

# A Mouth-Watering Prospect: Salivation to Material Reward

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The term “hunger” and terms referring to its physiological correlates, notably “salivation,” are used to refer to desire for material rewards across languages and cultures. Is such usage is “merely metaphorical,” or can exposure to material reward cues evoke a salivary response? Results of an experiment show that individuals salivate to money when induced to experience a low power state but not when induced to experience a high power state. A second experiment shows that men salivate to sports cars when primed with a mating goal but not in a control condition. These findings suggest that salivary secretion is stimulated by material rewards in the presence of a highly active goal to obtain the rewards and that the motivation to acquire material rewards might more closely resemble physiological hunger than previously assumed. Implications for material addictions and decision making and directions for future research are discussed.

Although, from a biological perspective, hunger is a physiological drive state directing an organism to food, the term “hunger” is used metaphorically across languages and cultures to express desire more generally (Gibbs, Costa Lima, and Francozo 2003; Lakoff and Johnson 1999). Furthermore, in English and other languages, metaphorical expressions referring to physiological correlates of hunger and craving to express desire for nonbiological incentives are common in everyday language, most notably in the case of salivation, such as the notion of a “mouth-watering prospect,” or of “salivating at the sight of a new sports car” (Gibbs et al. 2003; Lakoff and Johnson 1999). An intriguing question that arises is whether such language is merely metaphorical or whether a visceral, hunger-like physiological process might, indeed, be involved in the motivational drive to acquire material rewards.

In the present research, I examine this question by testing whether material rewards can elicit salivation. Salivation is one of several physiological events, including increased gastric motility and the secretion of gastric enzymes, that play a specific functional role in digestion and that are activated as part of the cephalic phase response (i.e., the anticipatory

phase of digestion; Lashley 1916; Pavlov 1927; Winsor 1930; Wooley and Wooley 1973). Moreover, salivary secretion depends on the motivation to acquire food, with research showing that salivation to food-related cues correlates with hunger (operationalized as duration of food deprivation) in both animals (Finch 1938; Pavlov 1927) and humans (Wooley and Wooley 1973). Importantly, salivation is not ordinarily under conscious control (Lashley 1916; Winsor 1930). Thus, if salivation is stimulated by material rewards, it might suggest that the motivation to acquire artificial incentives parallels a visceral, hunger-like drive more closely than previously assumed.

I first discuss relevant prior research on the involvement of the motivational system in the acquisition of artificial rewards and then describe the experiments that I performed. Afterward, I discuss possible interpretations and implications of the findings and directions for future research.

## BACKGROUND

Animals’ survival depends on their ability to identify and approach stimuli with reward value in the environment. This process involves making associations between external cues and internal representations of value. Whereas this ability likely emerged in order to propel animals toward natural incentives, such as food, water, and sex, research shows that the neural reward system plays a similar role in the pursuit of artificial reinforcers, as in the pursuit of natural incentives. In particular, research in animals has indicated that common neural pathways underlie the motivation and reward systems for food and addictive drugs (Volkow and Wise 2005). Both food- and drug-related cues elicit activation of the same

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neural systems associated with reward in cortico-striatal-hypothalamic circuits (Brody et al. 2002; Childress et al. 1999). Moreover, food and drug cues have been shown to lead to similar gene expression patterns (i.e., patterns of information that genes transmit) in the activated areas (Kelley, Schiltz, and Landry 2005). Suggestive evidence of a common neural reward system underlying food and drug reward also comes from research on drug cessation in people: quitting cocaine (Brodie, Figueroa, and Dewey 2003) and quitting smoking (Lerman et al. 2004; Stamford et al. 1986) have been shown to lead to substantial weight gain, with evidence suggesting an increase in the value of food reward following smoking cessation (Lerman et al. 2004).

Recent brain imaging studies in people have also shown that nonbiological reinforcers, such as money (Breiter et al. 2001; Knutson et al. 2001; Pessiglione et al. 2007), music (Menon and Levitin 2005), sports cars (Erk et al. 2002), and luxury goods (Craig et al. 2010), among others, can elicit neural activation in the same dopaminergic reward circuitry associated with drug and food rewards (for a review, see Camerer, Loewenstein, and Prelec 2005). Moreover, research has shown that activity in such areas during exposure to a target product predicts purchase behavior (e.g., Knutson et al. 2007). These findings support the involvement of the neural reward system in the motivation to acquire material rewards.

