# MAKING SENSE OF GROUNDED COGNITION:

# THE INTERPLAY OF ACTUAL AND SIMULATED SENSORY EXPERIENCES OF TASTE

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**Making Sense of Grounded Cognition: The Interplay of Actual and Simulated Sensory Experiences of Taste**

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## ABSTRACT

Previous literature of grounded cognition has mainly demonstrated the influence of bodily states on abstract conceptual processing in the mind. On the other direction, it has also demonstrated the influence of the mind on behavioral performance, intention, and attitudes. The present research illustrates effects of both directions in a more concrete, deliberate, and sensory level by showing the bidirectional influences of actual and mentally simulated sensory experiences (mental image) of taste. In study 1, I show that actual taste of a salty and spicy food item could induce a contrast effect on the imagined sweetness of a sweet food item in mental simulation. This effect is only present for subjects who experience a high degree of mental simulation of the sweet food item but not for subjects experiencing a low degree of simulation. In study 2, I show the opposite that mental simulation of a salty and spicy food item could induce a contrast effect on the actual perceived sweetness of a sweet food item. This effect is more pronounced for subjects experiencing a high degree of mental simulation of the salty and spicy food item but is debilitated for subjects experiencing a low degree of simulation. The pattern of the results renders those pure semantic and cognitive models unlikely to account for the observed findings. The present research thus acts as cogent evidence supporting the multimodal simulation construct and extends findings in the grounded cognition literature.

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# 1. INTRODUCTION

Imagine finding a new chocolate brownie product at the local bakery that you have never tried before. How do you make product evaluations before a purchase decision is made? Under such circumstances, especially those involving food products, two strategies may be common for most of the consumers. First, when possible, consumers can evaluate the product by actually tasting it. Alternatively, consumers automatically or upon being encouraged may evaluate the product by mentally simulating the sensory experience of tasting it (MacInnis & Price, 1987). Both strategies may be applied for different products depending on their respective availabilities. Under some situations, consumers may be incidentally eating (thinking about) some other food when mentally simulating (actually tasting) the product at evaluation.

A question arises—will these actual taste experiences and mentally simulated taste experiences have a direct impact upon each other (in a bottom-up manner, i.e., without involvement of interpretation and prior knowledge in the formation of perception and judgment)? This question is important as it points to some debates about the nature of mental representations in the field of cognitive psychology (Barsalou, 1999). It is important also because its implications help marketing practitioners make more careful arrangements or controls in promotion.

The answer to this question appears negative from the perspective of traditional cognitive psychologists. It has long been assumed that our cognitive representations and operations are rooted mostly on amodal symbols (Fodor, 1975; Pylyshyn, 1984). These theories hold the view that original sensory inputs from various sensorimotor modalities of the body (e.g., perception, motor action, and introspection) must first be transduced into abstract symbols in the brain. It is these abstract symbols that underlie and afford our cognitive representations and activities.

One consequence of this abstraction process is the loss of the analogical modality-specific information and thus the resulting symbols are *amodal* (consists of language-like symbols without analogical information of various sensorimotor systems). For example, these perspectives assume that when we mentally simulate the experience of eating potato chips, only feature lists of the relevant situations are highlighted but these lists should have nothing to do with the relevant sensorimotor systems. Likewise, any actual sensory experience can hardly exert any influence on our cognitive activities directly online before it is translated into operational symbols in the brain. In other words, these views assume that our minds and bodies are highly dissociated and actual experiences and mental simulations should work in a parallel way.

However, much evidence suggests a necessary revisit of this question. Numerous studies from the neuroimaging literature indicate that mutual neural substrates underlie both mental simulations and actual perceptions. For examples, almost identical brain areas underlie both visual mental imagery and actual visual perceptions (Klein et al., 2004; O'Craven & Kanwisher, 2000); viewing pictures of manipulable objects activates neural circuits involved in actual grasping motion (Chao & Martin, 2000); and pictures of appetizing foods activates gustatory cortices (Simmons, Martin, & Barsalou, 2005). This close intimacy between mental simulations and actual sensory perceptions makes it reasonable to infer that mentally simulated taste experience and actual taste perceptions could interfere with each other in a direct and bottom-up manner.

The present research aims to empirically explore the above question in a consumer behavior context. Specifically, it shows that incongruity in taste (flavor) between actual and simulated taste experiences can have bidirectional impact upon each other. Since taste may involve all other senses such as touch, smell, sound, and vision (cf. Krishna, 2010, 2012), the term incongruity here mainly refers to disharmony in flavor. Through two studies, we demonstrate that actual taste of something spicy and salty can cause later mental simulation of a piece of dessert to be sweeter and attitude towards the dessert to be higher (study 1). In the other direction, prior mental simulation of something spicy and salty can cause the actual perceived sweetness of a piece of dessert to be higher and can also heighten the attitude and purchase intention of the dessert (study 2). Importantly, in both of the two studies, the effects are more pronounced for subjects who experience/use a high degree of mental simulation when evaluating the stimulus, but not for those subjects who employ a low degree of mental simulation.

The present research belongs and contributes to the domain of sensory marketing, which refers to “marketing that engages the consumers’ senses and affects their perception, judgment, and behavior” (Krishna, 2012, p.333). According to Krishna, sensory marketing involving sensations and perceptions can be used to influence both abstract notions and perceived quality of the product, and the link connecting the concrete sensation/perception to these various psychological or behavioral effects is based upon grounded cognition theories (see figure 2, Krishna, 2012).

The present research is also in line with the grounded cognition perspective for it provides an appropriate theoretical account for the underlying mechanisms of the hypothesized findings. As discussed later, purely amodal and cognitive theoretical models are highly unlikely to account for the observed findings. In addition, importantly, the findings of the present research bridge two critical research gaps in the grounded cognition literature by demonstrating the sensorimotor systems' influences upon mental imagery instead of abstract conceptual processing, and by demonstrating the influences from mental imagery or simulation on actual perceptions instead of behavioral performances or intentions.

Before the major hypotheses of this research can be made, explanations of the grounded cognition theories and reviews of relevant findings are necessary and helpful. The following section gives an adequate and relevant review of the grounded cognition literature in the fields of psychology and consumer behavior, identify the research gaps, and establish the research hypotheses.

# 2. LITERATURE REVIEW AND HYPOTHESES

## 2.1 Grounded Cognition

Traditional research on human cognition leans heavy on the theoretical perspective that cognitive representations and functional operations are rooted mostly on amodal symbols (Fodor, 1975; Pylyshyn, 1984). This view assumes that informational inputs from various sensorimotor modalities (e.g., perceptions, motor action, and introspective states) of a person during knowledge acquisition and interaction with the real world are transduced into abstract symbols which afford later mental representations, cognitive operations, and memory. However, different theoretical stands on the nature of cognitive representations have also accumulated converging evidence during the past decades. This line of research, which may be categorized under the term *grounded cognition*, points to the view that our cognitions also utilize heavily on actual bodily states and mental representations that are grounded across various sensorimotor systems (Barsalou, 1999, 2008; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005).

### 2.1.1 Theoretical Foundations

Barsalou's (1999) Perceptual Symbol System (PSS) theory serves as a major cornerstone for recent grounded cognition studies (some other theories also contribute to the development of grounded cognition, for reviews, see Niedenthal et al., 2005; Barsalou, 2008). It differs with the traditional approach on the nature of mental representations that underlie human cognition (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). The PSS theory proposes that our mental representations in cognition are not based exclusively on abstract and amodal symbols but also ground on the sensorimotor systems of our body and simulations in the modality-specific regions of the brain. Specifically, according to the PSS theory, our mind records information across modalities (perception, motor action, and introspection) during knowledge acquisition and there is no such a region in the brain where these modality-specific information is transduced into abstract symbols specific for cognition (cf. Damasio, 1989). Consequently, the processing of concepts and constructions of sensory imageries in our minds are not based upon disembodied symbols but upon multimodal representations/simulations that incorporate and represent information from various sensorimotor modalities, which include perceptions, motor actions, and introspections.

This assumption of multimodal mental representations/simulations in cognition has two major implications. First, inputs from different modalities of the sensorimotor systems should have direct impact upon cognition, since they are considered integral and legitimate constituents of the knowledge association network of many concepts. Second, relevant literature reveals that the multimodal mental representations have their neurobiological substrates, which are corresponding simulations in the modality-specific neural regions in the brain (e.g., Barsalou, 2008; Niedenthal et al., 2005). This implies a more direct and spontaneous influence from cognition to neural activities and even behaviors and intentions. The first line of implication mainly points to the concept of embodied cognition, which denotes influences of actual bodily states on conceptual processing. The second line of implication has been researched under the concept of situated conceptualizations and actions (Barsalou, 2003), which denotes the reversed influences from conceptual processing on modality-specific systems. The following subsections give relevant reviews of these two lines of research in psychology as well as in marketing research in order to further explicate the grounded cognition theories and help to identify the research gaps that the present research sets to bridge.

### 2.1.2 Embodied Cognition—Influences of Actual Bodily States on Conceptual Processing

The origin of grounded cognition views traces back to early findings that demonstrated the possibility of hardwired bodily states influencing upon cognitions (which broadly includes attitude, social perception, judgment and decision making, emotion, memory, and etc.). In embodied cognition research, the pertinent bodily states that are able to exert an influence upon cognition differ with their degrees of innateness to learnedness. At one extreme, highly innate bodily states may serve as a hardwired mechanism of cognition. A prototypical exemplification of this sense of embodied cognition is the Hard Interface Theory (Zajonc & Markus, 1984). It proposes that our bodily states (including muscular states, motor actions and endocrine activities) may function as ‘hard representations’ to our cognition without corresponding ‘soft representations’ in the brain. It means that cognitive representations that are essential to any cognitive activities consist of not only mental forms but also actual embodiments.

