

A taster for time: Monday is sweeter than Friday

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Abstract: Space-time metaphors in English and Chinese connote two metaphorical representations of time in space: the ego-moving representation and the time-moving representation. Extant research thereon has evinced that the choice of either is subject to both spatial and non-spatial factors (e.g., emotion). Conjoining two separate lines of inquiry, one into the relationship between emotion and time and the other into the metaphorical associations between taste and emotion, the current research examined the bidirectional relationship between taste and time. In Study 1, participants tasted sweet-, sour-, bitter-, and spicy-dominated snacks before responding to the temporally ambiguous “Next Wednesday’s meeting” question (Li, 2019) and the results showed that those who tasted sweet snack reported more time-moving perspectives than ego-moving perspectives whereas the opposite tendency was registered in those who tasted the other three snacks. The taste-aroused approach motivation rather than the taste-induced emotion was a reliable predictor of the temporal perspective preference. By priming participants with either the time-moving or the ego-moving frame of reference, Study 2 investigated the reverse influence of temporal perspective on taste preference and the results indicated that compared to the ego-moving prime, the time-moving prime prompted a distinctively stronger liking for the sweet-tasting snack as a result of relatively low happiness and approach motivation. Taken together, the results suggest that how people metaphorically conceptualize time can be modulated by taste, providing corroborative evidence for the embodied cognition that the understanding of abstract concepts are grounded in sensory, motor, and affective experiences.

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1. Introduction

1.1. The spatial nature of time

Well-documented and widely-recognized is the fact that time is literally represented and metaphorically conceptualized in spatial terms (Boroditsky, 2000; Boroditsky & Ramscar, 2002; Casasanto & Boroditsky, 2008; Clark, 1973; Evans, 2004; Fuhrman & Boroditsky, 2010; Gu et al., 2017; Lakoff & Johnson, 1980; Moore, 2014; Yu, 1998). In mandarin Chinese, the ultimate way to designate morning (上午 “up noon”), noon (中午 “mid noon”) and afternoon (下午 “down noon”) is via the coupling of space and time, forming what is aptly known as space-time metaphors. English, among other western languages, conventionalizes such space-time metaphorical expressions as “the dawn of mass vaccination against Covid-19 is *approaching*” and “we are *approaching* the last day under lockdown”. The former instantiates the time-moving metaphor in which the future moves toward and past the motionless ego (observer) whereas the latter exemplifies the ego-moving metaphor where the ego actively moves toward the stationary future.



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The presence of these two polarized metaphorical representations is no mere linguistic veneer; it has a psychological foundation. In the most paradigmatic study designed by McGlone and Harding (1998: Experiment 2), participants were first primed with straightforward context sentences that were either phrased in the ego-moving frame (e.g., *We passed the deadline two days ago*) or in the time-moving frame (e.g., *The party is coming up in two days*). They were then exposed to an ambiguous target statement that read, "The meeting originally scheduled for next Wednesday has been *moved forward* two days" before indicating the day of the week on which the rescheduled meeting would be held. The results showed that how participants disambiguated the situation was determined by the direction of movement implied in the priming statements. In other words, participants induced with the ego-moving primes tended to answer "Friday" by interpreting the phrasal verb "moved forward" in consistence with the ego-moving representation and disambiguated it to mean "later than planned"; on the contrary, those induced with the time-moving primes were more likely to answer "Monday" by translating the phrasal verb in a time-moving perspective-consistent way into "earlier than planned". In so doing, the psychological reality of the two contrastive ways of perceiving temporal passage in space is proven.

Inspired by this paradigm, psychologists and cognitive linguists alike carried out a concatenation of experiments to further investigate whether movement in real and imagined space would influence how people conceptualize time (Boroditsky, 2000; Boroditsky & Ramscar, 2002; Gentner et al., 2002). In one study, for example, participants were asked to imagine themselves either riding on a chair toward a fixed spot (priming the ego-moving perspective) or standing in a fixed spot and reeling in the chair toward them using a role (priming the time-moving perspective) before answering the ambiguous "Next Wednesday's meeting" question. Results showed that the majority of participants who envisaged the chair drawing near them tended to conceptualize the future as coming toward them and picked "Monday" for an answer whereas those who primed to visualize themselves moving toward the chair preponderantly responded "Friday". Not only does this finding confirm that our comprehension of time is indeed grounded in our movement in space (Lakoff & Johnson, 1980, 1999), given that the direction of navigation in space would dictate how time was perceived to be traveling, but more importantly, considering the imaginative nature of the navigation, it emphasizes that such spatial experience need not be sensorimotor in nature (Boroditsky & Ramscar, 2002). Built on this insight, investigations into the possible influence of fictive motion (Matlock, 2004a; 2004b; Matlock, Ramscar & Boroditsky, 2005) and abstract motion (Matlock, 2010; Matlock, Holmes, Srinivasan, & Ramscar, 2011) on temporal reasoning ensued with positive results found, thus forming a compelling chain of evidence substantiating the underpinning role of spatial information in processing the abstract concept of time.

