

Review

Psychological Effects of Sweet Taste and Sweet Taste Preference

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Abstract: This review summarizes current studies on the psychological effects of sweet taste and its role in overweight and obesity. Recent psychological studies demonstrate intriguing relationships between the experience of sweet taste and social perceptions and behavior. For example, studies show that experiencing sweet taste affects “helping behavior” or interest in initiating a romantic relationship. Furthermore, given that the role of sweet taste in obesity has been suggested, we reviewed studies on the relationship between sweet taste preference and eating behavior, thereby examining the role of sweet taste (and the preference for it) in the global rise of overweight and obesity in adults and children. Finally, we provide an outlook on future research perspectives on the psychological effects of sweet taste, and suggest some fundamental issues that future research should address to help provide a comprehensive understanding of how sweet taste and sweet taste preference affect our thinking and eating behaviors.

Keywords: sweet taste; obesity; personality; sweet preference; embodiment



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1. Introduction: A Psychological View of Taste

Recent theoretical considerations suggest that our cognitions may not be independent from our senses [1]. Our thoughts, impressions, judgements, and feelings can be influenced by basic sensory perception experiences, often more than we want to admit to ourselves. The interaction between cognition and taste may be particularly influential. For example, recent studies showed a link between morality and taste by demonstrating that gustatory disgust affects moral decisions. Eskine et al. reported that physical disgust (a bitter taste) evoked feelings of moral disgust, in particular in participants with politically conservative attitudes [2]. Similarly, Chapman et al. showed a physiological overlap between oral and moral disgust. They found similar facial motor activity when responding to disgusting pictures, taste disgust, and disgust in moral scenarios. In all three conditions, the levator labii muscle of the participant's face was activated [3]. This finding of overlapping neurophysiological mechanisms in both physical and moral disgust is also supported by neuroimaging studies (e.g., [4]). The idea that morality is based on emotions and bodily sensations is not new and has been discussed in philosophy before. For example, in 1751, David Hume argued that moral judgments are based on emotions rather than rational thinking and understanding [5].

However, whereas the above-mentioned studies point to a relationship between, for example, bitter taste and feelings of moral disgust, other taste types seem to affect cognition and emotional behavior beyond moral thinking. This review focuses on the psychological effects of sweet taste. In contrast to the link between a bitter taste and moral perception, the experience of a sweet taste has been reported to activate mindsets related to prosocial behavior, romantic feelings and approaching attitudes.

Given that relatively few studies addressed psychological effects of sweet taste, the present work represents a narrative review and does not include a systematic review of the literature. The articles on psychological effects of sweet taste address a specific audience in

the field of psychology; thus, a narrative review for a broader audience may be helpful to enhance our understanding of psychological mechanisms related to the consumption of sweet foods. This understanding is important in respect to its relationship with overweight and obesity in the present day. Therefore, we also briefly discuss the role of sweet taste or sweet taste preference in eating behavior and obesity. Finally, we explore whether the psychological effects described in the beginning might help individuals in controlling their body weight.

This review considered studies that describe psychological effects of sweet taste experience. For choosing those articles, we used a search strategy examining electronic databases until September 2021 (PubMed, PsycINFO), using search terms sweet AND taste AND (prosocial OR altruistic OR social OR embodiment OR conceptual metaphors OR metaphors OR attraction OR love OR romantic). We had no date limit for our searches. Furthermore, for choosing articles with respect to the relationship between sweet taste preference and obesity, we examined articles based on a search strategy using search terms sweet AND taste AND preference AND (obesity OR overweight).