Empirical findings supporting the Hard Interface Theory have mostly come from studies in the sphere of affective science. A good example is the facial feedback hypothesis. In a well-designed experiment, Strack, Martin, and Stepper (1988) let one group of subjects hold pens in their mouth in a way that facilitated the muscular activities involved in the action of smiling. They had another group of subjects hold pens in their mouth in a way that inhibited the muscular activities involved in smiling. The resulted facial expressions cannot be labeled under any clearly defined emotion categories. The researchers then let subjects from these two groups to rate several cartoons on how funny they are. The results show that subjects holding a pen in their mouth in a way that facilitates muscular activities in smiling reported more intense humor responses than subjects in the smile inhibiting condition did, and that the facial feedback didn't operate on the cognitive component of the humor response. This research confirmed the facial feedback hypothesis which claims the "causal assertion that feedback from facial expressions affects emotional experience and behavior" (Buck, 1980, p.813). Various other studies in affective science have also reported the role of bodily states in the automatic processing, categorization, and recognition of emotions (e.g., Neidenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Wallbott, 1991; Zajonc, Murphy, & Inglehart, 1989). This line of research shows us the essential role of these innate somatic (relate to the body and distinct from the mind) responses in conceptual processing.

Highly innate somatic responses may not be a consequence of social learning or motivational association. These highly innate bodily states can be considered to influence cognition as 'hard representations'. However, research has found various bodily states that are capable of affecting cognitions as a result of learned associations or co-occurrences in past real life experiences. For example, Wells and Petty (1980), under the pretext to test certain qualities of a headphone, had their subjects either nodding their heads or shaking their heads while listening to some messages. They found that subjects who nodded their heads while listening to the messages had more favorable attitudes towards the messages compared to subjects who shook their heads while listening. Chinese ideographs presented to western students gained more positive feelings when the students initially judged them during arm flexion (an approach behavior) than during arm extension (an avoidance behavior; Cacioppo, Priester, & Berntson, 1993).

The associations between these motor behaviors and their conceptual meaning are clearly a result of social and cultural learning, for in some cultures (for example, Albania) nodding and shaking your head may mean exactly the opposite as compared to that in most countries of the world and the valence attached to arm flexion and extension is likely an artifact of human practice. At the other extreme, Chandler and Schwarz (2009) have demonstrated that pure culturally idiosyncratic gestures, such as extending one's middle figure (under a pretext that does not induce its social meaning), can prime and influence judgments as well—an exemplification of totem embodiment (Cohen & Leung, 2009).

Motor behaviors associated with approach vs. avoidance have been repeatedly found to influence not only the encoding of attitudinal information but also the processing and retrieval of it. Chen and Bargh (1999) have demonstrated that subjects' processing of valenced words are faster when the valence of the words matched the valence of the responding behavior resulting from social learning (e.g., pulling—approach, pushing—avoidance). Forster and Strack (1996, 1997) have showed that subjects posturing an approach behavior (pulling up on a table from underneath its bottom surface) retrieved more positive-valenced information whereas subjects posturing an avoidance behavior (pushing down on a table on its top surface) generated more negative-valenced information.

All these findings as well as numerous other findings in the embodied cognition literature can be considered to work by activating simulations in which the pertinent bodily states are associated with the relevant concepts as a result of neural coactivation, which can be a result of either innate somatic responses or learned associations from past real life experiences. The presence of these actual bodily states works like a prime that makes the associated concepts ready and active, and thus facilitates the processing of these concepts.

### 2.1.3 Embodied Cognition in Marketing Research

Marketing researchers have also exploited theories and findings in embodied cognition research to discover their contributions and implications to consumer behavior research in the recent years. In a close vein with psychological studies demonstrating the effects of bodily movements or postures on attitude formations (e.g., Cacioppo et al., 1993; Chen & Bargh, 1999; Wells & Petty, 1980), Labroo and Nielsen (2010) had their subjects mentally simulate the physical sensations of either pulling a product towards themselves (the approach condition) or pushing the product away (the avoidance condition). The product used in this experiment is canned red curry grasshopper, which is commonly considered aversive by American students. The authors found a significant enhancement of the liking of the grasshopper in the approach condition compared to that of the avoidance and control conditions. Thus, merely mentally simulating the physical sensation of approaching can improve the evaluation for even naturally aversive products.

The authors explained their findings using the embodied cognition perspective, arguing that the simulation of respective sensations activates "a host of perceptual, motor, and introspective states normally associated with the sensation and acquired when experiencing the sensation" (Labroo & Nielsen, 2010, p.144).

Hung and Labroo (2011) argued that firming one's muscle is often concomitant with situations of endurance and self-regulation. Based on embodied cognition theories, they inferred and successfully demonstrated that firmed muscles can be not only a simple company or consequence, but also a cause of strengthened self-regulation. Results from their study (Hung & Labroo, 2011) show that subjects firming their muscles are more likely to overcome aversive information to make a donation, to withstand immediate physical pain, and to consume some unpleasant product for long-term benefits.

Several studies have demonstrated that the concept of psychological or interpersonal warmth is embodied in physical warmth (IJzerman & Semin, 2009; Williams & Bargh, 2008; Zhong & Leonardelli, 2008). Based on this insight, Hong and Sun (2012) discovered a compensatory effect of the bodily sensation of warmth upon the liking of romance movies. They demonstrated that holding a cup of iced tea as well as being in lowered ambient temperature can cause enhanced desire for romance movies, which are generally associated with psychological warmth.

#### 2.1.4 Situated Conceptualizations and Actions—Influences of Conceptual Processing on Modality-Specific Systems

The research on facial feedback hypothesis by Strack et al. (1988) mentioned in the previous section has nicely demonstrated the causal flow from facial expressions to emotional responses. A recent study by Niedenthal, Winkielman, Mondillon, and Vermeulen (2009), however, has showed us the other side of the story. Using technology of facial electromyography (EMG), they found evidence of subjects employing facial embodiments when processing the conceptual meaning of emotional words but not when merely processing the case of the letters of the words. The activities of the cheek, brow, eye, and nose regions involved during specific emotions are reactivated during conceptual processing of the emotion concepts. This research implies that the causal relationship between conceptual processing of emotion and facial expressions can be bidirectional.

Influences of conceptual processing in the mind on sensorimotor systems have been demonstrated and conceptualized in the literature. According to the PSS theory, the simulation process is highly dynamic and context-dependent, preparing an individual ready for the processing of a specific category member in the specific situation at hand (Barsalou, 2003; Niedenthal et al., 2005). In this sense, our conceptualizations and cognitions are *situated*. *Situated conceptualizations* consist of a package of situation-specific inferences that include (1) contextually-relevant properties of the focal category, (2) background setting information, (3) likely actions the agent could take for specific goals under the situation, and (4) likely introspective states that the agent might have towards the category under the situation (Barsalou, 2003). Output from sensorimotor systems that are influenced by the simulations of situated conceptualizations under particular goal context can be referred to as *situated action* (Barsalou, 2008).

Neuroimaging evidence gives primary supports for situated conceptualizations and actions. Numerous studies have shown that mutual neural substrates afford both actual perceptions and mental imageries. For examples, a neural circuit involved in grasping were activated as subjects viewed pictures of manipulable objects (Chao & Martin, 2000); conceptual processing that is likely to involve mental imagery activates regions of visual association cortex (Kan, Barsalou, Solomon, Minor, & Thompson-Schill, 2003); people spontaneously simulate mental imageries or rely on multimodal representations when reading and conceptually processing (Bransford & Johnson, 1973; Speer, Reynolds, Swallow, & Zacks, 2009; Zwaan, Stanfield, & Yaxley, 2002); when reading manual-action verbs, the right premotor cortex was activated for the left-handed whereas the left premotor cortex was activated for the right-handed, showing that mental simulations are tailored to actual performances of a specific individual (Willems, Hagoort, & Casasanto, 2010).

With these findings showing a close intimacy between actual perceptions and mental simulations, we can well infer that activation of mental simulation should have some impact on actual perception or performance. Indeed, current research has shown that the influence of situated conceptualization can go beyond mere neural activations in the modality-specific regions in the brain and move on to affect actual behavioral performance, intentions, and judgments. For example, imagining performing certain activities can exert actual influence on musculature and cardiovascular systems (Deschaumes-Molinaro, Dittmar, & Vernet-Maury, 1992; Jeannerod, 2001). Ackerman, Goldstein, Shapiro, and Bargh (2009) have demonstrated that people can have ego-depletion (Muraven & Baumeister, 2000) by merely taking the perspective of the protagonist when reading a story of self-control. The authors explained their finding using the mental simulation account—reading and simulating the self-control story likely activated a multimodal representation of that activity, which subsequently led to the depletion of self-regulatory resources. We may thus conclude from this line of research that the multimodal mental simulations could create vicarious experiences that are more than shows in our abstract mind, but could cause consequences as those of the real ones.

