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Review

The tempted brain eats: Pleasure and desire circuits in obesity and eating disorders

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ABSTRACT

What we eat, when and how much, all are influenced by brain reward mechanisms that generate "liking" and "wanting" for foods. As a corollary, dysfunction in reward circuits might contribute to the recent rise of obesity and eating disorders. Here we assess brain mechanisms known to generate "liking" and "wanting" for foods and evaluate their interaction with regulatory mechanisms of hunger and satiety, relevant to clinical issues. "Liking" mechanisms include hedonic circuits that connect together cubic-millimeter hotspots in forebrain limbic structures such as nucleus accumbens and ventral pallidum (where opioid/endocannabinoid/orexin signals can amplify sensory pleasure). "Wanting" mechanisms include larger opioid networks in nucleus accumbens, striatum, and amygdala that extend beyond the hedonic hotspots, as well as mesolimbic dopamine systems, and corticolimbic glutamate signals that interact with those systems. We focus on ways in which these brain reward circuits might participate in obesity or in eating disorders.

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1. Introduction

Palatable foods and their cues can carry motivational power. The sight of a cookie or the smell of a favorite food may evoke a sudden urge to eat, and a few bites of a tasty morsel can spur an urge to eat more ("l'appétit vient en mangeant" as the French phrase goes). In a food-rich world, cue-triggered urges contribute to the likelihood that a person will eat right now, or over-eat at a meal, even if one intended to abstain or to only eat moderately. By influencing choices of whether, when, what, and how much to eat, cue-triggered urges contribute bit by bit to long-term caloric overconsumption and obesity (Berthoud and Morrison, 2008; Davis and Carter, 2009; Holland and Petrovich, 2005; Kessler, 2009).

It is not just the food or cue by itself that exerts this motivating power: it is the response of the perceiver's brain to those stimuli. For some individuals, brain systems may especially react to generate compelling motivation to overeat. For everyone, evoked urges may become particularly strong at certain moments of the day, and when hungry or stressed. The variation in motivational power from person to person and from moment to moment arises in part from the dynamics of brain reward circuits that generate "wanting" and "liking" for food reward. Those reward circuits are the topic of this paper.

Where does food pleasure or temptation come from? Our fundamental starting point is that the temptation and pleasure of sweet, fatty, or salty foods arise actively within the brain, not just passively from physical properties of foods or cues themselves. "Wanting" and "liking" reactions are actively generated by neural systems that paint the desire or pleasure onto the sensation—as a sort of gloss painted on the sight, smell or taste (Table 1). Even a tempting chocolate cake is not so much necessarily pleasant, but our brains are biased to actively generate "liking" to its chocolaty creaminess and sweetness. The sweetness and creaminess are keys that potently unlock the generating brain circuits which apply pleasure and desire to the food at the moment of encounter (Berridge and Kringelbach, 2008; James, 1884; Kringelbach and Berridge, 2010). Yet it is the opening of the brain locks that is most crucial, not just the keys themselves, and so we focus here on understanding the brain's hedonic and motivational locks.

Active brain generation is evident by considering that hedonic biases are not fixed but rather are plastic. For example, a once-"liked" sweet taste can become unpleasant while remaining sweet as ever, such as occurs in taste aversion learning (Garcia et al., 1985; Reilly and Schachtman, 2009; Rozin, 2000). Conversely, a nastily intense salty taste can switch from unpleasant to pleasant during moments of salt appetite, in which the body lacks sodium (Krause and Sakai, 2007; Tindell et al., 2006). And similarly, although our brains are biased to perceive bitter tastes as especially unpleasant, hedonic plasticity allows many individuals to find the tastes of cranberries, coffee, beer, or other bitter foods quite pleasant once cultural experience has made their bitterness into a key for hedonic brain systems. More transiently but universally, hunger makes all foods more highly "liked," while satiety states dampen "liking" at different times in the same day, a dynamic hedonic shift called "alliesthesia" (Cabanac, 1971).

2. Roles of brain reward systems in growing rates of obesity?

The incidence of obesity has risen markedly in the past three decades in the USA, so that today nearly 1 in 4 Americans may be considered to be obese (Prevention, 2009). The rise in body weight may be due mostly to the fact that people are simply