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Review

From lab to clinic: Extinction of cued cravings to reduce overeating

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HIGHLIGHTS

- Food cue reactivity (FCR) sabotages healthy eating.
- FCR induces weight gain and impedes weight loss (maintenance).
- FCR is easily acquired but the extinction of appetitive responding is difficult.
- Food cue exposure should include new procedures to be more effective.

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ABSTRACT

Food cue reactivity is a strong motivation to eat, even in the absence of hunger. Therefore, food cue reactivity might sabotage healthy eating, induce weight gain and impede weight loss or weight maintenance. Food cue reactivity can be learned via Pavlovian appetitive conditioning: It is easily acquired but the extinction of appetitive responding seems to be more challenging. Several properties of extinction make it fragile: extinction does not erase the original learning and extinction is context-dependent. These properties threaten full extinction and increase the risk of full relapse. Extinction procedures are discussed to reduce or prevent the occurrence of rapid reacquisition, spontaneous recovery, renewal and reinstatement after extinction. A translation to food cue exposure treatment is made and suggestions are provided, such as conducting the exposure in relevant contexts, using occasional reinforcement and targeting expectancy violation instead of habituation. A new hypothesis proposed here is that the adding of inhibition training to strengthen inhibition skills that reduce instrumental responding, might be beneficial to improve food cue exposure effects.

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1. Introduction

Imagine a table full of your favorite sweet and savory temptations. Imagine the taste of these delicious foods. Imagine that you could eat them all without any restrictions. You will probably notice that your mouth is starting to water, and you might feel an intense desire to eat, even though you are unaware of many other physiological preparatory responses, such as insulin release, ghrelin response, stomach secretions, dopamine changes, activation of reward-associated areas in the brain and so on (see e.g., [21,45,65,72,88]). These appetitive responses to cues that signal the availability of food are collectively called food cue

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reactivity; the responding prepares the body for food intake and increases one's motivation to eat (e.g., [55]). Food cue reactivity during exposure to tasty foods is a normal and healthy response [22,43,54,55]. However, compared to people without eating concerns, food cue reactivity is significantly stronger in concerned eaters, such as unsuccessful dieters, bulimia nervosa patients, binge eaters and obese people [22,39,41,49,56,61,73,78,87].

Increased food cue reactivity motivates eating, even in the absence of hunger and in excess of calories physically needed, and therefore easily results in overeating and weight gain [8,10,35,42]. For example, overweight children demonstrated cued overeating while lean children did not and, in the overweight children, the amount eaten correlated strongly with increased salivary responding during exposure to the food ($r = 0.62$; [39]). Food cue reactivity not only contributes to the maintenance of overeating and weight gain – it also increases the risk of relapse during and after weight loss [42,43]. Though there exist individual differences in food cue reactivity [14,50], increased reactivity to food cues usually follows from Pavlovian appetitive conditioning, i.e., associative learning.

2. Acquisition of food cue reactivity

Food cue reactivity is easily learned. The early observations of Ivan Petrovich Pavlov are the most well-known: Pavlov observed digestive preparatory responses (e.g., salivation) in response to stimuli that signaled dog food, for example specific sounds or footsteps of the person feeding the dog (see [71]). During Pavlovian conditioning - or associative learning - the organism learns that a neutral stimulus predicts the occurrence of a second stimulus (e.g., the eating of dog food). The neutral stimulus will soon produce the same response in the organism as the second stimulus – in the above mentioned case of Pavlov's dog: salivation. A large number of animal studies show that physiological responses elicited by food intake (e.g. insulin release, blood sugar increase and salivation) can be brought under the control of any stimulus predictive of food intake, such as odors, sounds, lights and time of the day ([10,12,19]; see [35,66,68,89,90,92]). Of interest is that these stimuli also potentiate feeding in sated states [10,90]. Context cues are also able to drive consumption: Rats consume significantly more less-preferred food (chow) when exposed to context cues that were previously paired with the intake of highly palatable foods [4]. Thus, context-cues associated with palatable food intake might drive overeating in rats, even when the rats are sated and when the food is less-preferred. Cue-conditioned overeating is quickly learned and particularly strong when palatable foods (high in calories, fat, salt and sugar) are involved in the cue - intake associations [4]. All kinds of cues and/or contexts can be associated with intake and become signals (conditioned stimuli; CS) for consumption (unconditioned stimulus; US).