In another line of research, Glenberg and Kaschak (2002) showed that when subjects used a forward hand movement to respond to the coherence of a sentence, their responses were faster when the judged sentence described a forward movement than a backward one. This effect is probably a consequence of situated conceptualization—reading the sentence involves the situated conceptualization which includes the simulation of the forward movement. This simulation of action makes actual motor action that is compatible with it in a more readily state and thus the processing or performance of the action is facilitated.

In addition, studies by Tucker and Ellis (1998, 2001) supports the idea that our minds often automatically simulate specific actions we could perform under goal-directed situations, and this mental simulation facilitates actual actions to which it mimics.

Subjects in Tucker and Ellis' (1998) studies were asked to judge as fast as possible whether a graspable object is upright or inverted defined with regard to its normal use. Though the left-right orientation of the object was judgmentally irrelevant, subjects responded faster when their responding hand was the same one as in a simulated grasping action of the object depicted on the computer screen (for instance, if the subject uses his or her right hand to response, a cup with its handle on the right side will be judged faster than a cup with its handle on the left side). The authors concluded from their findings that visual stimuli can automatically potentiate possible actions they afford, and our intentions to act operate upon mental representation of possible motor actions.

### 2.1.5 Situated Conceptualizations and Actions in Marketing Research (Intentions and Judgments)

Building on Tucker and Ellis' (1998, 2001) findings, Elder and Krishna (2012) carried out a series of studies in a consumer behavior context and further extended the implications of situated conceptualizations from affecting performed actions to affecting even purchase intentions. Two of their studies (study 1a & 1b, Elder & Krishna, 2012) showed and replicated the finding that advertisings that facilitate mental simulation of affordable actions towards a favorable product (for instance, a pictorial ad of yogurt with the spoon resting on the side of the plate that matches the subject's dominant hand, compared to ads depicting spoon on the side of the plate that matches the subject's non-dominant hand or ads depicting no spoon) can result in higher purchase intention of the product depicted. Ads that facilitate mental simulations of affordable actions towards an unfavorable product, on the other hand, decrease the purchase intention (Study 3, Elder &

Krishna, 2012). Moreover, the authors demonstrated that the effects on purchase intentions are mediated by mental simulations (Study 4, Elder & Krishna, 2012).

Interestingly, most studies in Elder and Krishna's (2012) research included only purchase intention as the dependent measure but not product evaluations. In their study 4 (Elder & Krishna, 2012), attitude toward the product (bad/dislike/unpleasant versus good/like/pleasant) was included as a dependent measure but failed to reach significance. In another similar research, however, Shen and Sengupta (2012) have demonstrated that occupying subjects' dominant hand can lead to lowered evaluations of the target product because it makes the mental simulation of the affordable action disfluent. However, when the object being held is compatible with the target product (e.g., holding a fork when evaluating a plate of noodles), evaluations of the target product are enhanced (Study 4, Shen & Sengupta, 2012). This effect occurred because this time the simulation of affordable actions is facilitated rather than impaired.

Together, evidence from section 2.1 has shown that the nature of the mental representations of consumers is rather compatible with the grounded cognition perspective. The multimodal simulations in the PSS theory act like a platform where the mutual impacts of actual sensorimotor inputs and conceptual processing are made possible.

### 2.2 Context Effects of Taste Perceptions

Context effects and biases are one of the major influences of taste perceptions (Lawless & Heymann, 2010), and under most circumstances they shall take the contrastive direction. For example, a low sodium soup with the same level of salt concentration was presented either with two lower salt-concentration soups or with two higher salt-concentration soups. The results show that the rating of the saltiness intensity of the target soup was significantly higher for the one in the lower salt-concentration context condition than the one in the higher salt-concentration context condition—a clear demonstration of contrast effect (Lawless, 1983). In another study, Mattes and Lawless (1985) found that when subjects were asked to optimize the level of sweetness or saltiness of a beverage by diluting or concentrating the beverage, the resulting level of sucrose and NaCl differed significantly for subjects starting at a very sweet or salty point, compared to subjects starting at the bland point, with the level of the former groups being significantly higher than that of the latter groups. The influence of this effect is very robust and bottom-up for it remained significant even the subjects were financially incented to try to achieve the same end-points in both trials, and it could not be attributed to sensory adaptation or lack of discrimination (Mattes & Lawless, 1985).

Though it may be less straightforward, the result in Mattes and Lawless's (1985) study is still a demonstration of contrast effect of taste perceptions. We can think of as if there is a value lying in the middle somewhere that represents the real optimizing level of the beverage (let's denote it as level a). For subjects starting at a dense point, a higher level of density (let's denote it as level b) is perceived by the subjects as if it were the real optimizing level (level a, which actually is lower than level b). Hence in this situation, the perception of a certain level of beverage density (level b) is biased in the direction against the context (a dense starting point), and therefore there is a contrast effect. The same rationale applies to the bland starting point condition.

Context effects are shown not limited to influence only actual taste perceptions but also mental simulation or memory of taste experience. In the so-called 'reversed-pair' paradigm in context effects studies, the contextual item appears after the actual perception of the target item, and thus any effect from the contextual item is supposed to impact on the mental simulation or memory of the experience of the target item but not on actual perceptions. Nevertheless, this paradigm shows similar contrast effects with those reported in the normal paradigm (e.g., Lawless, 1994; Lawless, Glatter, & Hohn, 1991). For instance, a shift in the rating of sweetness was observed when either a higher or lower sweet item was evaluated between the tasting and rating of a fruit beverage (Lawless, 1994).

## 2.3 Proposal of the Present Research

### 2.3.1 Identifying the Research Gaps

The literature of embodied cognition so far has mostly concentrated on studying the effects of bodily states and movements upon abstract cognitive processing (cf. Reimann et al., 2012). As reviewed in section 2.1.2 & 2.1.3, these include the effects of facial expressions on emotion processing (Niedenthal et al., 2009; Strack et al., 1988); the effects of head movements on attitude formation (Briñol & Petty, 2003; Tom, Pettersen, Lau, Burton, & Cook, 1991; Wells & Petty, 1980); the effects of movements or postures of upper and lower limbs on attitude formation, processing of valenced information, retrieval from memory, and willpower (Cacioppo et al., 1993; Chen & Bargh, 1999; Forster & Strack, 1996, 1997; Hung & Labroo, 2011), and also recently, the effects of sensory perceptions on social cognition and consumer choice (Hong & Sun, 2012; Williams & Bargh, 2008). Embodiment research has also demonstrated that our body can exert influence upon cognitive process in other ways, including influencing the amount of thinking, the direction of thinking, as well as thought-confidence (Briñol & Petty, 2008).

However, embodiment researchers may be overly fascinated by findings demonstrating the capability of concrete sensorimotor inputs affecting abstract conceptual processing and also the vice versa (see Lee & Schwarz, 2012) that they overlooked a concrete yet pervasive and important form of mental representation—mental imagery or simulation. Mental imagery, in the sphere of consumer behavior studies, is defined as "a process by which sensory information is presented in working memory" (MacInnis & Price, 1987, p.473). Such mental presentations "preserve the perceptible properties of the stimulus" and can "ultimately give rise to the subjective experience of perception" (Kosslyn, Ganis, & Thompson, 2006, p.4; see also MacInnis & Price, 1987). It is thus an indispensable form of mental representation that is clearly distinct from abstract conceptual processing (Paivio, 1986), and has long been an important topic of cognitive and consumer behavior research.

This undue negligence of mental imagery and simulation seems surprising given the importance of mental imagery in social cognition and marketing studies. In the field of social cognition, mental imagery and relevant constructs have wide implications in memory, emotion, persuasion, cognitive processing style, judgment, self-insight, mental representations, and et cetera (Libby & Eibach, 2011, in press). Mental imagery plays an even more important role in consumer behavior research. It affects a broad range of consumption processes and experiences including, for example, incidental learning, brand evaluation, conjunctive probability assessment, purchase intention, purchase time, consumption experience, and so on (MacInnis & Price, 1987). Relevant to the present study and a common consumption scenario, consumers often use elaborate preconsumption imagery as a vicarious consumption experience to mentally evaluate the product when situational contingencies do not allow nor encourage a real product trial. MacInnis and Price (1987) proposed that since mental imagery offers a sensory substitute, this deliberate vicarious consumption experience will be most influential when the product concerned is sensory in nature.

The question of whether sensorimotor systems can influence concrete mental imagery or simulation is worth investigating because contradictory predictions about this question may both be inferred. On the one hand, one may assume that concrete forms of mental representations should be more easily influenced by the concrete bodily states and sensory perceptions because of their close intimacy in nature. On the other hand, one may well argue that because mental imageries and simulations are concrete, they can be clearly construed and are not as easily biased as abstract conceptual processing. Therefore, the discussions above reveal an apparent need for researching the sensorimotor systems' influences on multi-sensory imagery in marketing as well as social cognition studies.

On the other hand, as we have reviewed, research in situated conceptualizations and spontaneous mental simulations has so far demonstrated their influences upon neural activations, behavioral performances, intentions, and judgments. There is little research demonstrating their abilities to influence actual sensory perceptions or judgments. Relevant evidence has come from another line of research in which abstract conceptual processing is found capable of influencing sensory perceptions or judgments. For example, recalling experiences of being socially excluded leads to lowered estimation of ambient temperature (Zhong & Leonardelli, 2008). Important information causes the weight of a book to be estimated higher (Schneider, Rutjens, Jostmann, & Lakens, 2011; but see Zhang & Li, 2012). By a similar vein of arguments, whether mental imagery or simulation can influence actual sensory perception is worth researching because a positive answer may be inferred from their intimacy and yet a negative answer can be inferred when it is reminded that certain sensory perceptions, such as the deliberate sensory experience of tasting of foods, can be quite concrete and intense that it seems very tenable to subtle or subconscious influences.