In addition to evidence suggesting the involvement of the general reward system in the motivation to acquire food, evidence also shows that physiological events thought to be specific to the motivation to acquire food can also be stimulated by artificial incentives. In particular, it has been found that the desire to obtain artificial biological reinforcers (i.e., drugs) is associated with release of the hunger-stimulating brain-gut peptide ghrelin (Jerlhag et al. 2009; Tessari et al. 2007) and salivation (Cooney et al. 1984). However, unlike material rewards, drugs directly impact biological processes, leaving open the question of whether the motivation to acquire nonbiological rewards might similarly involve physiological processes typically associated with hunger. To address this open question, I performed two experiments.

## EXPERIMENT 1: MONEY

Money can be thought of as the ultimate material reward, since it represents a medium of exchange through which all other rewards might be obtained. The mere concept of money has been shown to have dramatic effects on behavior (Vohs, Mead, and Goode 2006; Zhou, Vohs, and Baumeister 2009). Indeed, it has been argued that money can be conceptualized as a drug in that it imitates the action of biological incentives in driving behavior (Lea and Webley 2006). Thus, in experiment 1, I examined whether the motivation to obtain money can stimulate salivation during money cue exposure.

Specifically, I examined whether one's state of power could stimulate a salivary response to money. I focused on power because power, defined as asymmetric control over resources and individuals, is a pervasive element in social

interactions (Magee and Galinsky 2008), significantly affecting people's thoughts (Brinol et al. 2007) and behaviors (Galinsky et al. 2006; Magee, Galinsky, and Gruenfeld 2007; Rucker and Galinsky 2008) across a broad swath of domains. Moreover, because money represents personal freedom, status, and control of resources (Vohs et al. 2006), its reward value should be greater for the powerless than for the powerful. Indeed, consistent with this view, research shows that the poor (Bruner and Goodman 1947) and the powerless (Dubois, Rucker, and Galinsky 2010) perceive money as physically larger than the rich and the powerful, a phenomenon assumed to reflect differences in the motivation for money. Thus, if salivation is stimulated in association with the motivation to obtain money, individuals induced to feel powerless should manifest a greater salivary response during exposure to money cues than individuals induced to feel powerful.

## Method

Experiment 1 had a 2 (stimulus cue: money vs. control)  $\times$  2 (power: low vs. high)  $\times$  2 (time: baseline vs. cue exposure) design, with stimulus cue and power as between-subject factors and time as a within-subject factor. Participants were 169 undergraduates at Northwestern University.

## Procedure

Participants were first provided instructions for a task ostensibly examining consumers' salivary response to food stimuli. Participants were informed that the experimenters were interested in measuring the salivary response to viewing different food items and that some participants would view different food items during the saliva measurement and other participants would view nonfood items during the saliva measurement, with the latter serving as a control. In fact, all participants viewed images of nonfood items, either images of money or control images (pictures of office supplies), depending on the assigned condition.

The method used to measure salivation was derived from Peck (1959) and involved both a 2-minute baseline measurement and a second 2-minute measurement following the power induction manipulation. The dependent variable was the difference in salivation between the baseline and subsequent measurements. For the baseline measurement, participants were provided with three dental rolls and were asked to place two rolls between their cheeks and lower gums, and the third crosswise and under the tongue. The dental rolls were 1.5-inch-long cylindrical cotton rolls typically used in dental offices to absorb saliva during dental procedures. They were instructed to sit in silence for 2 minutes while viewing an "X" on a computer screen. Afterward, the dental rolls were extracted with tweezers and sealed in a plastic bag. The amount of salivation was determined by the weight of the sealed bag minus the weight of the previously weighed bag and rolls using a scale with accuracy to 10 milligrams.