2. Love Is Sweet: Sweet Taste and Romantic Mindsets

When we perceive the world around us, our minds have to form coherent images of this world, so that we could communicate successfully with our conspecifics. Although our brains seem to be very good at this task, recent research demonstrates that we are not always entirely independent in our social perceptions and decisions. For example, bodily sensations coming from tactile, olfactory, visual, or gustatory modalities seem to influence (or prime) our social perceptions [1,6]. How do these sensory experiences affect our thinking? According to the conceptual metaphor theory, language seems to be crucial here. This theory argues that (at least some) metaphors are not mere figures of speech, but actively affect our minds and the way we perceive and think [7,8]. Thus, certain figures in our language may affect our thinking and are grounded in our mindsets [7–10]. These conceptual metaphors may be based on sensory or motor experiences we made in early life and now represent scaffolds for our present perceptions and decisions [11]. One example for these conceptual or embodied metaphors is the concept of warmth. It has been demonstrated that feeling physical warmth (holding a warm cup of coffee) makes one likely to perceive an individual as having a trustworthy personality. This has been explained by the warmth metaphor, which links physical warmth to trust [12,13]. However, it still remains a matter of debate whether linguistic metaphors cause those embodiment effects, or whether “the metaphors are the result of preverbal mechanisms that shape both our language and thought” [14]. In the latter view, those embodiment effects might also be present in preverbal infants or even in animals [14,15].

One of the strongest and most common metaphors seems to be sweet taste, which has been linked to a romantic dimension in many languages. Thus, love is sweet in English, German, and even Mandarin. Numerous studies demonstrate that this metaphor affects our decisions and behavior, and thereby may be described as conceptual or embodied metaphor. For example, Chan et al. [16] induced feelings of romantic love (or jealousy) by asking participants to write about a time when they felt romantic love (or jealousy). They then had to rate a drink as part of an unrelated study on “individual differences in taste sensitivity” with respect to its taste (sweet, sour, bitter, salty, spicy). The drink was always plain distilled water. Results showed that individuals induced to feel romantic love feelings rated the water as sweeter than those who were instructed to feel jealousy. No effects were found for other tastes. In particular, the authors did not find that an induced feeling of jealousy lead to the participants perceiving the water as more bitter. Thus, jealousy tastes neither bitter nor sour [16], suggesting that not all taste perceptions affect our social perceptions and behavior. Ren et al. examined the same relationship between sweet taste and romantic perceptions but tested the effect in the opposite direction. Participants were given a sweet snack (cookies or soft drink) or a non-sweet control (salt-vinegar chips or distilled water) before being asking to complete a questionnaire on their current or

hypothetical relationship. Results showed that participants who consumed the sweet snack evaluated a hypothetical relationship more positively than those who experienced a non-sweet taste. Similarly, the authors could also show that sweet taste made individuals more interested in starting a new romantic relationship [17]. The results are supported by another study examining the effects of sweet taste on the romantic dimension of the sweet metaphor. The authors demonstrated that eating a sweet snack (in contrast to a salty snack) had an impact on subsequent attractiveness ratings of faces (but not of art pictures unrelated to the sweetness metaphor) (see Figure 1) [18].

