeel

Mouritsen & Styrbæk (2017) state that our understanding of the interplay between chemical sensory impressions and mouthfeel is more limited than the understanding of how sight, hearing, and somatosensory impressions are integrated. 'Mouthfeel' is the central element of the total flavour experience (Mouritsen & Styrbæk, 2017), therefore, it would be of some value if we could acquire certain findings on the interaction of 'spicy' and 'numbing' with mouthfeel. However, 'spicy' and 'numbing' have a very limited relation with mouthfeel according to our data. Words collocated with 口感 'mouthfeel' can be found in the corpus, such as (Q) 弹 'bouncy', 爽脆 'refreshing and crispy/crunchy', 嫩滑 'tender and smooth', etc., but they only refer to the texture of foods in the pot. Only a few words describing mouthfeel could be identified in the collocations with spicy and numbing, for example, 麻 'numbing' can coexist with 厚重 'thick and heavy' 8.82 and 干 'dry' 7.76; while 辣 'spicy' can collocate with 不燥 'not dry' 9.44 and 干 'dry'[6] 8.66.

5 Conclusion

Due to the time-honoured culture originated from 五味 'five tastes', Chinese people have a deep-rooted belief that 'spicy' and 'numbing' are two of the basic tastes. However, the usage of Chinese language concerning spicy and numbing food demonstrates that Chinese people actually perceive such flavours as the non-taste chemesthesis. Being non-tastes, spicy and numbing do interact with taste and smell to some extent, but only have a limited relation with mouthfeel.

An explanation from synaesthesia studies can be provided to account for the divergence of 'spicy' and 'numbing' being deemed tastes while perceived as chemesthesis. Linguistic synaesthesia is a metaphorical process of transfer from one sensory modality (source) to a different one (target). A perceptual experience related to one sense is described by lexical means usually associated to a different sense (Strik Lievers & Huang, 2016). It is thus possible that in our case of 'spicy' and 'numbing', tastes and chemesthesis may exhibit such a synaesthetic relation.

Chemesthesis, as we mentioned previously, is chemical sensitivity derives from nerve fibres of touch, temperature, and pain, and should be classified as touch in the Aristotelian five-sense system (Strik Lievers & Huang, 2016; Zhao, Xiong & Huang, in press). Zhao & Huang (2018), Zhao, Huang & Long (in press), Zhao, Xiong & Huang (in press) claim that 辣 'spicy', together with 苦 'bitter' and 酸 'sour', demonstrate the transfer from taste to touch (in the five-sense system)[7], as in 感觉眼辣手冷 'feeling burning pain in eyes and cold in hands', 苦寒 'bitter cold', 觉得鼻子一酸 'feeling sore in the nose'. Some findings in our study can fit exactly into this model of synaesthesia. Being two of the basic tastes in Chinese culture, 'spicy' and 'numbing', via synaesthesia, can collocate with 'hurt' and 'irritation' of the tactile sense, as shown in section 3.1 and 4.1. They also have extended meanings related to physical irritation and numbness, as discussed in section 3.4. It is most likely that the neurophysiological properties of 'spicy' and 'numbing' as chemesthesis are the bases of such synaesthesia.

Several limitations to this study need to be acknowledged. First, the relations, especially the differences in spicy and numbing perceived by Chinese people are rarely looked into. This is due to the characteristics of our data source. The food types we choose are considered to contain the most concentrated spicy and numbing flavour, thus such two flavours must be very closely interrelated in

[6] More precisely, here 干 and 不燥 mean '(not) causing the effect of dryness'. According to Filingeri *et al.* (2014), humans are not provided with specific skin receptors for sensing wetness and humidity, and wetness perception is intertwined with the ability to sense cold temperature and tactile sensations. Therefore, 干/燥 'dry' may also belong to chemesthesis, and refer to a special condition of mucous membranes, where with some humidity is the norm. In that case, 厚重 would be the only mouthfeel word in our data that collocates with spicy and numbing.

[7] In determining the basic perception lexemes of words, previous studies adopt a combination of introspection and linguistic literature. For the identification of syneasthesia in Chinese, the criteria are mainly based on the abundant classic texts, highly reliable ancient and modern dictionaries, and the radicals of most Chinese characters (Strik Lievers & Huang, 2016; Zhao, Xiong & Huang, in press).

the corpus. In fact, as mentioned by Dunlop (2008), Sichuan pepper is typically used in conjunction with the chillies. The collocations of 麻 'numbing' in Figure 1 has clearly displayed its relation with 辣味 'spicy taste' 12.41 and 辣 'spicy' 9.95.

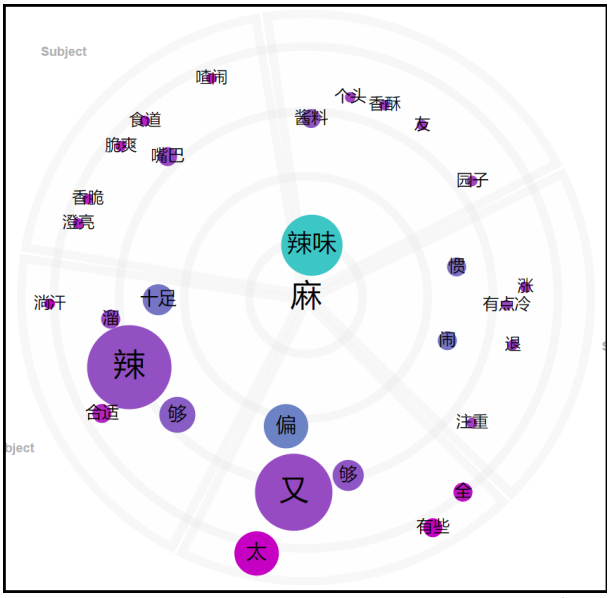

Figure 1: Visualisation of collocations with 麻 'numbing' in the *Sketch Engine*

Second, spicy and numbing are proved to be related to senses of touch, pain and temperature, but the thermal aspect of chemesthesis can hardly be discussed in this study. Some collocations with words related to high temperature were found, such as 热 *re* 'hot', nevertheless, the hot pot and skewer hot pot are both boiling hot, so it is difficult to figure out if the hot feeling is caused by chemesthesis or the hot broth. A possible study in the future will be on the linguistic uses when people are having spicy and numbing cold dishes.

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