Before completing the second saliva measurement, par-

Participants completed a series of unrelated tasks of about 10 minutes' duration, the last of which was ostensibly unrelated to the other tasks but actually served as the manipulation of power. In particular, power was manipulated by asking participants to write about a time they either had or lacked power (Galinsky, Gruenfeld, and Magee 2003). They were asked to describe in detail what happened and how they felt. After the power induction manipulation, participants completed the second saliva measurement, which was performed identically to the first measurement, except that participants viewed either a picture of money or of office supplies (i.e., the control image), depending on assignment, on a computer screen during the measurement.

## Results

Responses of participants whose change in salivation from baseline to cue exposure was greater than 4 standard deviations from the mean were removed from further analysis, resulting in the responses of two participants being removed from further analysis. Removal of these two responses did not materially alter the results.

A mixed-model ANOVA, with time as a within-subjects factor, revealed a significant cue  $\times$  power  $\times$  time interaction ( $F(1, 163) = 4.10, p < .05$ ; see fig. 1). Importantly, among individuals exposed to money, there was a significant power  $\times$  time interaction ( $F(1, 82) = 6.54, p < .05$ ). This interaction indicated that power state had a significant impact on salivation among those exposed to monetary cues. Further, simple main effects showed that among those exposed to money cues, salivation was greater during exposure to money ( $M = 3.06$  grams) than at baseline ( $M = 2.29$  grams) when power was low ( $F(1, 37) = 13.03, p < .001$ ), whereas salivation did not significantly differ during exposure to money ( $M = 2.41$  grams) versus baseline ( $M = 2.26$  grams) when power was high ( $F(1, 45) = 1.30, p = .26$ ). Among individuals exposed to office supplies, the power  $\times$  time interaction was not significant ( $F < 1$ ), indicating that the effect of power on salivation was dependent on the nature of the cue.

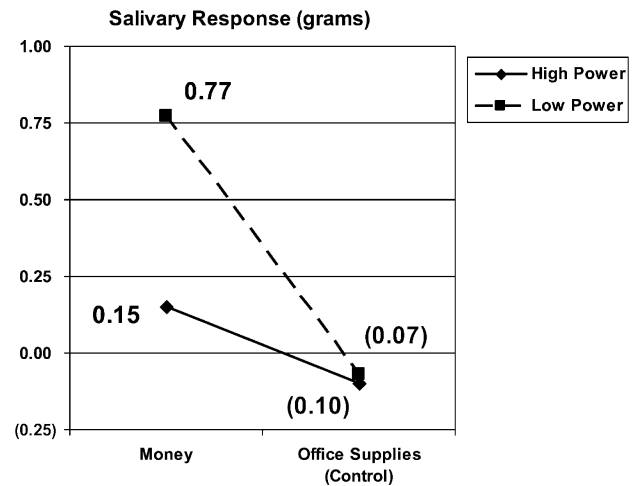
## Discussion

Experiment 1 found that exposure to money stimulated a salivary response among those induced to experience low power but not among individuals induced to experience high power. Further, salivation was not stimulated by exposure to office supplies regardless of power induction manipulation. These findings suggest that salivation is stimulated by money cues when the reward value of money is high.

A potential alternative explanation is that money's instrumentality in acquiring food leads people to equate money and food and, thus, that people were not salivating at money as money per se but at money as a representation of food (salivation can occur in response to food cues even in the absence of hunger; Pavlov 1927; Wooley and Wooley 1973). However, research shows that people do not perceive money in terms of the visceral rewards they can obtain with

FIGURE 1

CHANGE IN SALIVATION BETWEEN BASELINE AND CUE EXPOSURE BY CUE AND POWER (EXPERIMENT 1)



it; for instance, Brendl, Markman, and Messner (2003) found that individuals who craved cigarettes devalued money even though they could have used the money to acquire cigarettes. Further, an explanation that assumes that individuals salivate to money because it represented food does not readily explain the interaction observed with power. Nonetheless, experiment 2 sought to extend the finding of experiment 1 to the context of a nonmoney material reward, namely, sports cars.