To summarize, discussion in this section identifies two research gaps. First, there is little research on the sensorimotor systems' influences upon mental imagery or mental simulations of sensory experiences. Second, from the opposite direction, there is little research on the possibility of mental simulations of sensory experiences affecting actual sensory perceptions and judgments. The present research aims to address both these gaps.

### 2.3.2 Research Questions and Hypotheses

The present research tries to address the above gaps by investigating if actual and mentally simulated taste experiences can have reciprocal influences upon each other. Specifically, this research explores the effects of taste incongruity (disharmony in flavor) between actual and mentally simulated taste experiences in order to better capture the hypothesized effect. For instance, if something salty or spicy is eaten before a piece of dessert, the dessert should taste sweeter than when tasted alone, a manifestation of the contrast effect. This inference is made from the contrast effects demonstrated in taste research and from our life experience that we often want to eat something sweet after eating something salty or spicy. But will a mental simulation of the dessert eating experience be similarly influenced by prior actual taste of something salty or spicy? Or conversely, will an actual taste of the dessert be influenced by a prior mental simulation of eating something salty or spicy?

These questions are important because our knowledge and understanding of the relationship between actual and mentally simulated sensory experiences accrue from a scientific investigation of them. They are important also because a clear understanding of them contributes to better design of marketing plans. We argue that the answers to the above questions are both affirmative and therefore it is the main thesis of the present research to demonstrate a closer intimacy between actual and mentally simulated sensory experiences.

From the perspective of grounded cognition, simple conceptual processing of concepts related to desserts, say, ‘chocolate’, can induce automatic simulations across modalities in the actual sensorimotor systems (e.g., the gustatory and olfactory perceptions of the chocolate, the motor action of biting the chocolate, and the proprioceptive feelings of eating the chocolate). Mental imagery or simulation of the eating experience makes the activation of such multimodal simulations more definite and conscious, because it actually corresponds to a more deliberate format of the multimodal simulation construct in the PSS theory (Barsalou, 2008; Elder & Krishna, 2012).

Therefore, it can be inferred that mental simulations of taste and other sensory experiences may cause somatic and neural responses in actual sensorimotor systems much the same as real sensory perceptions do. Numerous studies support this inference. Relevant to the present research, Simmons et al. (2005) have showed that simply viewing pictures of appetizing foods can activate neural circuit in gustatory processing areas in the brain, which is also active during actual tasting of foods. These neural reenactments in the modality-specific regions constitute our conceptual knowledge and inference of taste (Simmons et al., 2005).

In the present research, I argue and demonstrate that because of the mutual neural substrates shared by actual perceptions and mental simulations of taste, mentally simulated taste experiences should be capable of being affected and affecting actual taste perceptions in a direct and bottom-up manner. Specifically, according to the contrast effects demonstrated in taste research and laymen knowledge, I expect that (1) the imagined sweetness of a mentally simulated piece of dessert will be heightened after actual taste of something salty and spicy; (2) the actual perceived sweetness of a piece of dessert will be heightened after mentally simulating the taste of something salty and spicy.

As demonstrated in the grounded cognition theories, multimodal mental simulations in cognitions activate neural substrates in modality-specific systems. This is the key mechanism connecting the mind and the sensorimotor systems and thus renders the close isomorphism of actual and mental simulation of taste experiences proposed in the present research. Thus, the proposed effects are contingent on whether such multimodal simulations are activated. Though such multimodal simulations are proposed as an integral and automatic component of cognition in the grounded cognition theories, the activation and influence of them in cognition are nevertheless not definite or invariant (Ackerman, et al., 2009; Eelen, Dewitte, & Warlop, 2013; Maglio & Trope, 2012; Solomon & Barsalou, 2004 ). Since mental imagery or simulation actually corresponds to the deliberate activation of the multimodal simulation (Barsalou, 2008; Elder & Krishna, 2012), I infer that the proposed effects should be more pronounced when subjects have a high degree of mental simulation of the target stimulus, and that the effects should be less pronounced or eliminated when subjects have a low degree of mental simulation of the target stimulus.

According to the discussion in this section, I generate the following specific hypotheses:

**H1a:** The imagined sweetness of a sweet food item in mental simulations will be heightened after actual taste of a salty and spicy food item (contrast effect).

**H1b:** The effect in H1a should be more pronounced for subjects who have used a high degree of mental simulation of the target stimulus.

**H2a:** The actual perceived sweetness of a sweet food item will be heightened after mental simulation of a salty and spicy food item (contrast effect).

**H2b:** The effect in H2a should be more pronounced for subjects who have used a high degree of mental simulation of the target stimulus.

# 3. METHODOLOGY

## 3.1 Study 1: Actual Taste Affecting Mental Simulation of Taste

Design and procedure

Fifty-three undergraduate students from the Hong Kong Polytechnic University participated the experiment for a reward of 20 HKD coupons. Data of two subjects were deleted because they failed to follow the experimental instructions, leaving a sample of fifty-one subjects in the data analysis ($M_{age}$ = 21.59 years; 11 males).

Upon arriving at the lab, subjects were told that the study is part of some new product tests hosted by the university on behalf of the marketing departments of several companies in the Asia-pacific region. For some of the subjects, they were told that due to different policies of the companies, some products are available for actual trial whereas others are not. Each of these subjects was then provided a plate of potato chips (about 25g, spicy pizza flavor; please see appendix for all the experimental stimuli) for actual taste and then evaluated a chocolate brownie product depicted on individual computer screens by mentally simulate the eating experience. For other subjects, no potato chips were provided and they only evaluated the chocolate brownie product using mental simulation. Study 1 employed a two-factor between-subject design with the actual taste of potato chips (yes, no) being manipulated and the degree of mental simulation of the eating experience of the chocolate brownie being measured.

Measures

*Dependent variables.* Evaluative questions of the simulated chocolate brownie product served as the dependent variables. The key research interest lay in the imagined sweetness of the chocolate brownie product, and two questions were asked to tap on that. The first question asked directly subjects' imagined sweetness of the brownie (1 = not at all sweet, 7 = very sweet). The second question asked subjects their estimated sugar content of the brownie (1 = very low, 7 = very high). These two items were combined to form a single 'sweetness' measure of the simulated chocolate brownie product ($r = .77$, $p < .00$; Cronbach's alpha = .87).

Following these two questions, I also asked subjects questions about the imagined softness (1 = not at all soft, 7 = very soft) and texture (1 = very bad, 7 = very good) of the chocolate brownie, the general pleasantness of the simulated eating experience (1 = very unpleasant, 7 = very pleasant), their wish for a real taste (1 = not at all, 7 = very much), attitude (1 = very unfavorable, 7 = very favorable), and purchase intention of the chocolate brownie (1 = not at all likely to purchase, 7 = very likely to purchase).

*Degree of mental simulation.* After the dependent variables, three questions were asked to measure subjects' degree of mental simulation of the chocolate brownie eating experience from three different perspectives (cf. Bone & Ellen, 1992). The first question asked 'To what extent did you form a mental image (a picture in mind; imagination) of eating the chocolate brownie when you were evaluating it?' (1 = not at all, 7 = to a great extent). The second question asked 'On general, how vivid or lively is your imagined experience of eating the chocolate brownie?' (1 = not at all vivid or lively, 7 = very vivid and lively). The last question asked 'How fluent or easy is it for you to imagine the eating experience?' (1 = not at all fluent or easy, 7 = very fluent and easy). These three items were combined to form a single measure of 'degree of mental simulation' of the chocolate brownie eating experience (Cronbach's alpha = .87).

*Control variables.* For the subjects in the potato chip condition, after they finished the evaluative questions of the chocolate brownie product, they answered some questions in evaluation of the potato chips they had just tasted (all in the format of seven-point Likert scale). One item also asked if eating the potato chips has changed the subjects' mood in either direction (1 = very bad, 4 = have no effect on my mood, 7 = very good). For all the subjects, they indicated their personal preference for chocolate products (1 = do not like at all, 7 = like very much) and their general mood of the day (1 = very bad, 7 = very good). Subjects also filled up some personal information at the end of the experiment.

Results

Compared to the middle value (3.5) of a seven-point Likert scale, subjects in the potato chip condition ($n$ = 29) considered the potato chips as being spicy ($M$ = 4.48, $SD$ = 1.64; $t(28) = 3.23$, $p < .01$) and salty ($M$ = 4.52, $SD$ = 1.33; $t(28) = 4.13$, $p < .00$). Thus, the potato chip could be considered as in taste incongruity with the sweet chocolate brownie. This flavor of potato chips was chosen simply to make sure that the two stimuli are not congruent in taste (spicy and salty against sweet). Between the potato chip and no-chip conditions, there were no significant differences in subjects' personal preference for chocolate products ($M_{chip}$ = 5.48, $M_{no\text{-}chip}$ = 5.59; $t(49) = -.34$, $p = .73$) or general mood of the day ($M_{chip}$ = 4.76, $M_{no\text{-}chip}$ = 4.50; $t(49) = .96$, $p = .34$). Subjects in the potato chip condition generally had a positive preference for potato chip products ($M$ = 4.62, $SD$ = 1.55) and a positive attitude towards the specific stimulus in this study ($M$ = 5.00, $SD$ = 1.28). Eating the potato chips also affected subjects' mood in the positive direction to a little extent ($M$ = 4.69, $SD$ = 1.14). Given the fact that potato chips are generally considered as a kind of common snack among the population, the data here was considered normal and didn't have the potential to constitute any confounding effect.

