ARTICLE IN PRESS
JCPS-00536; No. of pages: 10; 4C:

Available online at www.sciencedirect.com
ScienceDirect

Journal of Consumer Psychology xx, x (2016) xxx – xxx

JCP JOURNAL OF CONSUMER PSYCHOLOGY

Research Article

Bidirectional contrast effects between taste perception and simulation: A simulation-induced adaptation mechanism

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Accepted by Cornelia Pechmann and Amna Kirmani, Editors; Associate Editor, Anirban Mukhopadhyay

Received 24 July 2014; received in revised form 11 April 2016; accepted 13 April 2016

Abstract

Four experiments reveal that actual taste perception and mental simulation of taste can exert a bidirectional contrast effect on each other. Experiment 1 shows that similar to actual taste experience, simulated taste experience is influenced by a prior actual taste in a contrastive manner. Experiment 2 shows that this contrast effect of actual taste on taste simulation occurs only when people adopt an imagery-based rather than an analytical processing mode. Experiment 3 demonstrates the bidirectional nature of the current effect and again shows that it depends on people's use of mental simulation. Lastly, experiment 4 replicates the observed effect in a realistic marketing environment. These findings support the proposition of a simulation-induced adaptation mechanism. Theoretical and practical implications of this research are discussed.

Keywords: Contrast effect; Taste perception; Mental simulation; Mental imagery

Imagine that you have just enjoyed a slice of pizza and are now looking at pictures of brownies and contemplating whether you should order one. Although actual perceptions of taste influence each other (Lawless, 1983), will the consumption of pizza influence the imagined taste of the brownie, making it seem sweeter than it actually is? In such a situation, the taste of the brownie has to be simulated, and the subsequent purchase decision must be based on this pre-consumption mental simulation of taste (MacInnis & Price, 1987). Given the ubiquitous use of taste simulations in our daily lives, it is somewhat surprising that so little research has addressed this topic, especially the ways in which taste simulation is influenced by actual taste experience. In the present research, we explore the idea that actual taste perception could exert a contrast effect on subsequent mental simulation of taste (and vice versa), and we demonstrate that taste simulation closely resembles actual taste in these bidirectional effects.

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Contrast effect in taste perception

Taste perceptions are susceptible to context effects and biases (e.g., Lawless, 1983, 1994; Lawless, Glatter, & Hohn, 1991; Lawless & Heymann, 2010; Mattes & Lawless, 1985). Research has shown that human taste perceptions are in no way accurate or consistent, and they can be largely influenced by contextual factors in a bottom-up manner. More specifically, judgments of actual taste are often made in contrast to contextual taste stimuli (i.e., prior tastes). For example, it has been shown that sodium soups with the same level of salt concentration often taste saltier when sampled after a low salt-concentration soup than after a high salt-concentration soup (Lawless, 1983). Mattes and Lawless (1985) asked participants to optimize the level of sweetness/saltiness of a beverage by diluting or concentrating the original high- or low-concentration fluid and found that levels of sucrose and salt of the optimized beverage were significantly higher when the original beverage featured a high versus low concentration of the substance. Examples of contrast effects in taste experience are ubiquitous in our daily lives. For instance, we

http://dx.doi.org/10.1016/j.jcps.2016.04.002
1057-7408

Please cite this article as: Si, K., & Jiang, Y., Bidirectional contrast effects between taste perception and simulation: A simulation-induced adaptation mechanism, *Journal of Consumer Psychology* (2016), http://dx.doi.org/10.1016/j.jcps.2016.04.002

might find a serving of dessert to be sweeter when eaten after a salty dish and perceive the same dessert to be less sweet after intakes of other sugary foods (cf. Guinard & Brun, 1998; Rolls, Rolls, Rowe, & Sweeney, 1981; Yee, Sukumaran, Kotha, Gilbertson, & Margolskee, 2011).

Contrast effects in taste perception can be explained by Helson's (1964) adaptation-level theory. This theory proposes that judgments of a stimulus in a context follow a linear function of the stimulus' deviation from the adaptation level, which is a type of running average of the context stimuli. For actual taste perceptions, contrast effects occur because the neural circuits responsible for taste processing are adapted to a certain level of activation during the processing of the contextual (i.e., prior) food stimulus. Later taste perception is judged in relation to this adapted level of activation (Helson, 1964). However, what happens when a simulated taste follows the contextual (and actual) stimulus? In the current research, we propose and show that taste simulations are isomorphic to actual tastes in terms of perceptual properties in that contrast effects occur bidirectionally between taste perceptions and simulations.