1.2. The influence of emotion on time

Based on the spatial nature of time, non-spatial factors that could prompt movement simulation in the psychological space are explored, emotion being a prime example. Cross-linguistic evidence attests to the spatial underpinning of affective states, as manifested in such metaphorical expressions as "欢欣雀跃 (jump for joy)" or "垂头丧气 (down in the dumps)" (Lakoff & Johnson, 1980; Yu, 1998). Because the conceptualizations of emotion and time share physical experience in space, the conceptual link between emotion and time is established. Using the temporal disambiguation paradigm (McGlone & Harding, 1998), the general empirical observation made is that positive emotions are more associated with the ego-moving perspective and negative emotions are more associated with the time-moving perspective (Margolies & Crawford, 2008; McGlone & Pfiester, 2009; Richmond et al., 2012). Most recently, Zheng and collaborators (2019) investigated how future emotional events would influence people's temporal perspective preference in a Chinese context and found that positive future events provoked in participants a stronger

partiality for the ego-moving perspective. On the other hand, drawing on the knowledge that meeting deadlines for assignments has been regarded as one of the most common triggers of academic stress (Abouserie, 1994) and that stress was found to be positively correlated with negative affect and lack of personal agency (Clark & Watson, 1991), Duffy and Evans (2017) correctly predicted that the time-moving perspective (answering Monday) would be more prevalent in university students' response to the modified paradigm ("Next Wednesday's assignment deadline has been moved forward two days"), as a result of psychological aversion being translated into physical withdrawal. Yet, it seems too cursory to bind emotional negativity to the time-moving perspective when the emotionally unfavorable trait of anger is found to produce a stronger bias for the ego-moving perspective (Hauser et al., 2009). This aberration is explained by the fact that anger, unlike other typical negative emotions and traits (e.g., fear or sadness) that cause behavioral retreat, leans toward the approach end of the motivation spectrum (Harmon-Jones, 2007) and creates the urge to move forward. In this sense, an angry self mirrors the ego in the ego-moving representation in terms of their common motivation to shorten the distance between themselves and the target. Arguably, every emotion has an inherent valence and an aroused motivation and the reason why people in emotionally diametric states (happy vs. angry) share the propensity for the ego-moving perspective is that both emotions are characterized by the approach-motivation.

1.3. The influence of taste on emotion

In another trajectory of inquiry, research has suggested that emotion is both itself and subject to gustation (Bredie et al., 2014; Gayler & Sas, 2017; Rousmans et al., 2000; Russell, 2003; Zhou & Tse, 2020). Using such labels as "good taste" and "bad taste" to judge something abstract as pleasant and unpleasant dates back centuries (Vainik, 2018). Indeed, a cornucopia of taste-based emotional expressions fill everyday parlance. In Chinese, we use "苦尽甘来 (bitterness ends sweetness begins)" to ring out the tough past and ring in the bright future, "吃醋 (eat vinegar)" to describe a person's envious or jealous feelings occasioned normally in a love relationship, "火辣 (fire spicy)" to portray a shrewish temperament and most quintessentially, "酸甜苦辣 (sour sweet bitter spicy)" to encapsulate the ups and downs of a life journey. Literature abounds with empirical studies demonstrating the influence of gustation on emotion (Chapman et al., 2009; Eskine, Kacinik & Prinz, 2011; Eskine, Kacinik & Webster, 2012; Moll et al., 2005; Sagioglou & Greitmeyer, 2014; van der Wal & van Dillen, 2013). For example, relying on physiological parameters of skin and heart indicators, Rousmans and collaborators (2000) found that the four primary tastes (i.e., sweet, salty, sour and bitter) produced significantly varied automatic nervous system (ANS) responses, such that sweet taste induced weaker ANS responses whereas saltiness and sourness induced stronger ANS responses, with bitter taste generating the most powerful responses of them all. This means sweet taste is most intimately connected with pleasant feelings and bitter taste with unpleasant feelings. Indeed, unlike sweet taste that signifies the attractive feelings of love (Chan et al., 2013), bitterness signals toxicity and acts as a warning against consumption of foods bearing such taste (Schienle et al., 2015). Similar to bitter taste, sour taste is also a protective or warning system and when exposed to sour stimuli, humans would present a "sour face" featured by strong facial grimace (Spielman & Lischka, 2004). Further, electrophysiological evidence showed that negative facial processing was done faster with an acidic taste (Liang et al., 2021). Although humans have receptors for bitter, sweet, salty, sour and umami (Brody, 2012), that for the spicy taste is not included in the club of basic tastes (Chandrashekar et al., 2006). Nevertheless, spiciness figures prominently in Chinese and other countries' food cultures (Ji et al., 2013). Research found that consumption of spicy food led to higher levels of perceived aggressive intent in others (Batra et al., 2017) and preference for spicy food gave an impression of proneness to anger (Ji et al., 2013: Experiment 1). Taken together, the relevant literature on the taste-emotion association converges in corroborating that

sensory-perceptual resources are recruited in the processing of more abstract concepts (Winkielman et al., 2015) in general. In particular, it evinces the positive emotional valence of sweetness and the negative emotional valence of bitterness, sourness and spiciness, with specific associations made between sweetness and pleasure, bitterness with displeasure, sourness with jealousy and spiciness with anger/aggressiveness. This insight, coupled with the previous research that found the impact of emotion on time (Hauser et al., 2009; Lee & Ji, 2014; Margolies & Crawford, 2008; Richmond et al., 2012; Zheng et al., 2019) leads to the primary aim of the current research, which is to investigate the influence of tastes, a hitherto unexplored factor on time conception.

1.4. The influence of time on emotion

Equally well-recorded is the reverse effect of time on emotion (Hauser et al., 2009; Richmond et al., 2012; Ruscher, 2011). For instance, knowledge of the active ego in the ego-moving metaphorical representation and the passive ego in the time-moving metaphorical representation led to the confirmed hypothesis that participants primed with the ego-moving perspective would forecast a considerably weaker grief intensity and shorter grief duration of a bereaved mother than those primed with the time-moving perspective (Ruscher, 2011). In a similar vein, Richmond and collaborators (2012: Study 5) found that participants who completed the ego-moving scheduling task scored significantly higher levels of happiness. In contrast, participants primed with the time-moving perspective reported significantly higher degrees of anxiety and sadness/depression. Hence, it is safe to conclude that the ego-moving representation affords more agency and positivity than the converse time-moving representation of time.