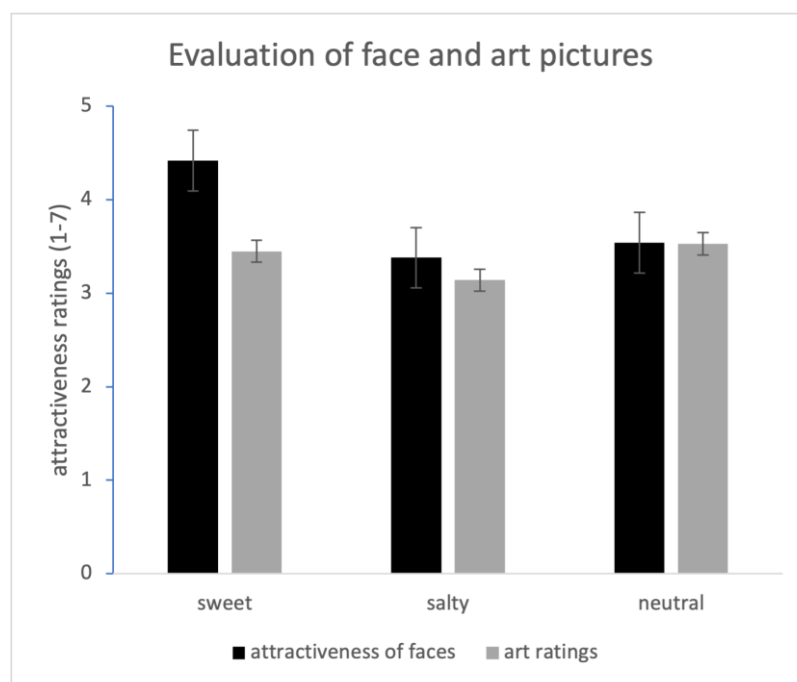


Figure 1. Participants in this study tasted sweet, salty, and neutral stimuli before performing a task in which they had to rate the attractiveness of faces (with art pictures as control stimuli). When briefly experiencing sweet taste before, attractiveness ratings of faces (of the opposite sex) showed higher scores compared with priming with a neutral or a salty taste. Furthermore, the study showed that participants after sweet taste priming reported more often that they could imagine asking the depicted person to invite him or her for a coffee. Thus, sweet taste experiences induced romantic mindsets. In contrast, stimuli unrelated to romantic or approaching behavior, such as abstract art pictures, were not altered by taste experiences (data taken from [18]).

While the above-mentioned studies rely on behavioral data, a recent study used imaging data to examine the psychological sweet effect. This approach promises an understanding of the underlying mechanisms of the reported effects. While recording their brain activity with electroencephalography (EEG), Wang et al. exposed their participants to sweet taste or control conditions and subsequently asked them to perform a lexical decision task, including romantic and control items. They found an enhanced N400 component for romantic words in the sweet taste condition, suggesting that sweet taste facilitates the semantic processing of romantic cognitions [19,20], thereby supporting the above mentioned behavioral research.

As mentioned above, sweet taste is linked metaphorically to romantic feelings in many languages. However, in some languages or cultures, this link is not present. In Israeli culture, sweetness is used as a metaphor for inauthenticity. Gilead et al. conducted a study that included 62 Israeli participants who had to eat sweet or spicy snacks, and then were asked to perform a social judgement task [14]. They found results according to the specific

cultural-linguistic characteristics of the participants, suggesting that culture and language provide at least important contributions to the conceptual metaphor of sweetness and love.

Taken together, these results suggest that sweet taste may represent a conceptual metaphor and, thereby, has an impact on our romantic feelings and behavior (in contrast to bitter or sour taste).

3. Being a Sweetie: Sweet Taste and Prosocial Behavior

Recent research also reported relationships of taste experience with prosocial behavior. In a series of experiments Meier et al. found evidence for the assumption that sweet taste may work as a source domain for prosocial functioning [21]. For example, in one of their experiments, the authors invited students to participate in a “research study on taste”. They asked participants to either try a sweet (a small piece of milk chocolate) or a non-sweet snack (a cracker containing no sugar), or they assigned them randomly to a non-food control condition, and told them that they should later comment on that food. The participants were given 30 s to taste the snack and afterwards were asked to complete an unrelated questionnaire for one minute. When the participants finished their questionnaire, an experimenter informed them about another professor who had just stopped by, requesting volunteers for another (unrelated) study. The experimenter asked each participant how many minutes he or she would be willing to help in this experiment, and told them that the new study would start immediately upon completion of the food taste experiment. This measure served to provide information about the prosocial intentions and behavior of the participants. It should be noted that this request was placed before the consumed sugar of the snacks could be metabolized. Finally, participants evaluated the sweetness of the snacks and reported on their current mood states. Results revealed that those participants who tried the sweet snack before showed more prosocial intentions (offered more minutes to help) than the individuals in the control condition. These results were independent of the reported mood states. Thus, the experience of sweet taste made the participants more helpful.

Subsequent studies could replicate and extend these findings. Fetterman et al. examined within-person cross-day relationships between acting more prosocial and the consumption of sweet food. In two independent studies, the authors found that agreeableness levels were higher on days when sweet food consumption increased [22,23]. Another study examined German participants with the food-tasting paradigm described before, and showed—in two experiments—that the experience of sweet food (in comparisons to salty snacks or no food) increased prosocial intentions and behavior. There were no differences with respect to the overall likings of sweet vs. salty snacks and groups did not differ with respect to mood [18] (see Figure 2).