## EXPERIMENT 2: SPORTS CARS

Although luxury goods, such as prestigious brand names, sports cars, and jewelry, lack biological function, they are often highly desired due to their aesthetic and status-signaling qualities (Rucker and Galinsky 2008; Veblen 1899). Thus, experiment 2 sought convergent evidence to the findings in experiment 1 that material reward can stimulate salivation by examining salivation to sports cars among men. The experiment focused on the responses of men, given men's known penchant for the aesthetic and status-signaling qualities of cars (Belk 2004).

Experiment 2 further examined how men's salivation to sports cars would be affected by having been primed with a mating goal. This moderator was examined because prior research has shown that priming men with mating goals significantly affects their preferences (Griskevicius et al. 2007; Van den Bergh, Dewitte, and Warlop 2008). Of particular relevance, men primed with mating goals are more likely to express an intent to purchase conspicuous luxury products but not functional products, suggesting that men have a greater desire for status-signaling goods when primed with a mating goal (Griskevicius et al. 2007).

## Method

Experiment 2 had a 2 (stimulus cue: sports cars vs. control)  $\times$  2 (primed goal: mating vs. control)  $\times$  2 (time: baseline vs. cue exposure) design, with stimulus cue and primed goal as between-subject factors and time as a within-subject factor. Participants were 97 undergraduate men at Northwestern University. The saliva measurement was performed similarly to that described in experiment 1, except that, during the second saliva measurement, participants assigned to the sports cars condition viewed a series of pictures of sports cars on a computer screen, and participants who were assigned to the control condition viewed a series of pictures of fastening tools.

Prior to the saliva measurement, participants were primed with either a mating or control goal. To induce a mating goal, I adapted the procedure used by Griskevicius et al. (2007). In particular, participants were shown images of three attractive females and asked to choose with whom they would be most interested in going out on a date. They were asked to imagine what their idea of the perfect date would be like with this person and to spend 3 minutes describing the date in writing. Participants in the control condition were shown images of three barber shops and asked to choose at which shop they would most prefer to get their hair cut. They were asked to imagine what it would be like to get their hair cut there and to spend 3 minutes describing what it would be like. Afterward, the second saliva measurement was performed as described above.

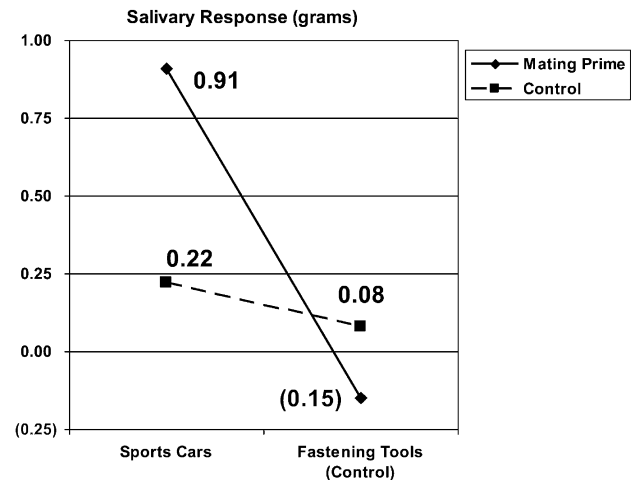
## Results

A mixed-model ANOVA, with time as a within-subjects factor, revealed a significant cue  $\times$  mating goal  $\times$  time interaction ( $F(1, 93) = 6.11, p < .05$ ; see fig. 2). Importantly, among individuals exposed to sports cars, there was a significant mating goal  $\times$  time interaction ( $F(1, 45) = 5.02, p < .05$ ). This interaction indicated that the mating prime had a significant impact on salivation among those exposed to sports cars. Further, simple main effects showed that among those exposed to sports cars, salivation was greater during exposure to sports cars ( $M = 3.26$  grams) than at baseline ( $M = 2.35$  grams) following a mating prime ( $F(1, 25) = 14.88, p < .001$ ), whereas salivation did not significantly differ during exposure to sports cars ( $M = 2.70$  grams) versus baseline ( $M = 2.48$  grams) in the absence of a mating goal ( $F(1, 20) = 1.45, p = .24$ ). Among individuals exposed to tools, the mating goal  $\times$  time interaction was not significant ( $F < 1$ ), indicating that the effect of a mating goal on salivation was dependent on the nature of the cue.