1.5. The influence of emotion on taste

The reverse impact of emotional response on taste perception has also been extensively studied (Chan et al., 2013; Keneko et al., 2020; Liang et al., 2020; Noel & Dando, 2015; Spence et al., 2019; Wang & Spence, 2018). In one study, resting on the finding that winning and losing at sport competitions can induce disparate affective responses, Noel and Dando (2015) evaluated how competition outcomes-manipulated emotional response would affect the taste perception of attendees following men's hockey games. The results showed that positive emotions were correlated with enhanced sweet and diminished sour intensities whereas negative emotions were associated with increased sour and decreased sweet perceptions. As far as bitter taste is concerned, the relative paucity on the empirical front is made up by the copious lexical evidence that has telescoped the emotion-bitter association into negativity-bitter correspondence (Zhou & Tse, 2020). Staying on the negative emotion, Ji and colleagues (2013: Experiment 2) found that participants who scored higher in anger trait preferred spicy food. In short, positive emotions have more bearing on sweet taste and negative emotions on sour, spicy and bitter tastes. Coalescing the two lines of research, that is, the influence of time on emotion and the influence of emotion on taste, forms the secondary aim of the current research, which is to examine how time conception would shape people's taste preference.

To accomplish these two aims, we conducted two studies to investigate the relationship between gustatory sensation and temporal representation. First, to examine how tastes would impact the way people reason about time, Study 1 compared interpretations of the "Next Wednesday's meeting" question made by Chinese participants who respectively consumed sweet-, sour-, bitter- and spicy-dominant snacks. Guided by the taste-emotion associations (Zhao & Tse, 2020) and the embodied connection between emotion, behavioral motivation and time (Hauser et al., 2009; Richmond et al., 2012), we included four specific emotions (i.e., happiness, jealousy, depression and anger) and approach-motivation as the principal influential variables. Drawing on the extant research that has by and large associated positive emotions with the ego-moving perspective and negative emotions (save anger) with the time-moving perspective (e.g. Zheng et al., 2019), we postulated that in response to the ambiguous temporal event, sweet taste and spicy taste

would be more likely to prompt the ego-moving perspective whereas sour taste and bitter taste would be more likely to evoke the time-moving perspective. This prediction was underlain by the secondary hypotheses that comparatively 1) sweet taste would generate greater happiness, sour taste greater jealousy, bitter taste greater depression and spicy taste greater anger; 2) sweet taste and spicy taste would effect stronger approach motivation but sour taste and bitter taste lower approach motivation. Second, to investigate how temporal perspectives would in turn shape people's taste preference, Study 2 primed participants with either the ego-moving- or the time-moving-framed contextual statements before asking them to pick one of the four differently flavored (i.e., sweet, sour, bitter, spicy) snacks for immediate consumption. Referencing the previous finding that the ego-moving representation was more bound up with happiness and approach motivation and the time-moving representation was more tied with sadness/depression and avoidance motivation (e.g., Marglies & Crawford, 2008; Richmond et al., 2012), we again involved the levels of happiness and approach motivation for their potential explanatory powers. The surmise made accordingly was that priming the time-moving perspective should evoke a lower level of happiness and approach motivation than priming the ego-moving perspective, and this would result in a higher percentage of sweet snack choice in the former as a means of emotional compensation.

2. The present studies

2.1. Experiment 1: The influence of taste perception on temporal perspective

2.1.1. Participants

A total of 262 students from two universities in southwest China participated with informed consent. Among them, 65 were in the Sweet condition ($M_{age}=20.15$; 38 females), 65 in the Sour condition ($M_{age}=20.32$; 42 females), 65 in the Bitter condition ($M_{age}=20.89$; 41 females), 67 in the Spicy condition ($M_{age}=20.97$; 42 females). All of them came from mainland China and their time was either compensated monetarily via WeChat Red Packet or otherwise with a notebook.

2.1.2. Materials and procedure

Participants in all conditions were gathered in four quiet classrooms. They each sat at a desk with a brandless bottle of mineral water (500 ml) and a booklet of questionnaire on it. They were first instructed to take a mouthful of water in order to cleanse their palate and then were briefed that the purpose of the experiment was to survey whether they would recommend the snack they were about to sample to be stocked in the vending machine to be installed later in the year in the Central Library. The caution that the experiment would involve eating snacks that contain wheat, soy and milk and that those who are allergic to the said ingredients should not sign up had been advised. After the briefing, the snacks were distributed across the classroom and they were individually:

- *Sweet condition*
One packet of OREO Original Flavor Chocolate Sandwich Cookies (22g per packet)
- *Sour condition*
A plastic jar of UDK Dried Plums (105g)
- *Bitter condition*
Two bars of Nuofan Dark Chocolate (10g per bar with 88% Cocoa)
- *Spicy condition*
Two packets of Zhangfei Spicy Hot Beef Jerky (14g per packet)

It was requested that the snack should be enjoyed throughout the questionnaire-filling process. That it would be best that at least one serving was finished by the end of the experiment was also recommended.