Simulation-induced adaptation

Although early conceptualizations suggested that sensory perception and simulation are dissociated from each other (cf. Fodor, 1975; Pylyshyn, 1984), recent research provides considerable evidence that common neural substrates underlie both actual and simulated sensorimotor experience (e.g., Chao & Martin, 2000; Djordjevic, Zatorre, Petrides, Boyle, & Jones-Gotman, 2005; O'Craven & Kanwisher, 2000), including taste (Simmons, Martin, & Barsalou, 2005). Simmons et al. (2005), for example, have shown that viewing pictures of appetizing foods activates neural circuits in the gustatory processing areas that are also active during the processing of actual tastes. These neural reenactments in the modality-specific regions constitute our conceptual knowledge and inference of taste. This is consistent with theories of grounded cognition (Barsalou, 1999, 2008), which hold that multi-modal mental simulation of sensorimotor experience is an integral part of our knowledge representation.

According to Simmons et al. (2005), for example, eating a slice of pizza activates neural circuits that are responsible for the processing of a later simulated taste of brownie. At the neural level, activations in the brain are very much alike for both a perception simulation and a perception–perception sequence of tastes. Thus, similar to the contrast effects between actual taste experiences, a contrast effect of actual taste perception on subsequent taste simulation is likely to occur. By the same token, mental simulation of a salty food item would activate the same neural regions governing the processing of actual taste perception and therefore would increase the perceived sweetness of a different sweet food item that is tasted later. Under the framework of adaptation-level theory (Helson, 1964), neural reenactments in modality-specific regions make actual (simulated) tastes constituents of the adaptation level for subsequent simulated (actual) tastes. We term this process *simulation-induced adaptation* and propose that it underlies our hypothesized bidirectional contrast effects between taste perception and simulation.

Helson (1964) made no predictions regarding whether people's mode or goal of processing would affect the adaptation level. The current conceptualization, however, posits that adaptation level is contingent on people's processing mode or goal. Although modality-specific mental simulation is proposed as an integral component of knowledge representation in theories of grounded cognition, the degree of simulation and consequently the influence of such simulations on judgments are nevertheless not invariant (e.g., Ackerman, Goldstein, Shapiro, & Bargh, 2009; Coventry, Christophel, Fehr, Valdés-Conroy, & Herrmann, 2013; Eelen, Dewitte, & Warlop, 2013; Solomon & Barsalou, 2004). Past research has shown that the extent to which individuals utilize mental imagery in information processing and decision making can be modulated by their processing mode or goal (Jiang, Adaval, Steinhart, & Wyer, 2014; Keller & McGill, 1994; Petrova & Cialdini, 2005; Shiv & Huber, 2000; Thompson & Hamilton, 2006). Since mental imagery corresponds to the deliberate activation of multi-modal mental simulation (Barsalou, 2008; Elder & Krishna, 2012), we expect that taste perception and simulation would be more likely to influence each other when people adopt an imagery-based processing mode.

The current research

Our research studies the bidirectional contrast effects between actual and simulated tastes and examines the moderating role of processing mode. Specifically, we propose that eating (imagining eating) a salty food item will lead people to judge a subsequently imagined (eaten) sweet food item to be sweeter, compared to conditions in which no such prior experience (imagery) exists. Moreover, in line with the simulation-induced adaptation mechanism, such contrast effects should be stronger when people adopt an imagery-based processing mode when evaluating the food item(s).

We test these hypotheses in four experiments. In experiment 1, we show that a prior actual salty taste increases judged sweetness for a subsequent sweet stimulus. Importantly, this effect occurred when the sweet stimulus was actually tasted as well as mentally imagined, supporting the proposed isomorphism between actual and simulated tastes. In experiment 2, we manipulate our participants' processing mode and show that the contrast effect of actual taste on simulated taste occurs only when participants adopt an imagery-based rather than an analytical processing mode. In experiment 3, we demonstrate a contrast effect from the opposite direction (the effect of simulated taste on actual taste) and show that it is also contingent on processing mode. In experiment 4, we replicate the observed effect in a realistic marketing environment to show its practical relevance.

In all the current experiments, sample sizes were determined prior to conducting the experiments and were affected by factors such as the experiments' sign-up rates and attendance rates. In addition to the key variables of interest, participants in most of our experiments were asked to answer some evaluative questions regarding the stimuli (see Methodological Details Appendix). These measures were added for the sake of the cover story and were not related to our hypothesis, nor did they