Research also reported relationships between personality traits and sweetness, suggesting that individuals who prefer sweet food are more prosocial and agreeable. Meier et al. reported that participants with the personality of liking sweet-tasting foods exhibited not only prosocial intentions, but also concrete helping behavior [21]. Thus, individuals having a “sweet tooth” might have more prosocial personality traits. However, these effects seem rather small, and it is unclear whether they are culture-dependent [24].

How can these effects be explained? As pointed out above, the conceptual metaphor theory argues that language may explain these embodiment effects. Figures, such as conceptual metaphors (in contrast to mere linguistic metaphors) may be grounded in our mindsets and thereby affect our thinking [7–10]. Sweetness is not only a taste, but also a metaphor. In many languages, this metaphor points to the meaning that love is sweet, suggesting a relationship between romantic love and sweet taste that we addressed in the previous chapter. In the English language however, there is also a second meaning of the sweet metaphor, which links sweetness with prosocial behavior. Being a “sweetie” means that this individual is a very helpful person. The term sweetness here refers to someone who is kind, friendly, and caring for others. However, the second meaning of the sweetness metaphor does not seem to explain the findings of sweetness and prosocial behavior found

in German participants [18]. Thus, preverbal mechanisms that might be independent from culture may explain those results. For example, early experiences with the physical world may structure our mindset and thereby influence our present behavior [11]. These mindsets could then form the links between sweetness and prosocial behavior. Given that breast/formula milk tastes sweet, it has been suggested that the relationship between helping behavior and sweet taste (and perhaps also with love) may be based on feeding behaviors during infancy [1,21]. Over time, this experience may have built a scaffold of our thinking. How may those scaffolds be represented in the brain? A neuroscientific view suggests that our brain uses brain regions in different ways depending on actual needs [25]. Thus, higher cognitions, such as prosocial behavior, may be built on evolutionary older perceptual programs and brain areas (the theory of neural reuse [25]) (e.g., [26]). However, future studies are needed to further understand the underlying neural mechanisms of the sweetness metaphor.

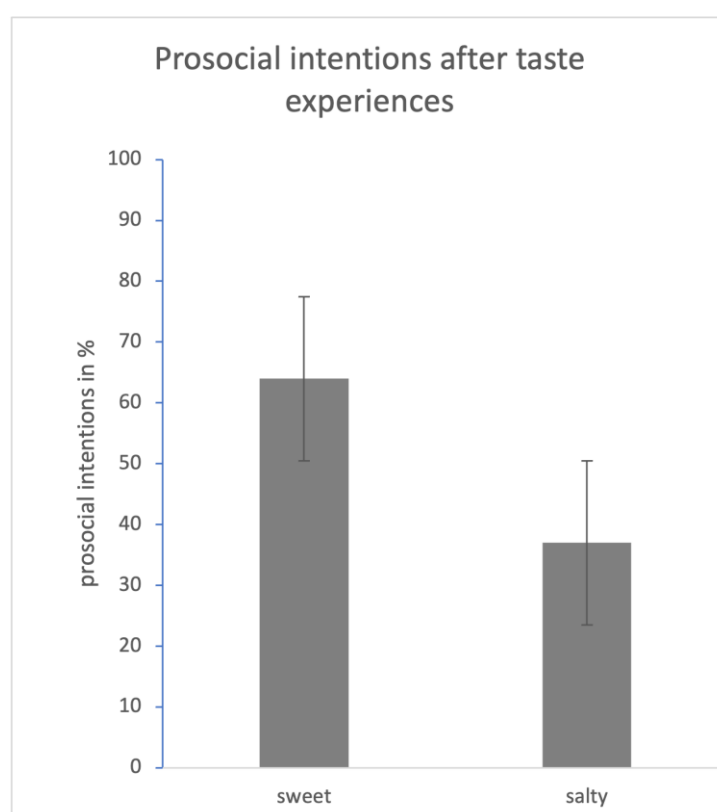


Figure 2. In this study, participants tasted sweet or salty stimuli and subsequently tested with respect to their actual prosocial or altruistic intentions. Prosocial intentions were more frequent when experiencing a sweet taste relative to a salty taste before. Prosocial intentions were measured by asking participants to volunteer in another unrelated study (data taken from [18]).