The questionnaire consisted of 4 sets of questions, each set occupying one piece of an A4 copy paper. Specific instructions were: 1) Please tear open the snack wrapper (or twist open the snack jar) in front of you. Have a taste of the snack first before rating your current

emotional state of happiness, depression, jealousy and anger on an ascending scale of “1” to “9”, with higher scores indicating greater such emotion; 2) Please intuitively respond to the following question: “下周三的会议被移动了两天。移动后的会议改在哪天举行 (Next Wednesday’s meeting has been *moved* two days. When is the meeting now that it has been moved?)” (Li, 2020; Zheng et al., 2019); 3) Please give the snack another try and respond to the following questions using a 4-point scale that ranged from “1 = very true for me” to “4 = very false for me”; 4) Please describe the taste in terms of sweetness, sourness, bitterness and spiciness on a scale of “1 = not at all” to “7 = extremely”; 5) Please refer to the scale below and indicate how much you enjoy the snack by putting a tick in the blank box corresponding to your evaluation score (9-point Hedonic Rating Scale: Mihafu et al., 2020). The third question consisted of the Chinese translation of the Drive subscale from the Behavioral Avoidance scales (Carver & White, 1994). Altogether, there were 6 statements in total, with two fillers. The four statements of interest were: a) 我会千方百计得到我想要的东西 (I go out of my way to get things I want); b) 当我想要某样东西时, 我通常会全力以赴去得到它 (When I want something I usually go all-out to get it); c) 如果我有机会得到我想要的东西, 我会马上行动 (If I see a chance to get something I want, I move on it right away); d) 当我追求某样东西的时, 我会“无所不用其极” (When I go after something, I use a “no holds barred” approach). They were designed to assess the tendencies to approach in general and the self-motivated chase of coveted objects in particular (Gray et al., 2016). Back translation of all the translation was done and double-checked by two translators with CATTI (China Accreditation Test for Translators and Interpreters) certificate.

2.1.3. Results and discussion

Screening checks. Data screening revealed that there were respectively 5, 6, 3 and 7 samples in the sweet, sour, bitter and spicy conditions that gave an either-or answer to the “Next Wednesday’s meeting” question. Therefore, those samples were excluded from the data analysis.

To check for the successful introduction of the intended taste stimuli, rounds of Chi-Square test of independence were run and the results revealed that differentiated ratings of the four tastes were given to different snacks. To wit, four taste conditions differed significantly in the evaluation of sweetness ($\chi^2_{1, 241} = 380.41; p < 0.001$, Cramer’s $V = 0.73$), sourness ($\chi^2_{1, 241} = 271.66; p < 0.001$, Cramer’s $V = 0.61$), bitterness ($\chi^2_{1, 241} = 246.56; p < 0.001$, Cramer’s $V = 0.58$), and spiciness ($\chi^2_{1, 241} = 241; p < 0.001$, Cramer’s $V = 0.58$) because cookies were rated to be dominant in sweetness, plums in sourness, chocolate in bitterness and beef jerky in spiciness (Table 1). The success of induction allowed the main analyses of the effect of tastes on time conception to proceed.

Table 1. Mean/standard deviation of the four tastes evaluation of each snack

	Cookies	Plums	Chocolate	Beef Jerky
Sweet	7.83/0.67	2.36/0.52	1.15/0.36	1.72/0.58
Sour	1.05/0.22	8.10/0.45	1.40/0.66	1.07/0.25
Bitter	1.18/0.47	1.08/0.38	8.16/0.61	1.17/0.38
Spicy	1.00/0.00	1.00/0.00	1.00/0.00	8.07/0.69

Main analyses. Contrary to expectation, nearly two thirds of the participants (65%) in the sweet condition interpreted the temporal ambiguity to mean “Monday” by adopting the time-moving perspective, which was significantly different from the rest that chose the ego-moving perspective ($Z = -2.20; p = 0.03$ by a Sign Test) (Table 2). Univariate analysis indicated that whilst levels of happiness ($F(3, 56) = 1.26; p = 0.30$) was not a reliable

predictor of the temporal perspective preference (Table 3), the approach motivation was ($F(5, 54) = 2.51; p = 0.04$) (Table 4).

Contrarily, 62.7% of the participants in the sour condition reported the bias toward the ego-moving perspective and understood the question to denote "Friday", which was markedly different from those who chose the time-moving perspective ($Z = -2.23; p = 0.03$ by a Sign Test) (Table 2). Univariate analysis indicated that ratings of jealousy ($F(1, 57) = 0.05; p = 0.95$) did not predict the preference for the temporal perspective (Table 3), but the approach motivation did ($F(5, 53) = 2.41; p = 0.05$) (Table 4).

Also contradicting the hypothesis, the bitter condition registered a little under two thirds of the participants (64.52%) who showed the propensity for the ego-moving perspective and deciphered the meeting to be rescheduled to "Friday". This percentage was significantly higher than that of the contrary perspective ($Z = -2.16; p = 0.03$ by a Sign Test) (Table 2). There was no meaningful relationship between feelings of depression and the temporal perspective preference ($F(2, 59) = 1.23; p = 0.30$) (Table 3), but the approach motivation proved a reliable predictor of the latter ($F(4, 57) = 3.05; p = 0.02$) (Table 4).

In agreement with the hypothesis, a full 71.7% of the participants in the spicy condition exhibited the inclination for the ego-moving perspective and decoded the ambiguity as "Friday", which was distinguishably different from those who adopted the opposite perspective ($Z = -3.23; p = 0.001$ by a Sign Test) (Table 2). Again, ratings of anger ($F(1, 58) = 1.99; p = 0.16$) did not predict the temporal perspective preference (Table 3) but the approach motivation did ($F(6, 53) = 2.91; p = 0.02$) (Table 4).