In sum, experiment 2 found that sports cars can stimulate a salivary response among men. In particular, this response was observed among those men for whom sports cars were temporarily made particularly desirable.

FIGURE 2

CHANGE IN SALIVATION BETWEEN BASELINE AND CUE EXPOSURE BY CUE AND MATING GOAL (EXPERIMENT 2)



## GENERAL DISCUSSION

Across two studies, the present research found that salivation, a correlate of physiological hunger, can be stimulated by exposure to material reward cues. In particular, this effect depended on the reward value (i.e., desirability) of the stimulus, with individuals induced to experience low-power (but not individuals induced to experience high-power) salivating to money and men primed with mating goals (but not men primed with control images) salivating to sports cars. These findings show that exposure to a material reward cue stimulates salivation when the reward value is high, such as when the reward is associated with a highly active goal. Thus, the findings suggest that the motivation to acquire nonbiological rewards might resemble a visceral, hunger-like process more closely than previously assumed.

By showing that material rewards can trigger physiological events associated with hunger and craving, the present research also adds weight to views that have conceptualized material rewards in biological terms. These include the notion that money can function like a drug (Lea and Webley 2006) and that addictions to gambling (Griffiths 1994), video games (Fisher 1994), and shopping (Dittmar 2004; Faber and O'Guinn 1992; Faber et al. 1995; Hirschman 1992; Richins and Dawson 1992; Rindfleisch, Burroughs, and Denton 1997; Rook and Hock 1985), among others, can mimic drug addictions. In particular, the present findings suggest the possibility that these analogies are not merely conceptual metaphors but reflect similar physiological processes in addiction to drugs and addiction to material rewards.

The present findings can also be related to recent research demonstrating that impulsivity is increased by tryptophan consumption, presumably by elevating the neurotransmitter

serotonin (Mishra and Mishra 2010). Specifically, the current findings suggest that the flow of causality is bidirectional, such that altering biological processes not only affects responses to material rewards but that material rewards affect physiological responses.

This surmise might have important implications for research on self-control and decision making, particularly in the context of consumers' financial decision making and spending. Prior research has argued that decision making occurs in the context of two very different motivational forces, "hot" visceral urges and "cool" dispassionate motivations, where the former include emotional states and motivational drives, such as hunger and thirst (Loewenstein 1996). Research has shown that visceral urges tend to narrow individuals' attention to the satiation of those urges and to devalue other goals (Brendl et al. 2003; Easterbrook 1959; Loewenstein 1996; Nordgren, van Der Pligt, and van Harreveld 2006). Visceral urges also cause a shift in individuals' temporal perspective toward the present and elicit a greater focus on one's self than on others (Loewenstein 1996). As a result, decision making in the context of visceral urges is often costly to individuals' long-term goals, as is clearly evident in the case of drug addicts who forgo all other goals for the transient urge fulfillment provided by a "fix" (Gawin 1991). The current findings potentially broaden the scope of the exploration of visceral factors on decision making to the context of nonbiological rewards, such as money or other material goods.

Nonetheless, the degree to which the motivation to obtain biological and nonbiological rewards might be anchored by common physiological (and psychological) processes remains unclear. For instance, it seems unlikely that withdrawal from craved material rewards would have the same symptoms as withdrawal from craved drugs due to the lack of direct biological action of material rewards. Future research comparing physiological processes between individuals with drug addictions and individuals with nondrug addictions might serve to further elucidate the common and divergent physiological and psychological processes associated with the motivation to obtain biological and material rewards.

### Why Does It Occur?

Unlike salivation in the case of food reward, salivation to material reward is not of any obvious function, thereby raising the question of why it occurs. One possibility is that salivation to material rewards is conditioned. For instance, it might be that early in development salivation becomes associated with the facilitation of food consumption, subsequently becomes associated with anticipation of food, and ultimately generalizes to other rewards. This account can be related to work by Razran (1939), who has shown that eating food during exposure to unrelated stimuli quickly conditions a salivary response to the unrelated stimuli (even when participants are not conscious that the stimuli were previously associated with food consumption). Although the research described in this article did not involve pairing

material rewards with food stimuli in order to condition a salivary response, Razran's findings raise the possibility that the salivary response to material rewards might have been conditioned incidentally early in development.