A set of regression analyses was first run with a dummy variable for the presence of potato chips (yes = 1, no = 0), the combined measure of the degree of mental simulation of the brownie eating experience (centered), and the interaction of the two as the independent variables. The results of this set of analyses are shown in Table 1.

TABLE 1
STUDY 1: REGRESSION ANALYSES

| DVs | Sweetness | | Softness | | Texture | |
|---|---|---|---|---|---|---|
| IVs | *β* | *t* | *β* | *t* | *β* | *t* |
| Chip-presence dummy | .08 | .67 | .09 | .68 | .07 | .46 |
| Degree of mental simulation (centered) | .02 | .10 | .58 | 2.84** | -.06 | -.28 |
| Interaction | .53 | 2.78** | -.24 | -1.16 | .28 | 1.28 |

TABLE 1 (CONTINUED)

| Pleasantness of the simulated eating experience | | Wish for taste | | Attitude | | Purchase intention | |
|---|---|---|---|---|---|---|---|
| *β* | *t* | *β* | *t* | *β* | *t* | *β* | *t* |
| .06 | .49 | .01 | .11 | .25 | 2.05* | .20 | 1.48 |
| .08 | .43 | -.09 | -.44 | .10 | .50 | .31 | 1.44 |
| .45 | 2.31* | .47 | 2.27* | .39 | 2.06* | -.06 | -.29 |

$^{*}p < .05$, $^{**}p < .01$

Results in Table 1 show that there was no significant effect of chip-presence at the mean value of degree of mental simulation ($\beta$ = .08, $t(47)$ = .67, $p$ = .51), neither was there any significant effect of degree of mental simulation when potato chips were not present ($\beta$ = .02, $t(47)$ = .10, $p$ = .92), on the imagined sweetness of the brownie. However, relevant to hypothesis 1a and 1b, there was a significant interaction effect of chip-presence and degree of mental simulation ($\beta$ = .53, $t(47)$ = 2.78, $p < .01$). This pattern also holds for the pleasantness of the simulation, wish for a taste of the brownie, and attitudes towards the brownie. In order to further decompose these interactions, 'spotlight analyses' (Aiken & West, 1991; Fitzsimons, 2008) were conducted at one standard deviation above and below the mean of the combined measure of degree of mental simulation. Results of the spotlight analyses are shown in Table 2.

TABLE 2
STUDY 1: SPOTLIGHT ANALYSES AT 1 *SD* ABOVE/BELOW THE MEAN OF DEGREE OF MENTAL SIMULATION

| | 1 *SD* above | | 1 *SD* below | |
|---|---|---|---|---|
| DVs | *β* | *t* | *β* | *t* |
| Sweetness | .43 | 2.45* | -.26 | -1.51 |
| Softness | -.07 | -.35 | .24 | 1.30 |
| Texture | .25 | 1.24 | -.12 | -.58 |
| Pleasantness of the simulated eating experience | .35 | 1.99* | -.23 | -1.30 |
| Wish for taste | .32 | 1.69† | -.29 | -1.54 |
| Attitude | .51 | 2.91** | -.01 | -.03 |
| Purchase intention | .16 | .83 | .24 | 1.24 |

(Table 2 shows only statistics of the chip-presence dummy variable in the regression equations)

†$p < .10$, *$p =< .05$, **$p < .01$

Supporting hypothesis 1a & 1b, results from the spotlight analyses in Table 2 show that for subjects who have activated a high degree of mental simulation (1 *SD* above the mean) when evaluating the chocolate brownie product, the actual taste of the potato chips before mental simulation has made the imagined sweetness of the brownie to be significantly higher compared to that of the no-chip present condition ($\beta = .43$, $t(47) = 2.45$, $p < .02$). However, for subjects who have used only a low degree of mental simulation (1 *SD* below the mean) when evaluating the chocolate brownie product, the actual taste of the potato chips before mental simulation had no significant effect on the imagined sweetness of the brownie compared to that of the no-chip present condition ($\beta = -.26$, $t(47) = -1.51$, $p = .14$).

Besides, for subjects who have activated a high degree of mental simulation when evaluating the brownie, the actual taste of the potato chips has made the simulated eating experience to be more pleasant ($\beta$ = .35, $t(47)$ = 1.99, $p$ = .05), has caused a stronger desire of the subjects to have a real taste of the brownie ($\beta$ = .32, $t(47)$ = 1.69, $p < .10$), and has enhanced subjects' attitude towards the brownie ($\beta$ = .51, $t(47)$ = 2.91, $p < .01$), compared to those of the no-chip present condition. However, these effects of the actual taste of the potato chips were all eliminated for subjects who have used only a low degree of mental simulation when evaluating the brownie (see right side of Table 2).

To better understand the interactions shown in Table 1, I went on to decompose them from the other perspective. I regressed each of the dependent variables on the degree of mental simulation and examined the slopes of the independent variable at each level of chip presence. The results of this set of regression analyses are shown in Table 3.

TABLE 3
STUDY 1: SLOPE ANALYSES

| | Chip present | | No chip present | |
|---|---|---|---|---|
| DVs | *β* | *t* | *β* | *t* |
| Sweetness | .71 | 5.23** | .02 | .08 |
| Softness | .30 | 1.62 | .52 | 2.74* |
| Texture | .28 | 1.52 | -.07 | -.32 |
| Pleasantness of the simulated eating experience | .61 | 4.00** | .10 | .44 |
| Wish for taste | .50 | 3.03** | -.10 | -.44 |
| Attitude | .67 | 4.66** | .09 | .41 |
| Purchase intention | .27 | 1.44 | .27 | 1.26 |

(IV: degree of mental simulation)
*$p < .05$, **$p < .01$

Results in Table 3 reveal that under normal circumstances (when no chips were present before the mental simulation), the judged sweetness of the brownie was not a function of the degree of mental simulation ($\beta$ = .02, $t(20)$ = .08, $p$ = .94). That means, simply simulating the brownie eating experience to a greater extent would have no influence on the judged sweetness of the brownie. However, when the potato chips were present, the more subjects used mental simulation in their evaluation of the brownie, the higher their judged sweetness of the brownie ($\beta$ = .71, $t(27) = 5.23$, $p < .00$). Supporting our postulated mechanism underlying hypothesis 1a & 1b, these results can be interpreted as evidence showing that the contrast effect between actual taste perceptions and mental simulations of taste was contingent on whether the multimodal simulations are activated.

Similarly, when no potato chips were present, the degree of mental simulation had no effect on the pleasantness of the simulated eating experience ($\beta$ = .10, $t(20) = .44$, $p = .67$), subjects' wish for taste of the brownie ($\beta$ = -.10, $t(20) = -.44$, $p = .67$), or subjects' attitude towards the brownie ($\beta$ = .09, $t(20) = .41$, $p = .68$). However, when chips were present, they could all be positively predicted by degree of mental simulation (pleasantness of the simulated eating experience: $\beta$ = .61, $t(27) = 4.00$, $p < .00$; wish for taste: $\beta$ = .50, $t(27) = 3.03$, $p < .01$; attitude: $\beta$ = .67, $t(27) = 4.66$, $p < .00$).

It may be intuitive to infer that the interaction effect of chip-presence and degree of mental simulation on the pleasantness of simulated eating experience, wish for taste, and attitude towards the brownie was mediated by any effect on the imagined sweetness of the brownie. To test this, a set of mediated moderation analyses were conducted. Theoretically, we would expect that degree of mental simulation would moderate the effect of chip-presence on imagined sweetness but it would not moderate the effect of imagined sweetness on the other three dependent variables.