One-way analyses of variance revealed that participants in the sweet condition reported significantly greater happiness than those assigned to the bitter condition ($p < 0.001$; $CI = [2.02-2.78]$), but not than those in the sour condition ($p = 0.08$; $CI = [-.025-0.74]$). Interestingly, the spicy snack should make participants substantively happier than the sweet option ($p = 0.01$; $CI = [-0.87- -0.10]$). As for jealousy, the sour snack generated significantly greater such emotion than the sweet ($p = 0.001$; $CI = [0.06-0.32]$) and the spicy conditions ($p = 0.01$; $CI = [0.02-0.28]$), but not than the bitter condition ($p = 0.66$; $CI = [-0.72-0.19]$). As regards depression, participants in the bitter condition gave considerably higher ratings than those in the other three conditions, $F(3, 237) = 129.98, p < 0.001$. However, no statistical significance was detected between the four conditions in respect of anger, $F(3, 237) = 0.95, p = 0.42$. In light of approach motivation, a Chi-Square test of independence was carried out and the results indicated that approach motivation scores differed noticeably among the four taste conditions ($\chi^2_{1,80} = 51.09; p < 0.001$, Cramer's $V = 0.46$), with sweet taste generating the weakest degree (Table 4). Finally, a correlation analysis found no meaningful relationship between happiness and approach motivation across sweet ($r = -0.23; p = 0.08$), sour ($r = 0.19; p = 0.16$), bitter ($r = 0.12; p = 0.34$), and spicy ($r = -0.07; p = 0.58$) conditions.

Table 2: Numbers of the ego-moving perspective and the time-moving perspective preferred by the four taste conditions

	Ego-moving perspective	Time-moving perspective
Sweet	21	39
Sour	39	20
Bitter	40	22
Spicy	43	17

Table 3: Mean/standard deviation of emotions rated by four taste conditions

	Happiness	Jealousy	Depression	Anger
Sweet	6.82/0.68	1.00/0.00	1.45/0.62	1.10/0.35
Sour	6.46/1.09	1.19/0.39	1.27/0.52	1.14/0.35

Bitter	4.42/0.62	1.13/0.34	2.77/0.61	1.21/0.41
Spicy	7.30/0.79	1.03/0.18	1.08/0.28	1.17/0.38

Table 4: Mean/standard deviation of approach motivation rated by four taste conditions

	Sweet	Sour	Bitter	Spicy
Approach motivation	9.97/1.26	11.20/1.32	11.39/0.86	12.32/1.37

For the most part, the results in Study 1 contradicted the hypothesis and generated evidence that when reasoning about time, participants who had the sweet-tasting snack were more likely to adopt the time-moving perspective than the ego-moving perspective but the opposite was true for those who had the sour-, bitter- and spicy-tasting snacks. The effect of tastes on temporal perspective preference was not attributable to the emotional responses elicited but to the approach motivation aroused by the gustatory stimuli. Noteworthy, a stronger inclination for the ego-moving perspective was observed in both the spicy condition and the bitter condition, where the former elicited the highest happiness and the latter elicited the highest depression. Built on the influence of taste perception on time conception, Study 2 proceeded to investigate the reverse impact by comparing the snack choices made immediately subsequent to the primes of ego-moving and time-moving contextual statements.

2.2. Experiment 2: The influence of temporal perspective on taste preference

2.2.1. Participants

A total of 83 undergraduate and postgraduate students from two universities in southwest China agreed to participate in the experiment. They were randomly assigned to the ego-moving (ME) group, 41 in total (27 females) with an average age of 20.80 years and the time-moving (MT) group, 42 in total (29 females) with an average age of 21.10 years. All of them came from mainland China and none of them had participated in Study 1. Their time was compensated with a notebook.

2.2.2. Materials and procedure

They were seated before desks in quite classrooms throughout the experiment. Copies of questionnaire were distributed and four kinds of snacks prepared. Modeled after the elicitation method used by Duffy (2014: Experiment 1) and based on the multi-item confirmatory questions created by Richmond and collaborators (2012: Study 1), the priming tasks were composed of three blank-filling exercises with preset answers. Exercises were respectively and in this order time-, day-, and date-centered questions, as in 1) 原本设定于早上 8 点的闹钟现在被移动了 10 分钟。现在闹钟是在早上_____响铃。(The original alarm set for 8 am has been moved 10 minutes. Now the alarm is set for _____.); 2) 原本计划于下周三举行的会议现在被移动了三天。现在会议是于_____举行。(Next Wednesday's meeting has been moved three days. Now the meeting is on _____.); 3) 原本定于 4 月 13 日开幕的校运动会被移动了一周。现在运动会于_____开幕。(The university sports meeting was due to take place on 13th April but the opening date has now been moved a week. Now the sports meeting kicks off on _____.). Participants were instructed to write in a specified time scheduled from either the ego-moving perspective or the time-moving perspective as different conditions dictated. Specifically, the ME group were instructed to write in individually 8:10, next Friday, 20th April (seeing themselves as actively approaching the future event) and the MT group to fill in 7:50, next Monday and 6th April (seeing the future event as coming toward the stationary self). All questions and instructions were printed on one side of the questionnaire. Following the filling drills and on the other side of the questionnaire, participants were then asked to rate their current feelings of happiness on an ascending scale of "1 = not in the least" to "9 = extremely" as well as the Chinese translation of the BAS Drive subscale (Carver & White,

1994). Finally, they chose one of the four snacks, i.e., Oreo Cookies, Dark Chocolate, Dried Plums and Spicy Beef Jerky for immediate consumption and rated the tastes (i.e., sweet, sour, bitter and spicy) of the chosen snack.