4. Sweet Taste Preference and Obesity

The previous paragraphs outlined psychological effects of perceiving sweet taste on the activation of romantic or prosocial mindsets. Considering the global rise of overweight and obesity in adults and children, it seems of particular interest how sweet taste and the preference for sweet taste affect our eating behavior. The liking of sweet taste seems to be very powerful in many individuals. Some researchers argue that the preference of sweet taste is innate to all of us, and important, because it enables us to detect plants with available glucose [27]. Thus, sweet taste preferences seem to be logical from an evolutionary perspective because it offers a primary energy source. Others point out that sweet taste is preferred in comparison to bitter taste due to the latter's capacity to signal toxicity (whereas sweet taste provides information on potential beneficial effects of food) [28]. However, in

present times, detecting beneficial plants or avoiding toxic foods seems to be less important. In contrast, overweight and obesity has become one of the leading challenges in the western world. So how does the preference for sweet taste affect our eating behavior today?

Based on the observation that the consumption of ultra-processed food is greater in individuals with overweight and obesity [29,30], it is widely assumed that the liking of sweet foods may contribute to the development of obesity. However, research on the relationship between sweet taste preferences and obesity revealed mixed results and remains inconclusive [31]. For example, Sobeck et al. investigated 150 children and found twice as many obese children in a group that preferred high sweet taste as compared to a group that preferred low sweet tastes [32]. In contrast, Hill et al. examined the relationship between the liking of fatty or sugary foods, fruits and vegetables, and adiposity measures in 366 children aged 7–9 years. They found no association between obesity and liking of selected foods [33]. In a large sample including 24,776 French adults over five years Lampuré et al. showed that unlike sweet and salt liking the preference for fat seems to be a major risk factor of obesity [34]. In a functional magnetic resonance imaging (fMRI) experiment DeFeliceantonio et al. demonstrated that combined foods high in fat and carbohydrate are more valued than equicaloric foods and that this effect is reflected by recruitment of reward related brain areas such as the striatum. Remarkably, this effect was independent of the personal preferences of the participants [35]. Thus, the relationship between the preference for sweet taste and overweight and obesity seems to be more complex than assumed. The lack of converging results may be explained by different designs, types of sugary foods, and participants (e.g., children of different age or adults).

Interestingly, it has been reported that taste perception in obesity is altered for sweet (and other) taste, which might explain a possible higher consumption of sweet foods in this group. For example, it has been shown that, in flies, a high-sugar diet results in decreased activity of neurons responsible for sweet taste perception, thereby leading to a reduced perception of sweet taste [36]. In addition, it has been shown in mice that chronic low-grade inflammation, due to obesity, diminishes the number of taste buds in gustatory tissues [37]. However, systematic studies in humans addressing the association between sweet taste threshold and obesity (e.g., BMI) reveal inconclusive results [31]. While some studies found support for a negative relationship between BMI and sweet (and other) taste perceptions [38–40], other studies found no effects [41–44], or even reported rather enhanced than reduced sweet taste sensitivity [45,46]. These mixed results may be at least partly explained by different approaches to measure taste [47]. Furthermore, an age-related general and gradual decline in the ability to detect sweet taste has to be considered as well [48]. However, the known age-related changes in sweet taste preferences (with higher sweet taste preferences in children and adolescents) cannot be explained by those changes [49]. Thus, further research is required.

Humans and animals may prefer sweet taste in contrast to, for example, bitter taste perhaps due to evolutionary reasons (see above), but it still remains unclear whether we may have learned the preference for sweet (or other) tastes in early childhood (or even in utero) or maybe acquire this liking later in life. A systematic review on in utero and early infant taste experiences and later taste preferences found no clear results. A “potential programming of sweet taste acceptance” was found only in studies with long-term exposure to sweet taste (or short-term exposure with immediate testing) [50].