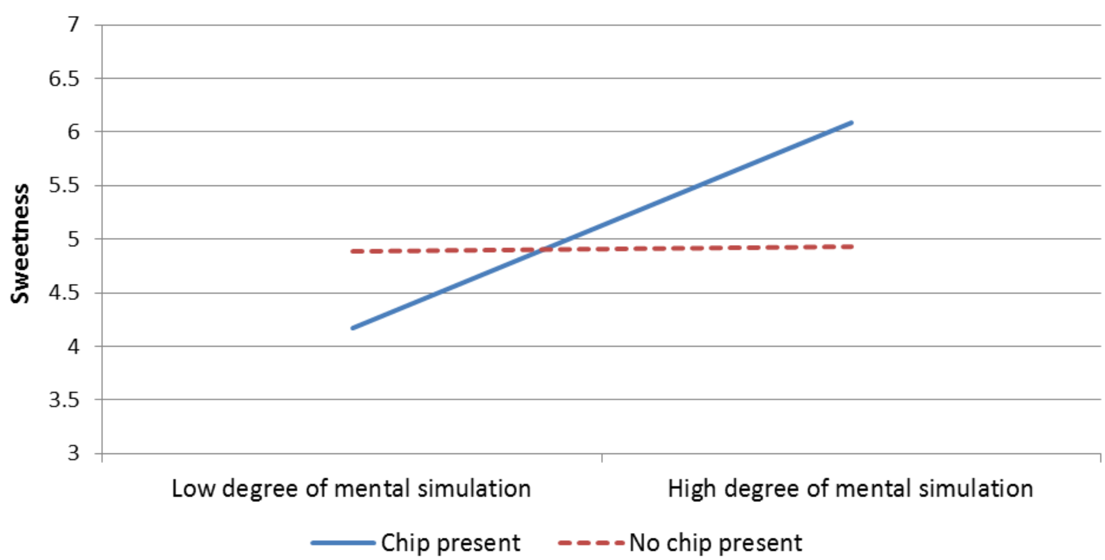
This was confirmed by mediated moderation analyses according to criteria of Muller, Judd, & Yzerbyt (2005). From Table 1 we know that there were overall moderating effects of degree of mental simulation on the three dependent variables, and thus the first criterion was met. Also from Table 1 we know that there was moderating effect of degree of mental simulation on the mediator, namely the combined item of sweetness, and thus the second criterion was also met. To establish the last criterion, I regressed respectively the three dependent variables on the chip-presence dummy variable, sweetness, degree of mental simulation, and both of the first two variables' interaction term with degree of mental simulation. For all the three dependent variables, the parameter estimate of sweetness was significant (pleasantness: $\beta = .29$, $t(45) = 2.00$, $p = .05$; wish for taste: $\beta = .42$, $t(45) = 2.79$, $p < .01$; attitude: $\beta = .28$, $t(45) = 1.95$, $p < .06$), and the interaction effect between chip-presence and degree of mental simulation became insignificant (pleasantness: $\beta = .25$, $t(45) = .83$, $p = .41$; wish for taste: $\beta = .13$, $t(45) = .42$, $p = .68$; attitude: $\beta = -.11$, $t(45) = -.37$, $p = .71$). Thus, results here support the statement that the interaction effect of the taste of chips and degree of mental simulation on the pleasantness of the simulated eating experience, wish for taste, and attitude towards the brownie was mediated by the effect on the imagined sweetness of the chocolate brownie.

Discussion

Results of study 1 support hypothesis 1a & 1b and the postulated underlying mechanism. When subjects activated a certain degree of mental simulation while evaluating the chocolate brownie product, these simulations caused somatic and neural responses in the sensorimotor systems, which made the mental simulation of taste susceptible to influences from actual taste experience. Therefore, when subjects used a high degree of mental simulation, having tasted the potato chips caused the imagined sweetness of the brownie to be higher—a contrast effect that was likely to be observed had subjects tasted a real piece of chocolate brownie. When subjects used only a low degree of mental simulation, the actual taste of the potato chips had no significant effect on the imagined sweetness of the brownie, presumably because there were less or no somatic or neural reactions in the sensorimotor systems. Figure 1 gives a demonstration of this key finding.

**FIGURE 1**

STUDY 1: KEY RESULTS




From Figure 1 we can see that the degree of mental simulation had no effect on the judged sweetness of the brownie when no chips were present. This tells us that the heightened ratings of sweetness at high degree of mental simulation when chips were present were really caused by a contrast effect between the actual and simulated taste experience, but not because of a decrease of sweetness ratings in the no-chip condition.

Though not significant, results in Table 2 show that at low degree of mental simulation, subjects who have tasted the potato chips tended to rate the brownie less sweet compared to subjects who didn't taste the potato chips ($\beta$ = -.26, $t(47) = -1.51$, $p = .14$). The reason for this result may be due to the fact that when subjects evaluated the brownie using little mental simulation, they made the evaluations rather heuristically, and the taste of the potato chips biased their judgment in an assimilative way.

Very similar patterns as that of imagined sweetness were found for the following three items—pleasantness of the simulated eating experience, wish for an immediate taste of the brownie, and attitude towards the brownie (see Figure 2A-2C). These effects were mediated by the imagined sweetness of the brownie and they conform to lay experiences—the experience of eating a piece of dessert is more pleasant after a meal than eaten alone; we have a stronger desire for dessert after a meal than usual; and hence we probably have a better attitude towards dessert when it appears sweeter and we really want it.

Results from Table 1 & 2 show no evidence of the actual taste of potato chips exerting any effect on the softness, texture, and purchase intention of the simulated chocolate brownie. The null effect on purchase intention may probably be a result of the specific experimental setting, and the null effects on the other two may indicate that disharmony in flavor between actual and simulated taste experiences can only influence flavor but not other senses of taste. These null effects, however, should be interpreted with caution.

FIGURE 2A
STUDY 1

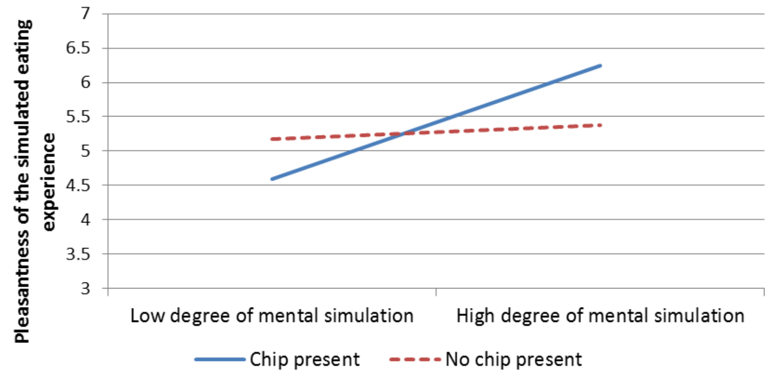



FIGURE 2B
STUDY 1

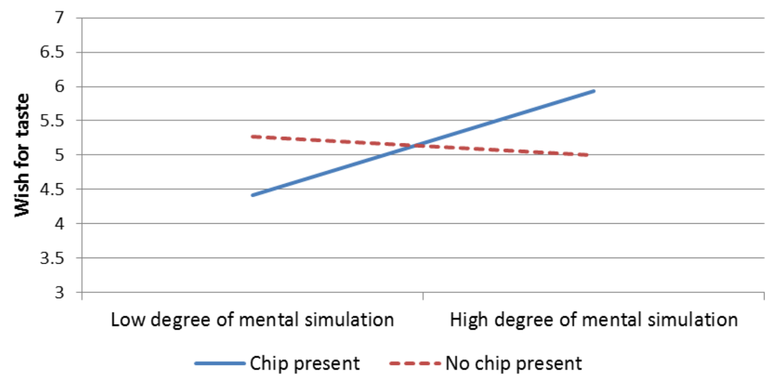
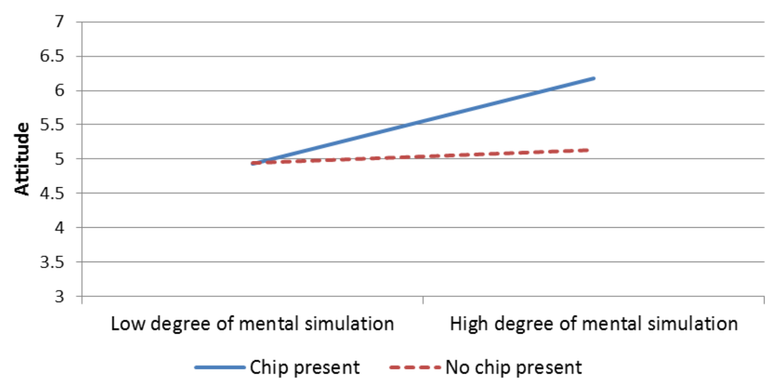



FIGURE 2C
STUDY 1



### 3.2 Study 2: Mental Simulation of Taste Affecting Actual Taste

Study 1 tested and supported hypothesis 1a & 1b by showing the influence of actual taste perception on mental simulation of taste. Study 2 was set to test hypothesis 2a & 2b and thus the opposite direction of influence from mental simulation of taste on actual taste perception.

Design and procedure

One hundred and fifty one undergraduate students from the Hong Kong Polytechnic University participated the experiment for a reward of 20 HKD coupons. Data of six subjects were deleted because they failed to follow the experimental instructions, leaving a sample of one hundred and forty five subjects in the data analysis ($M_{age}$ = 21.52 years; 38 males).

I used the same cover story as in study 1. For the treatment condition, subjects first evaluated a dried fish snack by mentally simulating the eating experience. The dried fish snack is common in countries like China and Japan, and the specific stimulus I chose was featured with spiciness and saltiness. Subjects then were each provided a piece of soft milk candy for actual taste and answered some questions about the candy. For the control condition, subjects only tasted and evaluated the soft milk candy.

Measures

Similar to study 1, most of the measures used seven-point Likert scales. Evaluative questions of the soft milk candy served as the dependent variables. I asked subjects the sweetness of their actual taste and their estimated sugar content of the candy. These two items were again combined to form a single perceived 'sweetness' measure ($r = .65$, $p < .00$; Cronbach's alpha = .79). Besides sweetness, I also asked subjects the perceived softness and texture of the milk candy, the general pleasantness of the eating experience, their attitude, and their purchase intention of the milk candy. For subjects in the treatment condition, evaluative questions for the dried fish snack were asked and the three items measuring degree of mental simulation in study 1 were also asked and combine to form a single measure of 'degree of mental simulation' of the dried fish (Cronbach's alpha = .76). Subjects in the treatment condition also indicated their personal preference for dried fish products and all subjects indicated their personal preference for milk candy products and their general mood of the day. Subjects also filled up some personal information at the end of the experiment.