2.2.3. Results and discussion

Screening checks. Knowing that the tastes of a snack would be inevitably mixed, we only included responses that registered correctly the most prominent and intended taste of the snack. If a snack was rated as inhabiting two tastes in equal measure, as in rating the plums as equally sour and sweet, such a response would be excluded. Altogether, the screening checks rendered 2 samples in the MT group and 1 sample in the ME group respectively invalid, all due to the said scenario.

Main analyses. On the whole, the results were in consistence with the hypothesis and the previous finding that the time-moving perspective induced greater happiness and approach motivation (Richmond et al., 2012; Ruscher, 2011). A Chi-Square test of independence showed that there was significant difference between the two groups in terms of snack choice ($\chi^2_{1,80} = 24.35; p < 0.001$, Cramer's V = 0.55) (Table 5). More specifically, compared with those in the ME group, participants in the MT group preferred in statistically significant numbers the Oreo cookies ($\chi^2_{1,80} = 24.29; p < 0.001$, Cramer's V = 0.55) but were drastically less likely to choose dried plums ($\chi^2_{1,80} = 4.10; p = 0.04$, Cramer's V = 0.23), dark chocolate ($\chi^2_{1,80} = 4.77; p = 0.03$, Cramer's V = 0.24), and spicy beef jerky ($\chi^2_{1,80} = 5.07; p = 0.02$, Cramer's V = 0.25). The employment of the same analytical test revealed that being primed with the ego-moving perspective made participants distinctly happier ($\chi^2_{1,80} = 10.38; p = 0.03$, Cramer's V = 0.36) and possess stronger approach motivation ($\chi^2_{1,80} = 12.24; p = 0.03$, Cramer's V = 0.39) than being primed with the contrastive time-moving perspective (Table 6). In short, priming the time-moving perspective made participants remarkably less happy and approach-motivated, as evidenced by the disproportionately high number of sweet-flavored snack choice of the MT group for sweet taste can improve mood (Meier et al., 2017).

Table 5: Numbers of snack choice made by the MT and the ME groups

	Oreo cookies	Dried plums	Dark chocolate	Spicy jerky
MT group	31	3	2	3
ME group	10	10	9	12

Table 6: Mean/standard deviation of happiness and approach motivation rated by the MT and the ME groups

	Happiness	Approach motivation
MT group	5.77/0.99	10.92/1.09
ME group	6.51/1.14	11.73/0.87

3. General discussion

3.1. Overview

Two studies have been conducted to investigate the relationship between tastes and the metaphorical perspectives of time. Study 1 compared the ways in which participants reasoned about a temporally ambiguous situation after ingesting sweet-, sour-, bitter- and spicy-dominated snacks. It was found that participants in the sweet condition tended to disambiguate the "Next Wednesday's meeting" as to be rescheduled earlier to the next "Monday" by adopting the time-moving perspective whereas those in the other three conditions interpreted it to be postponed to the next "Friday" by adopting the ego-moving

perspective. Further analyses revealed the uniform predictive power of approach motivation of temporal representation across four taste conditions, with spicy taste generating the strongest approach motivation and sweet taste the weakest. Partially echoing the previous findings on taste-emotion associations (Zhou & Tse, 2020) that associated sweet with happiness, sour with jealousy, bitter with sadness and spicy with anger, our results showed that 1) it was only when compared with bitter taste that the tight connection between sweet taste and happiness was proven strong, for sweet taste generated no greater happiness than sour taste; 2) the jealous ratings given by the sour condition, albeit significantly higher than those given by the sweet and the spicy conditions, were not markedly different from those given by the bitter condition; 3) bitter taste generated significantly higher degree of depression than the other three tastes; 4) spicy taste brought about an outstandingly high level of anger rather than an overridingly high level of happiness. Replicating previous results (Hauser et al., 2009; Richmond et al., 2012) to a certain degree, our findings showed that participants with stronger approach motivation would lean toward the ego-moving perspective but this was the case in spite of consuming contrasting tastes of spicy and bitter and generating polar opposite emotions of happiness and depression. Probing into the reverse effect of temporal perspective on taste preference, Study 2 primed participants with either ego-moving- or time-moving-framed contextual statements before asking them to choose the four differently flavored snacks. The results revealed that participants primed with the time-moving perspective desiderated the sweet-dominated snack considerably more but coveted the other three options significantly less than those primed with the ego-moving perspective.

3.2. Discussion

The reason why participants leaned toward the time-moving perspective and reported the least approach motivation after consuming sweet-dominant cookies is probably because sweet is the foremost and the most familiar taste that is synonymous with mother's love and care (Meier et al., 2012). In this sense, experiencers of sweetness would most likely nestle in such feelings and have every wish to perpetuate the status quo, mirroring the temporal attitude that characterizes the present hedonists (Zimbardo & Boyd, 1999). Indeed, research found that people with higher present hedonism tended to adopt the time-moving perspective and demonstrated lower levels of personal agency (Richmond et al., 2012). Given that participants tasting the bitter chocolate gave distinctively higher ratings of depression than those in the comparative groups and that they also exhibited a relatively high level of approach motivation, we believe that this bitter-induced inclination for the ego-moving perspective could be accounted for by the fact that bitter is a marker for toxins that is incompatible with survival instinct (Sagioglou & Greitemeyer, 2016) and it is human nature to withdraw from things and people they find aversive or even threatening. In other words, the oral objection to bitterness and the psychological rejection it brings on would activate a flight-like behavioral mode, one that features involuntarily getting away from the current state of unpleasantness. This behavioral tendency bears no small resemblance to the ego-moving representation in which the ego is metaphorically conceptualized as leaving the present for the future. Indeed, previous research has shown that recalling an unpleasant past event is more likely to prompt the ego-moving perspective (Lee & Ji, 2014). Another possibility is that in Chinese, bitterness is often associated with the notion of going through tribulations (e.g., 吃苦 "eating bitter"), and research found that tasting something bitter increased self-reported motivation and intention to exert effort for Chinese participants (Xu et al., 2020). Thus, the possibility that the bitter-induced approach motivation was driven by the tenacity and endurance as a result of language-specific metaphorical connotations cannot be discounted. Also generating the propensity for the ego-moving perspective was the sour taste, whose jealous ratings were distinctly higher than those given by the sweet and spicy tastes but not by the bitter taste. Sour and bitter both carry negative emotional valence (Zhou & Tse, 2020) and in Chinese

