

Review

Extrinsic information influences taste and flavor perception: A review from psychological and neuroimaging perspectives

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ABSTRACT

The perception of taste and flavor can be greatly biased by extrinsic cues, or the information about a food that comes from outside of the food itself, such as package designs, brands, prices, and so on. In order to understand taste/flavor experiences in a broader context, it is necessary to consider factors other than the food/tastants themselves. This review aims to summarize some of the relevant findings from psychological and neuroimaging studies, focusing on depicting how extrinsic cues exert their effect on taste and flavor. Currently, the most frequently considered psychological mediator for the effects of extrinsic cues is expectation. Depending on the gap between expectation and taste/flavor experience, four major models predict outcomes of expectation effects: (1) assimilation, (2) generalized-negativity, (3) contrast, and (4) assimilation-contrast. Among them, the most influential is the assimilation model proposing that taste/flavor experiences are modified toward what one expects. Thus far, all the neuroimaging studies examining the influence of extrinsic cues have dealt with assimilation effects. They suggest that when extrinsic cues influence taste/flavor perception, cortical representations of taste/flavor are also modulated. Collectively neuroimaging findings partly answer questions arising from psychological aspects: the influence of extrinsic cues is not due to superficial response bias but to truly changed perception. These findings, albeit limited to assimilation effects, suggest that combined understanding from both psychological and neuroimaging studies would help deepen our understanding of the taste experience.

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Abbreviations: NST, nucleus of the solitary tract; MEG, magnetoencephalography; fMRI, functional magnetic resonance imaging; OFC, orbitofrontal cortex; mOFC, medial OFC; PFC, prefrontal cortex; mOFC, medial orbitofrontal cortex; vmPFC, ventromedial prefrontal cortex; dlPFC, dorsolateral prefrontal cortex; SFG, superior frontal gyrus; rACC, rostral anterior cingulate cortex; ERP, event-related potential; PET, positron emission tomography; fNIRS, functional near-infrared spectroscopy.

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1. Introduction

“Is the proof of the pudding in the eating?”

We tend to believe that the taste of a food is inherent to the food itself: Good pudding should taste good regardless of its appearance. However, a large body of evidence suggests that our taste experience is influenced by information coming from outside of the food itself, such as package designs, brand names, prices, and so on [1–6]. In fact, such extrinsic cues can greatly bias the perception of taste. A striking example comes from a recent study on wine tasting that examined how labeling modifies the evaluation of wine [7]. While the addition of tartaric acid, which is characterized with sourness and astringency, reduced the perceived sensory quality of wine in blind tastings, this effect was masked by labeling with a country of origin and price, with the latter having by far the strongest influence on wine evaluation. Obviously we have to understand taste experiences in a broader context, namely, by considering factors other than the food/tastants themselves.

Such a notion is especially pertinent in the field of consumer psychology where the need to understand the effects of packaging or labeling on taste perception is eminent. More and more studies have identified extrinsic cues that influence taste experiences (reviewed in [4,5]). Meanwhile, recent advances in non-invasive human neuroimaging techniques have made it possible to examine how extrinsic cues influence central processing of taste to produce integrated taste experiences: the physiological basis for our subjective experiences can be visualized as activation patterns in the brain. Combined understanding from both psychological and neuroimaging studies would help deepen our understanding of the taste experience.

Thus, this review aims to summarize some of the relevant findings from psychological and neuroimaging studies, focusing on depicting how extrinsic cues exert an effect on taste and flavor. At the same time, we reveal gaps in the literature that need to be filled in by future studies to provide a holistic view on the effects of extrinsic cues on taste and flavor.

2. Definitions of taste and flavor

Before considering the effect of extrinsic cues, we should clarify the notions of “taste” and “flavor”, as they are often used interchangeably in the literature. Taste is a distinct constituent of the five senses and is distinguished from odor and texture in a strict sense. From a biological perspective, taste arises from an interaction between water-soluble chemicals, called tastants, and taste buds on the tongue, palate, pharynx, epiglottis, and the upper third of the esophagus. There are many tastants, but they only produce one (or sometimes a few) of five basic taste qualities in humans: bitterness, saltiness, sourness, sweetness, and umami (savoriness).

While taste sensation is at the core of our subjective taste experience, we almost always experience it with simultaneous inputs from other sensory modalities. For example, tastants ineluctably stimulate oral somatosensory sensations, and most foods contain volatile chemicals that stimulate olfaction. In particular, odors from foods in the mouth travel retronasally (i.e., from the back of the oral cavity and nasopharynx) to the olfactory epithelium. All of these sensations together form sensory percepts of the foods in the

oral cavity, and are often perceived as a unified “taste” in a broad sense. To avoid confusion between “taste as in common usage”, and “taste as a unimodal sensation”, hereafter we will follow the convention in chemosensory studies where “taste” refers to a unimodal sensation, while the multisensory percept arising from foods in the oral cavity connotes “flavor” [8] (Fig. 1, lower box). While our main focus is the sense of taste, we also consider studies on flavor, since most of the “tastes” that we encounter in daily life are experienced in the form of flavor.

In considering the effects of extrinsic cues, we should also note affective aspects of taste. Taste not only conveys sensory qualities, such as sweetness or saltiness, but is also deeply associated with value and affect. For example, sweetness is a signal of high-energy nutrients, while bitterness signals a greater likelihood of toxicity. Such associations between each taste quality and its corresponding food value, and the resulting affect seems innate: even newly born babies who have not yet had eating experiences have been found to like sweetness and dislike bitterness [9–12]. Reflecting such strong associations between affect and taste, past studies on taste/flavor experiences have almost always evaluated both sensory and affective aspects, namely, perceived intensity and pleasantness. Following this tradition, we also integrate the affective aspect of tastes and flavors in this review.

3. Effect of extrinsic cues

Taste/flavor experiences are influenced by many factors (Fig. 1), including both human-side factors, such as physiological state or genetic background (reviewed in [13–17]), and factors associated with foods, such as their appearance, or eating contexts (reviewed in [18–20]). The current review is concerned with the information about a food that comes from outside of the food itself, but not its chemical and physical constituents. These are referred to as “extrinsic cues” in the consumer psychology literature [21,22].

Various aspects of extrinsic cues have been shown to influence taste/flavor experiences: brand names, prices, country of origin, food ingredients, nutritional information, and descriptions

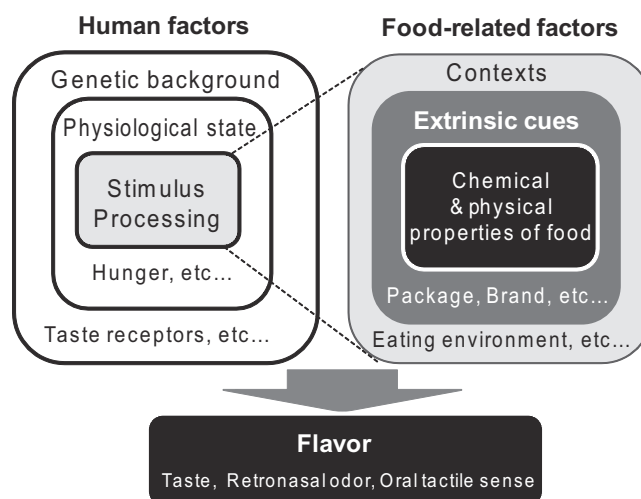


Fig. 1. Various factors that influence the taste/flavor experience. Food-related factors are divided into three broad categories according to the concept of products in consumer psychology.

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