Results

Compared to the middle value (3.5) of a seven-point Likert scale, subjects in the treatment condition ($n = 72$) considered the depicted dried fish snack as being spicy ($M = 4.60$, $SD = 1.18$; $t(71) = 7.87$, $p < .00$) and salty ($M = 4.81$, $SD = 1.64$; $t(71) = 7.80$, $p < .00$). Thus, the dried fish snack can be considered as in taste incongruity with the soft milk candy. There were no significant differences in subjects' personal preference for milk candy products ($M_{treatment} = 4.72$, $M_{control} = 4.47$; $t(143) = 1.17$, $p = .24$) or general mood of the day ($M_{treatment}$ = 4.86, $M_{control}$ = 4.95; $t(143) = -.48$, $p = .63$) between the two conditions. Subjects in the treatment condition had a rather neutral preference for dried fish products ($M$ = 4.14, $SD$ = 1.79) and imaging the eating experience of the dried fish affected subjects' mood in the positive direction to a little extent ($M$ = 4.43, $SD$ = 1.22).

TABLE 4
STUDY 2: ONE-WAY ANOVA

| | Sweetness | Softness | Texture | Pleasantness of the eating experience | Attitude | Purchase intention |
|---|---|---|---|---|---|---|
| $M_{treatment}$ | 5.61 | 5.90 | 4.96 | 5.10 | 5.01 | 4.25 |
| $M_{control}$ | 5.30 | 5.75 | 4.42 | 4.68 | 4.53 | 3.73 |
| $F$ | 4.01* | .71 | 6.29* | 3.83* | 4.71* | 3.77* |
| $d$ | .33 | | .42 | .33 | .36 | .32 |

*$p$ =< .05

To test hypothesis 2a, I conducted a set of one-way ANOVAs with the combined measure of 'sweetness' and other evaluative questions of the milk candy as dependent variables (see Table 4). As hypothesized, after mental simulation of the salty and spicy dried fish snack, subjects' rated sweetness of the milk candy became significantly higher compared to that of the control condition ($M_{treatment}$ = 5.61, $M_{control}$ = 5.30; $F(1, 143)$ = 4.01, $p < .05$; $d$ = .33), demonstrating a contrast effect. Besides, compared to the control condition, subjects in the treatment condition also perceived the texture of the milk candy to be better ($M_{treatment}$ = 4.96, $M_{control}$ = 4.42; $F(1, 143) = 6.29$, $p = .01$; $d = .42$), and their eating experiences of the milk candy were more pleasant ($M_{treatment}$ = 5.10, $M_{control}$ = 4.68; $F(1, 143) = 3.83$, $p = .05$; $d = .33$). Subjects in the treatment condition also had higher attitude and purchase intention towards the milk candy product than subjects in the control condition (attitude: $M_{treatment}$ = 5.01, $M_{control}$ = 4.53; $F(1, 143) = 4.71$, $p < .05$; $d$

= .36; purchase intention: $M_{treatment}$ = 4.25, $M_{control}$ = 3.73; $F(1, 143) = 3.77$, $p = .05$; $d$ = .32).

To test hypothesis 2b, I regressed the combined sweetness measure on the combined measure of degree of mental simulation for the treatment condition. Degree of mental simulation of the dried fish failed to predict the later perceived sweetness of the milk candy within the treatment condition ($\beta = .07$, $t(70) = .62$, $p = .54$). Despite this, I picked out subjects in the treatment condition who had degree of mental simulation scores one standard deviation above ($n$ = 14) or below ($n$ = 15) the mean and compared them with the control condition respectively. The results of the ANOVA analyses are shown in Table 5 (I also included the two individual items of which the combined single item of 'sweetness' was composed).

TABLE 5
STUDY 2: ONE-WAY ANOVA WITH POST HOC SUBGROUPING

| | ($n$ = 73) | 1 *SD* above the mean of degree of mental simulation ($n$ = 14) | | | 1 *SD* below the mean of degree of mental simulation ($n$ = 15) | |
|---|---|---|---|---|---|---|
| | $M_{control}$ | $M_{treatment}$ | *F* | *d* | $M_{treatment}$ | *F* |
| Tasted sweetness | 5.16 | 5.50 | .97 | | 5.53 | 1.49 |
| Estimated sugar content | 5.44 | 6.07 | 3.89* | .56 | 5.47 | .01 |
| Combined sweetness | 5.30 | 5.79 | 2.50 | | 5.50 | .51 |
| Softness | 5.75 | 6.14 | 1.86 | | 6.20 | 2.60 |
| Texture | 4.42 | 5.57 | 8.35** | .81 | 4.87 | 1.34 |
| Pleasantness of the eating experience | 4.68 | 5.64 | 5.84* | .69 | 4.87 | .21 |
| Attitude | 4.53 | 5.64 | 7.25** | .76 | 5.07 | 1.93 |
| Purchase intention | 3.73 | 4.93 | 5.88* | .69 | 4.33 | 1.66 |

*$p$ =< .05, **$p$ < .01

Results from Table 5 support hypothesis 2b. Specifically, mentally simulating the eating experience of the dried fish snack with a relatively higher degree of mental simulation (1 *SD* above the mean) promoted contrast and enhancement effects on most of the evaluative items of the milk candy (the estimated sugar content, texture, pleasantness, attitude, and purchase intention). However, when subjects' degree of mental simulation of the dried fish eating experience was low (1 *SD* below the mean), the treatment effect of the experiment was weakened and there were no longer significant contrast or enhancement effects on any evaluative items of the milk candy.

Discussion

Generally, results of study 2 support hypothesis 2a & 2b. Mentally simulating the salty and spicy dried fish snack was capable of heightening the actual perceived sweetness of the soft milk candy, demonstrating a contrast effect. Moreover, similar to the results of study 1, mental simulation of the dried fish snack has also enhanced the pleasantness of the eating experience and attitude towards the actual soft milk candy. These effects were all expected to be observed had the subjects tasted a real product of the dried fish. However, unlike the results of study 1, results of study 2 have also showed that mental simulation of the dried fish could enhance the perceived texture and purchase intention of the actual tasted milk candy.

Data in study 2 failed to demonstrate a positive correlation between degree of mental simulation of the dried fish and the perceived sweetness of the milk candy. A close examination of the data suggests that the reason may be a restriction of range. Moreover, when I removed data of two subjects in the treatment condition who had sweetness ratings outside two *SD*s of the mean, the correlation approached marginal significance. Nevertheless, using a post hoc subgrouping approach, the analysis has revealed pattern of data that supports H2b--the contrast and enhancement effects on the evaluation of the milk candy were more pronounced for subjects who have used a high degree of mental simulation when evaluating the depicted dried fish snack. However, all of these effects were weakened and failed to reach significance for subjects who have only used a low degree of mental simulation when evaluating the dried fish. Therefore, results here again support the postulated mechanism underlying these effects—mental simulation of the dried fish activated somatic and neural responses in the sensorimotor systems, which in turn were capable of influencing later actual taste.

In study 2 I have also investigated the possibility that the manipulation's effects on the pleasantness of the eating experience, attitude, and purchase intention towards the milk candy were mediated by the effect on sweetness. However, unlike the results in study 1, the analyses in study 2 didn't support this mediation[1]. One reason to explain this substantively is that subjects in study 2 may not necessarily hold better evaluations towards the soft milk candy product the sweeter it is, whereas this implicit theory worked for the chocolate brownie product used in study 1.

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[1] When I regressed respectively the three variables on both the treatment membership dummy variable and the combined measure of sweetness, the former remained significant (pleasantness: $\beta = .16$, $t(142) = 1.95$, $p = .05$; attitude: $\beta = .19$, $t(142) = 2.31$, $p < .05$; purchase intention: $\beta = .18$, $t(142) = 2.12$, $p < .05$) whereas the latter was not (pleasantness: $\beta = -.01$, $t(142) = -.17$, $p = .87$; attitude: $\beta = -.08$, $t(142) = -1.00$, $p = .32$; purchase intention: $\beta = -.10$, $t(142) = -1.22$, $p = .23$), and thus the test failed to support a mediation of sweetness according to Baron and Kenny's (1986) criteria.

## 4. CONCLUSIONS AND GENERAL DISCUSSIONS

Putting together, study 1 and 2 provide reasonable evidence of bidirectional influences between actual and simulated taste experiences. Both hypothesis 1 and 2 are supported: actual taste can induce a contrast effect for later mental simulation of taste (study 1), and mental simulation of taste can also cause a contrast effect for later actual taste (study 2). Both of these effects are more pronounced for subjects who used a high degree of mental simulation of the stimulus, but are eliminated for subjects who used a low degree of mental simulation, thus supporting the multimodal mental simulations as the key mechanism underlying the observed effects. In addition, study 1 has shown that the contrast effect on imagined sweetness of the target stimulus has enhanced the pleasantness of the imagined eating experience and has caused the desire and attitude towards the target stimulus to be higher. In study 2, there was also an enhancement effect on the perceived texture of the target stimulus, and this has led to enhanced pleasantness of the eating experience and also higher attitude and purchase intention of the stimulus. These additional effects conform to lay experiences in actual taste perception and thus act as further evidence of the isomorphism between actual and simulated taste experiences.