An alternative account is that salivation to nonbiological incentives might simply be an epiphenomenal side effect of the natural reward system. This interpretation can be related to recent research showing that desire activated in one domain can induce approach behavior in a different domain (e.g., Briers et al. 2006; Li 2008; Van den Bergh et al. 2008; Wadhwa, Shiv, and Nowlis 2008); correspondingly, inhibition of desire in one domain also appears to influence inhibition in a different domain (Tuk, Trampe, and Warlop 2011). Such findings have generally been interpreted to reflect costly by-products of an otherwise useful system, and a similar interpretation for the findings of the current studies is plausible. Interestingly, with regard to this possibility, although the control of salivation is complex and not well understood, research suggests that activation of dopaminergic receptors in the brain, which is known to play a key role in reward response, also increases salivation in both rodents (Pazo, Tumilasci, and Medina 1981) and humans (Tumilasci et al. 2006). This adds weight to the possibility that salivation, though likely purposed for digestion early in evolutionary development, has incidentally become associated with a generalized reward response.

### What Does It Measure, and How Might It Be Used?

Another important question raised by the current findings is what salivation does in response to material rewards measures. Although salivary secretion might be stimulated by a combination of factors, including liking, desire, and simple anticipation of reward, research on the salivary response to food and alcohol cues offers the intriguing possibility that salivary secretion might, in some cases, reflect desire that is inaccessible to self-report. With respect to food, research has found that salivation to food cues is greater in the obese than in normal-weight individuals (Epstein, Paluch, and Coleman 1996), greater in dieters than in nondieters (the former have been found to be more likely to gain weight; Klajner et al. 1981), and greater in those gaining weight than in those maintaining weight (Guy-Grand and Goga 1981), whereas self-reported liking or desire often do not differ among these groups. Based on such findings, some researchers have posed that a heightened salivary response might reflect desire uninhibited by conscious interference (e.g., Pecina and Smith 2010).

In alcoholics, a number of studies have found that exposure to alcohol cues stimulates salivation (Cooney et al. 1984; Reid et al. 2006; Rohsenow et al. 1992). Moreover, research has found that salivation to alcohol cues is weakly or nonsignificantly correlated with a self-reported urge to drink and self-reported enjoyment of the sight and smell of alcohol (Reid et al. 2006; Rohsenow et al. 1992). In contrast, salivation is greater among those with greater alcohol de-

pendence and is predictive of both the quantity and frequency of drinking following a detox program (Rohsenow 1999; Rohsenow et al. 1992). Based on these findings, it has been argued that cue-induced salivation might reflect autonomic desire (Reid et al. 2006).

If salivation can, indeed, tap into desire that is inaccessible to self-report, then it might be a particularly useful tool. Currently, the use of fMRI (functional magnetic resonance imaging) is often justified by claims that it can uncover processes that might not be accessible to introspection (see, e.g., Knutson et al. 2007). In comparison to fMRI, measuring salivation is a decidedly low-tech method. Therefore, if future research finds that salivation can predict behaviors independently of self-reports, its accessibility suggests that it might make a valuable research tool.

Nonetheless, despite the possibility that salivary reactivity might detect nonconscious desire in some individuals, experimental evidence specifically aimed at addressing the role of salivation in the motivational process is limited and open to interpretation, and much future research will be needed to establish what salivary reactivity represents in the context of material incentives. Specifically, future research might investigate how salivation to material rewards is associated with measures of desire and liking (e.g., self-reports, smiling), as well as with other related constructs and behaviors both in individuals displaying and not displaying addictive behaviors with respect to material rewards. Additional research might examine whether salivation to material reward is correlated with a generalized state of desire (e.g., does being hungry increase the effect?) or with neural activation in known dopaminergic reward targets. Finally, future research might investigate how individual differences in salivation to material rewards is related to the consumption behaviors of investing, gambling, and spending. Such research is likely to illuminate the potential of measuring salivation to offer novel insights into consumption behaviors.

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