we use “酸苦 (sour bitter)” to express poignancy and pain, which are concomitant characteristics of anyone jealous of a love rival or intolerant of unfaithfulness. Due to there being no correlation found between jealousy and temporal perspective, it would be unsafe to relate jealousy to the ego-moving perspective. Nonetheless, the explanation for the sour-induced ego-moving perspective bias might be helped with the insights from the more recent research findings. It was found that sourness was most strongly associated with surprise (Gayler & Sas, 2017), in which case it is possible that had surprise been included as an independent variable of emotion, the relationship between sour-induced emotion and temporal perspective choice might have been different. More probably, another study found that sour is potentially linked with the risk-taking behavior (Vi & Orbrist, 2018) that embeds an urge to make a break from the present for new challenges, which is not dissimilar to the approach-oriented behavioral tendency that spicy taste is normally associated with (Byrnes & Hayes, 2016). In this case, the sour-induced preference for the ego-moving perspective may be the result of potential taste-related personality traits (e.g., Sagioglou & Greitemeyer, 2016). In the same vein as the sour taste, spicy taste also led to the partiality for the ego-moving perspective. However, behind this tendency lies not the spicy-induced anger, as is the case with metaphorical association on the semantic level (Zhou & Tse, 2020), because instead of provoking angry feelings, tasting the spicy snack actually produced the highest degree of happiness among the four. Because people with positive emotions are more likely to adopt the ego-moving perspective (Richmond et al., 2012; Zheng et al., 2019), the spicy-induced ego-perspective bias could be put down to the happiness generated. Three possibilities may explain the spicy-happiness association. The first one involves the origin of the participant population. The majority of the participants came from south China where eating spicy food is of culinary and physical necessity because of the damp and humid climate. It is therefore possible that they enjoy the spicy taste the most for its familiarity and health benefits. Similarly, due to our failure to ask the participants' personal liking for the snack, the possibility that the spicy snack (i.e., beef jerky) as a whole made participants happier more than the single spicy taste did cannot be excluded; after all, taste, flavor and texture are perceived during chewing and will all contribute to the appreciation of the food (Pereira & van der Bilt, 2016). The third and most probable cause has to do with the fact that spicy taste is associated with adventurous (Mukherjee et al., 2017; Wang et al., 2016) and aggressive (Batra et al., 2017) personalities and seeking risk is a primitive behavior that may lead to happiness by affording excitement through self-actualization (Vi & Orbrist, 2018). Apart from accounting for the spicy-happiness connection, this explanation also sheds light on the spicy-induced high approach motivation, as adventure and risk seeking implants the behavioral inclination of someone actively approaching a new goal, a pattern that typifies the ego-moving perspective of time. Either way, spicy taste is more closely related to the ego-moving perspective.

Seemingly contradictorily, both spicy and bitter conditions, where the greatest happiness and the greatest depression were reported, yielded high approach motivation. The explanation might have to do with the fact that emotion is elementally a two-pronged motivational system, one characterized by the appetitive tendency and the other the defensive tendency (Lang et al., 1997). The appetitive state is primarily activated by pleasantly valenced stimulus and the defensive state by unpleasantly valenced contexts and in both contexts, approach- and avoidance-directed behaviors are functional (Lang & Bradley, 2013). Approach motivation features behaviors that engage goals, whereas inhibitive and passive behaviors typify avoidance motivation (Higgins, 1997). This would suggest that the approach motivation in the case of spicy taste was activated by the pleasant emotion that was the product of personally judged palatable food consumption because the happier you feel about something, the stronger motivation you have toward approaching it. The approach motivation that was shared by the bitter taste, on the other hand, was

activated by the urge to get rid of the present unpleasantness. As mentioned earlier, unpleasant contexts can activate both approach-driven and avoidance-driven behaviors (Lang & Bradley, 2013) and when the unpleasantness of the bitterness set in, the experimenter could not disengage from the said feeling quickly enough by actively moving away from it and approaching something more pleasant. This is not exceptional considering that it is human's biological instinct to avert things and people that displease them because psychological discomfort can be translated into physical distance. Yet, no correlation between happiness and approach motivation was detected, thus rendering the account of emotion-mediated approach motivation invalid and the established understanding that positive affect is typically associated with approach motivation and negative affect with avoidance motivation (Margolies & Crawford, 2008; Richmond et al., 2012) unchallenged. Nevertheless, a more nuanced approach toward emotion-motivation relationship is warranted. The proposition that approach motivation may be activated whenever the experimenter feels the urge to distance themselves from the present in time or the current position in space, irrespective of being driven by aspiration or desperation is worth pondering. Finally, in line with the previous observation (Richmond et al., 2012), our results also showed that stronger approach motivation is connected with higher likelihood of the ego-moving perspective. This link is formed via their similar movement pattern in space as the "ego" in the ego-moving perspective is metaphorically represented as proactively approaching a certain future event.