Similarly, it is relatively easy for humans to learn food cue reactivity and cued eating through associative learning. Very young children (3–5 years old) demonstrated increased intake and shorter latencies to eat in a context that was associated with eating [3], and undergraduates demonstrated increased salivation responses to neutral cues that they had learned to associate with food consumption [38]. Several recent well-controlled experimental studies show that only four to six associations between a neutral stimulus and actual food intake are necessary to learn that a stimulus predicts intake, after which the mere presence of the food-signaling stimulus is sufficient to elicit eating expectations and desires [6,7,63,75–77,79–82].

Environmental contexts can also act as signals for intake. A virtual reality study used various contexts such as an Italian plaza and a dojo (Japanese room to practice martial arts) to predict milkshake intake, and demonstrated classically conditioned eating desires and salivary responses only in the context that predicted milkshake intake [75]. A daily life analogy is that if one always eats crisps on the couch when viewing one's favorite television series, just sitting on the couch and hearing the theme song of the series might make one crave crisps. Even when one is satiated (e.g., after dinner), the signal that predicts consumption is able to elicit food cravings (i.e., intense desires to eat specific foods) and, therefore, the motivation to eat.

Potentially every stimulus or context can act as a food-predicting signal: food preparing rituals, the seeing, smelling and tasting of foods, interoceptive contexts like physical state (hunger/deprivation, satiety), hormonal state, mood state, expectations, thoughts about foods, physical contexts like a room, specific location, shopping mall, furniture, television, music, computer, and so on. Bongers & Jansen [7] demonstrated that learning to associate specific mood states with intake caused the eating-related emotions to elicit cued cravings and food selection. A daily life example is the eating of e.g. chocolate (nearly) always when feeling sad (often referred to as ‘emotional eating’). When cues or contexts reliably predict intake, they are able to elicit mental representations of the US (food). When confronted with the cue or context (CS), memories of the tasty foods are activated and desires to eat, or food cravings, are triggered - even in the absence of hunger.

To summarize, in our current society, highly rewarding calories are easy-to-get: fast food is available everywhere and most people like it. Palatable high-calorie foods are primary positive reinforcers and have high potential for conditioning. Any time food is ingested, the cues and contexts that are present at the time can become associated with eating [12,46,69,89]. Cued cravings are quickly learned. Associative learning will be stronger when the probability relationship between exposure to cues/contexts and reinforcement increases and when the US is more intense (e.g., more calories, higher palatability) [35].

3. Extinction of food cue reactivity

Cued cravings might easily sabotage healthy eating. Dieting, losing weight and the maintenance of lost weight will also be more difficult with increasing levels of food cue reactivity. A reduction in reactivity to tempting food cues could eliminate the primary motivation for eating and might facilitate healthy eating, adherence to restrictive diets, weight loss and weight loss maintenance [42,44]. Indeed, obese individuals who have successfully lost weight salivated significantly less during food cue exposure compared to unsuccessful obese dieters [5,41]. Though these studies were correlational, they indirectly support the idea that decreased cue reactivity is associated with successful dieting and weight loss. Therefore, a key question is: How can food cue reactivity – including food cravings – be effectively extinguished?

Pavlovian learning theory posits that Pavlovian extinction is the royal road to learn that a cue or context predicts no longer predicts intake. During a most straightforward Pavlovian extinction procedure, the cue or context that once signaled intake remains systematically unreinforced, i.e., the associated tasty foods are no longer eaten. Consequently, cue reactivity or learned appetitive responding should diminish [42]. When a person is on a restrictive diet during which he is exposed to all kinds of food cues but he does not eat (i.e. he is not reinforcing the cues that signal eating), his cue reactivity should, in the end, extinguish. However, this may take a while and as long as the person remains cue reactive his dieting efforts are easily undermined [77]. In addition to natural extinction by restrictive dieting being a lengthy process, many dieters do not expose themselves to powerful food-signaling cues as long as they are on a diet [42]. This avoidance behavior is especially characteristic of typical diets in which people only drink shakes or are highly selective in their food choices. These diets do not enable cue reactivity to extinguish, as these people avoid learning that the food-signaling cue does not predict intake. For successful dieting and a reduction of overeating, decreased cue reactivity seems necessary. But even when cue reactivity successfully extinguishes, food cue reactivity can easily return. Bouton [11–13,26] discusses several properties of extinction that make it fragile: Extinction does not erase the original learning and extinction is context-dependent. These properties threaten full extinction and increase the risk of relapse.