Brain imaging studies (as well as animals studies) showing an activation of the reward system related to sweet stimuli have gained attention, and have even led to an analogy between sugar and addictive drugs, such as cocaine [51]. So, what are the neural representations of our preference for sweet taste? Sweet stimuli processing has been shown to activate brain regions, such as the primary gustatory cortex (insula), postcentral gyrus, and thalamus [52], but an activation of the orbitofrontal cortex, a well-known part of the reward circuit of the brain, has also often been reported [53,54]. Here, it is important to stress that other studies may not have reported activation because functional brain activity in this region is difficult to detect due to the high susceptibility of signal drop out in standard

fMRI protocols. Furthermore, a number of factors in the experimental design may affect the observation of reward-related brain areas in relation to sweet taste [55]. However, several studies demonstrated that sweet stimuli may result in rewarding and craving similar to (or even higher than) addictive drugs [51,56]. This may reflect evolutionary arguments (see above) and might explain why many individuals have difficulty controlling the consumption of sweet foods.

Given that the taste of sweet snacks may feel much more rewarding, for example, when feeling hungry, context factors may be important when investigating the relationship between sweet taste and activation of reward-related brain regions. A recent meta-analysis of fMRI studies has found moderating effects of the relationship between sweet stimuli and activation of the reward system. The authors report that hunger, but not fasting or BMI, was linked to sweet stimuli-related activation of the reward circuit (orbitofrontal cortex and ventral striatum) in the brain [54].

The research on psychological effects of sweet taste, as well as the research discussed in this chapter, refers to sweet taste induced by different snacks (e.g., [21]) or other sweet foods (e.g., [33]). Do the results differ when nonnutritive sweeteners instead of natural sweets are used? Given that an increasing number of people try to replace nutritive sweeteners with nonnutritive sweeteners to address their desire for sweet taste with reduced calories, this question seems to be important. For the psychological effects of sweet taste on romantic mindsets or prosocial behavior, the role of nonnutritive sweeteners remains unclear, since there are no studies in this research area. However, given that the taste of, for example, sugar is different from nonnutritive sweeteners, and that brain areas processing those sweeteners may be different, it would be interesting to test whether the replacement of the sweet snack induces similar psychological effects. With respect to overweight and obesity, remarkable results (for example in rats) report that nonnutritive sugar changed behavior by increasing motivation for sweet foods, leading to weight gain in obese rats [57]. A recent fMRI-study confirmed these results by demonstrating differential effects of sex and obesity on reward processing of nutritive (sucrose) and nonnutritive sweeteners (sucralose). The authors showed that females and obese individuals have higher neural reward responses to nonnutritive sweeteners, thereby stressing the differential effects of biological factors [58].

How does our personality affect our eating behavior and the preference for sweet foods? Several studies examined how personality traits interact with eating behavior. Most studies use the “Big Five” theory of personality, which represents an established factorial approach to describe our individuality. These factors have been labelled neuroticism, extraversion, openness, agreeableness, and conscientiousness [59]. Extraversion has been related to high degree of sociability, assertiveness, and talkativeness. Neuroticism is reflected by the tendency to experience negative emotions, such as anxiety and irritability. Agreeableness is related to altruism and linked to cooperation and politeness. Conscientiousness is associated with being disciplined and achievement oriented. Finally, openness to experience reflects aesthetic sensitivity and intellectual curiosity [59]. With respect to the Big Five, sweet taste preferences have been linked, in particular, to the trait neuroticism [60]. For example, Elfhag and Erlanson-Albertsson found relationships of sweet taste preference with neuroticism personality traits in obese patients [61]. Saliba et al. examined sweet taste preferences when asking healthy participants to taste wine. They reported low openness and high impulsiveness associated with sweet preferences [62]. Neuroticism and agreeableness (negatively) have also been related to the susceptibility to hunger in overweight and obese women [63]. Taken together, sweet taste preference in obesity might be associated in particular with the personality trait neuroticism. However, further studies are needed to control for other factors that may drive this relationship.