There are some results of the present research that cannot be well explained by the current theoretical framework. In both studies, I found that the incongruity in taste (flavor) between actual and simulated taste experiences was not able to influence either the imagined or perceived softness of the stimuli. This may act as evidence that the incongruity in taste (flavor) can only influence the sense of gustation but not other senses of taste. This makes sense. Since according to our everyday experience, our taste of flavor may be easily biased (context effects) but not our perception of the haptic properties of the foods. However, results of study 2 have shown that there was a significant enhancement effect of the perceived texture of the actual tasted stimulus. Therefore, this result may contradict the inference we just draw from the findings on softness. I think that this contradiction may either reflect some important difference between the evaluation of a simulated stimulus and the evaluation of an actual stimulus that awaits future investigation. Or, this contradiction may merely be an artifact of the specific stimuli or the particular question wordings chosen in the present research. In addition, in study 1, there is a positive correlation between degree of mental simulation and the softness rating of the brownie when the potato chips are not present. I acknowledge that there is currently no appropriate theory to explain this finding and it may thus remain a problem of the present research. Nevertheless, a clarification of these issues and a further investigation of the differences between the two directions of influences are surely meaningful and valuable avenues for future research.

Similar to other studies in grounded cognition literature, the findings of the present research may also be challenged by other theoretical accounts, such as semantic associative network models and knowledge activation (Collins & Loftus, 1975; Higgins, 1996). One may argue that the observed effects were merely because the activation of the concept of potato chips or dried fish (and thus the concepts of salty and spicy) induced a purely cognitive contrast on later semantic ratings on taste. However, given the pattern of the data, I think that such purely cognitive accounts are highly unlikely to be the underlying mechanism of the present effects.

First, as Landau, Meier, and Keefer (2010) have argued, such models are unspecified and unfalsifiable, and are almost always able to provide explanation of the direction of effect on a post hoc basis. However, the mental simulation account is able to make a priori prediction of the direction of effect (contrast) based on an assumed isomorphism of actual and simulated taste experiences. Second, even if the pure cognitive account could explain the effect on items of taste perception, it should not have any influence on other items such as the pleasantness of the simulated/actual eating experience, wish for taste, attitude, and purchase intentions (in fact, associative network models may only manage to explain these effect difficultly based on their content-free nature) . However, results here have shown consistent effects on these items that conforms to our everyday experience.

Third, if it were the cognitive activation of the concepts of potato chips or dried fish that drove the observed effects, then it should equally influence not only ratings of sweetness but also ratings of softness, as we see no theoretical difference between the strengths of the associative links of saltiness and crispiness with these two stimuli. However, as the results show, both of the studies found no evidence of the manipulations influencing on ratings of softnesss. Lastly, it is especially difficult for the associative network models to explain the interaction effects found in both study 1 & 2. For example, in study 1, within the chip presence condition, the judged sweetness of the simulated brownie increased as the degree of mental simulation of the brownie increased, and compared to the no-chip presence condition, the direction of the effect even reversed as degree of mental simulation of the brownie changed. A simple and purely cognitive account is hard to well capture these dynamic and complex interaction effects on ratings of taste. It is even more difficult for these alternative accounts to explain those similar patterns of other dependent variables (pleasantness, wish for taste, attitude, and purchase intention). The mental simulation account, however, could parsimoniously account and make a priori predictions of these patterns of results.

Therefore, based on the above discussion, especially the last two points, those semantic or cognitive accounts could be ruled out as the major mechanism driving the results. These theoretical models, however, have challenged and successfully accounted for some findings in recent grounded cognition literature (e.g., Lee & Schwarz, 2012; Schnall, Benton, & Harvey, 2008; Zhang & Li, 2012). The present research thus offers substantive and cogent evidence that supports the multimodal simulation construct in the PSS theory and thereby makes grounded cognition theories more tenable to challenges from other theoretical accounts.

The present research is not only a test but also an extension of the grounded cognition theories. Previous research of embodied cognition has mainly demonstrated bodily states' influence upon abstract conceptual processing, such as attitude formation and retrieval, judgment, and social perception, in an incidental and unconscious way. The present research investigates sensorimotor systems' influence upon mental imagery and simulation, and has thus connected the body and mind in a more direct, concrete, and deliberate level. On the other hand, current evidence concerning the cognitive system's automatic influence upon the sensorimotor systems is rather limited. As it has been reviewed, current evidence is confined at levels of neural activation (e.g., Chao & Martin, 2000; Willems et al., 2010), cognitive resources (Ackerman et al., 2009), performance facilitation and inhibition (e.g., Glenberg & Kaschak, 2002; Tucker & Ellis, 1998, 2001), and intentions and attitudes (e.g., Elder & Krishna, 2012; Shen & Sengupta, 2012). The present research adds to the literature a more concrete and substantive form of influence from the cognitive system upon the sensorimotor systems by demonstrating the former's ability to impact on actual perceptions.

The present research is also rich in managerial implications, especially for the food and snack industry. Consumers may often use their mental imagery to simulate the taste or experience of some certain products, and this process may have some impact on the free trial of some other products or on their immediate taste of these products after purchase. Otherwise, consumers often receive a free trial product at the entrance of the shop, and this may have some impact on their mental simulation of other products. Thus, the finding of the present research helps marketing and product practitioners to better design their product evaluation and product trial programs in order to achieve maximum promotion effects or avoid some unwanted interference. For example, it helps managers to design the sequence between product evaluations and trials, helps to think of some supplementary stimuli to enhance product evaluations, and helps to better control and calculate the effects of some detrimental factors during product evaluations or trials. As shown in the present research, this trivia may be neglected by the marketing practitioners before but it is capable of influencing the perceived or simulated quality of the products and therefore has an impact on the attitude and purchase intention of the products. A thorough understanding of the present research and its extensions can be vital to these managerial issues.

## 5. LIMITATIONS AND FUTURE RESEARCH

Many problems remain unsolved in the present research. Both of the two studies measured the degree of mental simulations. To further establish validity of the important role played by this key construct, future research should manipulate instead of only measure the degree of mental simulations. Also, the present research used a combined measure of mental simulation which is composed of three dimensions—quantity, vividness, and fluency (cf. Bone & Ellen, 1992). Thus, the operational definition of the mental simulation construct in the present research may remain vague and unspecified. One way to solve this problem in the future is to specifically manipulate one dimension of mental imagery while keeping other dimensions constant to disentangle the different effects of these different aspects of mental imagery, if there is any. In addition, future research may use multi-item measures as in Bone and Ellen (1992) instead of single-item measures to more reliably represent these dimensions of imagery.

Results on softness ratings also provide much room for future research. Specifically, in both studies the stimuli used in actual taste and mental simulation differed in both flavor as well as in the soft-crispy dimension. Nevertheless, the present result revealed only contrast effects on the flavor dimension but not the soft-crispy dimension of taste experience. The implications and plausible explanations of this result are as follows.

First, since taste is a complex blend of various senses (Krishna, 2010, 2012), future research may wish to control for various dimensions of taste and to manipulate only one dimension to eliminate any confounding effects. As in the present research, it may be hard to infer whether differences in more than one dimension of taste strengthened or diluted the observed effects. The latter possibility suggests that future research may wish to study some stimuli that only differ in the soft-crispy dimension to see what happens.

Second, our mental imagery or simulation can differ from real experiences in that it is totally feasible for us to focus on one particular aspect or dimension of the experiences in our mental imageries and ignore or pay less attention to the others (cf. Libby & Eibach, in press). Hence it is possible that subjects in the present research somehow focused only on the evaluation of the flavor and paid minimal attention to the soft-crispy dimension of the stimuli in their mental simulations.

Factors such as the most salient feature of the stimuli may influence which dimension of them subjects will focus on. For instance, marshmallow may be more strongly associated with the feature of soft than either chocolate brownie or soft milk candy (despite the word ‘soft’) does, and less strongly associated with the sweet flavor than the other two. Thus, future research could change stimuli or use priming techniques to manipulate the salient feature of the stimuli in order to clarify the issue whether differences in other dimensions of taste between actual and simulated experiences could influence each other. However, the expected result may not be confined to a contrast effect.

Other limitations of the present research are also obvious and future research is warranted. First, the present research focuses only on taste perceptions. Future research could address sensory experiences in other domains, such as touch, smell, sound, and vision in a consumer behavior context. For example, in the domain of haptics (touch), future research may address the question of whether touching certain material in our hands could impact our mental simulation of the texture of something else, and whether mentally simulate touching some material could impact our actual perception and judgment of the texture or quality of something else.

Second, the present research taps on direct influences of actual versus simulated sensory experience within a sensory modality. Current research reveals that senses in different modalities can exert interactive impacts upon each other and affect information processing across modalities, a phenomenon that may be referred to as synesthesia or crossmodal correspondence (Spence, 2011, 2012). Thus, future research could explore possible exciting findings revealing reciprocal influences between actual and simulated sensory experiences across sensory modalities.

Lastly, future research should study whether bodily states or sensory perceptions could affect mental imagery in its various other attributes, such as the vividness of mental imagery or the visual perspective of mental imagery (see Libby & Eibach, 2011). Current research has done relatively little on that, and given the richness and tremendous potential of mental imagery studies (Libby & Eibach, 2011, in press; MacInnis & Price, 1987), this direction of research seems promising and meaningful. The grounded cognition perspective not only serves as a theoretical account of the present proposed findings, but may also provide a framework that is compatible with all these exciting studies in the future.

## APPENDIX


1. Potato chips used for actual taste in study 1

2. Picture of chocolate brownie used for mental simulation in study 1

3. Picture of dried fish snack used for mental simulation in study 2


4. Soft milk candy used for actual taste in study 2

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