Largely congruent with the taste-emotion metaphorical associations (Zhou & Tse, 2020), Study 1 produced confirmatory evidence of sweet-happiness, sour-jealousy and bitter-depression metaphorical couplings, thus corroborating the embodied metaphor theory that the understanding of abstract and intangible concepts is grounded in the bodily experiences (Lakoff, 2012). Exceptionally, we also observed the metaphor-inconsistent evidence for the spicy-happiness association, for which three explanations are provided. The first one has to do with the intensity of the tastes not being strong enough. For example, research has connected higher intensity of taste to stronger intensity of affective response (Wang et al., 2019). That the majority of the participants were from the south of China where spicy is the spirit of the regional cuisine makes it reasonably likely that they have an acquired higher spicy food tolerance and thus deem the spiciness of the beef jerky at a level that is not remarkable enough to override other concomitant balancing tastes of saltiness and sweetness. However, considering that the data entered for analysis were based on participants who had successfully discriminated the prominent taste from the obscure or non-existent ones in a given snack, this proposal lacks explanatory force. The second one concerns the fact that whilst taste is a single sensory experience on the tongue of sweet, sour, bitter, salty and umami, flavor involves a complex multisensory experience integrating taste, smell, touch and temperature (Gayler et al., 2019). Lacking information on how participants' preference on food flavor opens the possibility that it was not the single taste per se but the flavor of the snack or the snack itself that motivated the emotion. The final possibility is that as a result of indefiniteness on the origin of taste-emotion metaphorical associations in Chinese (and perhaps other languages), sensory judgments may not always influence emotions the way bodily based metaphors imply (Chan et al., 2013). In this case, what might be worth looking into in future is whether our taste-emotion metaphorical associations may not be restricted to one-to-one but extended to one-to-multiple pairings that are updated and informed by experiments done in real-life contexts. For example, studies have revealed that sourness was most strongly related to surprise (Gayler & Sas, 2017) and bitterness to fear (Chen & Chang, 2011).

Consistent with previous research that has demonstrated that time-moving representation would afford a weaker sense of optimism and personal agency (McGlone & Pfiester, 2009; Richmond et al., 2012; Ruscher, 2011), Study 2 found that participants primed with the time-moving perspective were disproportionately in favor of the sweet-tasting snack. This is probably because less happy emotion is more likely to be compensated by sweet

absorption (Aguiar-Bloemer & Diez-Garcia, 2018). For example, Cai and collaborators (2017) examined the effect of bitter flavor on consumer behavior and the results showed that drinking a bitter beverage decreases unhappy participants' inclination to save money. One possible reason was that the bitter taste activated pertinent negative concepts and made participants' unhappiness even worse. As such, individuals turned to the happiness-inducing behavior of spending money to neutralize the bitter-worsened unhappiness.

Taken together, the present study testifies to the theoretical accounts of embodied cognition that cognition involves a combined stimulation of sensory, motor or affective states (Ostarek & Huettig, 2019), with experience-sensitive sensory-motor simulations functionally contributing to higher-level cognitive processing (Ostarek & Bottini, 2020). Different gustatory stimuli will generate different emotions and different levels of approach motivation that simulate movement in the psychological space. This movement simulation forms the basis for the comprehension of temporal event as a result of the spatial grounding of time (Clark, 1973; Lakoff & Johnson, 1999). Moreover, it contributes to the multi-disciplinary research on the metaphorical representation of time by establishing a link between time and the seemingly unrelated domain of tastes, which validates that the same concrete and perceptual domain can lend itself to the conceptualization of more than one abstract domain (Niedenthal et al, 2005). For example, space, being the source domain for metaphorical mapping, can ground beyond time and towards other similarly abstract domains of emotion, social status and personality traits (Duffy et al., 2014; Hauser et al., 2009; Meier & Robinson, 2004). Adding force to this claim, our evidence suggests that the sensory-perceptual domain of taste can exert influence on emotion as well as time. Future inquiries into the potential roles of other senses (i.e., olfactory, tactile and auditory senses) in the malleability of time conceptualization may be considered.

4. Conclusion

People's reasoning about a temporally ambiguous event can be impacted by spatial and non-spatial factors (e.g., Boroditsky & Ramscar, 2012; Duffy et al., 2014). Among the latter, emotion has proven convincingly influential. Conjoining this with a separate line of research on the taste-emotion metaphorical associations, the current research has examined the bidirectional relationship between taste and time. The findings indicate that gustatory perception can influence temporal representation, in a way that is not so much dictated by taste-induced emotions as it is underlain by taste-induced approach motivation. Our results also confirm that positive and negative affects are respectively embedded in the ego-moving and the time-moving representations and suggest that the intensity of such affects may be moderated by tastes. Taken together, the data from the present research provide substantiating evidence for the malleability of people's conceptualization of time and the embodied basis of abstract concept comprehension. Further research should consider exploring the influence of sensory stimulation on temporal conception. For example, if sweet taste makes the experiencer lean toward the time-moving perspective (Study 1) and sweet taste and feelings of love share neural substrates (De Araujo et al., 2003; Ren et al., 2014), it would be interesting to know whether people in a romantic relationship would also tend to adopt the time-moving perspective when reasoning about the temporally ambiguous event. Contrastively, bitter taste prompts an adoption of the ego-moving perspective and bitter in Chinese is metaphorically consistent with motivation and exertion (Xu et al., 2020). Whether Chinese people going through a tough and challenging period would be more likely to adopt the ego-moving perspective than is normally the case or English speakers whose language does not have bitter-toughness metaphorical association also makes for a worthy follow-up investigation.

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