5. Discussion

In this review, we focused on psychological effects of sweet taste. In the first part, we reported studies that showed how sweet taste experiences could affect our social perception and behavior, suggesting a link between sweet taste and romantic mindsets, social behavior,

and approaching intentions. However, it remains unclear whether these effects are based on cultural- and language independent preverbal processes or, in contrast, can be tied to conceptual metaphors in our language. Future research is needed to further disentangle the underlying cognitive and neural processes for these results. Studies should ensure sufficiently large samples and consider more cross-cultural studies. In addition, given that only one imaging study on these effects has been conducted so far, additional studies aiming to unravel the neural underpinnings of those effects would be very interesting. Furthermore, given that the absolute effects are rather small (and still only a limited number of articles have been published), it remains unclear whether the reported effects may have a significant impact on practical life.

In the second part of our review, we briefly summarized findings on the role of sweet taste preference in obesity. Numerous studies addressed this question, but the results remain inconclusive. Thus, it remains unclear whether the preference for sweet taste is associated with a risk of obesity. The results suggest that the interaction between taste, personality, eating behavior and obesity may be more complex than assumed. However, a possible explanation for the inconclusiveness in results may be due to overall different types of sugar, intake form (liquid vs. solid), and quantity of intake between studies. Future research needs to take account of these variables. In addition, studies need to address the interaction between personality and eating behavior. Moreover, cross-cultural studies are needed, too. Finally, influences, such as sedentary lifestyles, insufficient physical activity, and age should be controlled in future research.

Several limitations of this mini review have to be noted. First, the present article is a narrative review. While for the psychological studies on the effects of sweet taste on behavior, narrative reviews may be justified because the limited number of studies, the number of studies on sweet taste, and sweet taste preference linked to obesity is much higher. For this part, systematic reviews might be valuable. However, the current article predominantly aimed to review psychological effects of sweet taste. A second limitation refers to the limited number of experiments (and, at times, small sample sizes) on psychological effects in sweet taste, on which basis this review attempts to draw conclusions. Last, this review could only very briefly touch cultural factors.

6. Conclusions and Future Perspectives

We conclude that sweet taste seems to have complex psychological effects. Tasting something sweet can result in activation of the brain's reward system. Furthermore, sweet taste preference might contribute to the development of obesity, but these studies are inconclusive. There is also research suggesting an altered sweet taste threshold in obesity, but again there are mixed results. Sweet taste has also been related to prosocial and altruistic intentions and behavior. Due to its strong relationships to the 'love is sweet' metaphor, it can activate a romantic mindset, resulting in an increased approaching behavior. Thereby, the results demonstrate the multifaceted power of this taste, which we tried to explain with evolutionary and cultural arguments.

Given the above-mentioned limitations, we have to be very careful when drawing further conclusions and implications out of the reviewed studies. Nevertheless, since a role of sweet taste preference for obesity has been suggested, possible practical consequences seem to be of particular interest. Can psychological effects comparable to those we introduced in the first part of this review potentially affect eating behavior in order to reduce the risk for overweight and obesity?

This idea is intriguing, but the research on psychological sweet effects is still in its infancy. Future studies could test whether psychological interactions of sweet taste with romantic mindsets or prosocial behavior may be particularly altered in obese individuals. If so, one could speculate that the awareness of those effects may help people to control body weight.

Furthermore, it is known that there are reciprocal relationships between obesity and depression [64]. Previous studies reported that, not only obese individuals (although the

results are inconclusive, see above), but also depressed patients, may have an altered perception of sweet taste [65]. Considering that psychological effects of sweet taste include prosocial and outgoing behavior, one might speculate that a training to improve sweet taste might change depressive symptoms and/or overweight and obesity. In fact, it has been shown that psychological sweet effects may alter depressive symptoms [23].

However, at least at present, it remains unclear whether the psychological effects may be used to improve an individual's health in the way we speculated. Nevertheless, the effects described at the beginning of this article demonstrate that sweet taste has complex psychological effects, which include positive and socially desirable outcomes.

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