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Research report

# Working for food you don't desire. Cues interfere with goal-directed food-seeking ☆

P. Watson [a,b], R.W. Wiers [a,b], B. Hommel [c,d], S. de Wit [b,e,*]

[a] Addiction Development and Psychopathology (ADAPT) lab, Department of Developmental Psychology, University of Amsterdam, The Netherlands
[b] Cognitive Science Center Amsterdam, University of Amsterdam, The Netherlands
[c] Cognitive Psychology Unit, Leiden University, Leiden, The Netherlands
[d] Leiden Institute for Brain and Cognition, Leiden, The Netherlands
[e] Department of Clinical Psychology, University of Amsterdam, The Netherlands

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ABSTRACT

Why do we indulge in food-seeking and eating behaviors at times when we are already fully sated? In the present study we investigated the hypothesis that food-associated cues in the environment can interfere with goal-directed action by eliciting food-seeking that is independent of the current desirability of the outcome. To this end, we used a computerized task in which participants learned to press keys for chocolate and popcorn rewards. Subsequently, we investigated whether satiation on one of these rewards would bias choice toward the other, still desirable, food reward. We found that satiation did indeed selectively reduce responding on the associated key in the absence of food-associated cues. In contrast, in a Pavlovian-instrumental transfer (PIT) test, satiation failed to reduce cue-elicited food-seeking: in line with our hypothesis, cues that had previously been paired with chocolate and popcorn led to increased responding for the signaled food reward, independent of satiation. Furthermore, we show that food-associated cues will not only bias choice toward the signaled food (outcome-specific transfer), but also enhance the vigor of responding generally (general transfer). These findings point to a mechanism that may underlie the powerful control that cues in our obesogenic environment exert over our behavior.


## Introduction

We live in an environment that is full of cues that remind us of palatable, energy-dense food, whether these are commercials on the television or food displays at the supermarket. This 'obesogenic environment' is thought to encourage excessive food consumption and has been cited as a leading cause in the growing epidemic of obesity (Cohen, 2008; Johnson, 2013; Swinburn et al., 2011). Statistics from the Organisation for Economic Co-operation and Development suggest that across the 34 member countries, 18% of the population is now obese (OECD, 2013) – a condition with well-documented negative health consequences (Dietz, 1998; Finkelstein, Ruhm, & Kosa, 2005; Puhl & Heuer, 2009; Wyatt, Winters, & Dubbert, 2006). It is therefore of crucial importance to identify the processes by which the obesogenic environment affects food-motivated behaviors.

Although many factors may contribute to food-seeking and consumption, recent studies suggest that associative learning processes play an important role (Bouton, 2011). The obesogenic environment provides ample opportunities for associations to be formed between foods, cues and actions. For example, as a result of Pavlovian stimulus–outcome (S-O) conditioning, cues such as advertising logos or food packaging may come to elicit craving for certain unhealthy snacks. Indeed, previous research has shown that television commercials promoting unhealthy foods increase consumption of these types of foods in both children and adults (Halford, Gillespie, Brown, Pontin, & Dovey, 2004; Harris, Bargh, & Brownell, 2009). Furthermore, more direct reminders such as the sight and smell of food have also been shown to increase food craving as well as consumption (Jansen, 1998; Jansen et al., 2003; Temple et al., 2006), sometimes even despite explicit intentions to diet (Fedoroff, Polivy, & Herman, 1997). Therefore, Pavlovian processes undoubtedly play an important role in food-motivated behavior. However, there are many situations in which instrumental actions need to be carried out to gain access to food – in order to buy food for dinner, for example, you may walk a specific route home from work via the supermarket. These instrumental actions are often goal-directed, in the sense that they are mediated by the current desire for the anticipated outcome of the action. However, some dual-process theories suggest that Pavlovian cues can interfere with goal-directed

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* Corresponding author.
*E-mail address:* s.dewit@uva.nl (S. de Wit).

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action (de Wit & Dickinson, 2009; Hogarth, 2012; Hogarth & Chase, 2011; Huys et al., 2011). As a result of separate Pavlovian and instrumental conditioning processes, Pavlovian cues that remind one of food can indirectly trigger the associated instrumental action independently of the current motivation for the outcome. For example, seeing the golden arches of the McDonald's restaurant chain on a billboard may remind one of cheeseburgers, the thought of which triggers the action of going to McDonald's, even when one is already fully sated. This interaction between Pavlovian cues and instrumental behavior – known as 'Pavlovian-instrumental transfer' (PIT) – may be a mechanism by which our obesogenic environment, saturated with reminders of food, biases our food-seeking behaviors and causes overconsumption.

To investigate the effect of Pavlovian cues on instrumental action, associative learning psychologists have developed the PIT paradigm. This paradigm has been adopted most extensively in animal studies (Colwill & Rescorla, 1988; Corbit & Balleine, 2005; Estes, 1948; Holland, 2004; Rescorla, 1994), but in recent years also in human studies (Allman, DeLeon, Cataldo, Holland, & Johnson, 2010; Bray, Rangel, Shimojo, Balleine, & O'Doherty, 2008; Hogarth, 2012; Hogarth & Chase, 2011; Lovibond & Colagiuri, 2013; Nadler, Delgado, & Delamater, 2011; Prévost, Liljeholm, Tyszka, & O'Doherty, 2012; Talmi, Seymour, Dayan, & Dolan, 2008). The classic PIT paradigm assesses the effect of a previously established Pavlovian cue on ongoing instrumental behavior. For example, in an animal study by Corbit, Janak, and Balleine (2007), a clicker cue was always followed by the delivery of food pellets and a tone cue by sucrose solution. During this Pavlovian (S-O) conditioning phase, the rats gradually learned to anticipate the delivery of food rewards when the cues were presented. In a separate instrumental (response–outcome; R-O) conditioning phase, two levers were inserted into the operant chambers and the rats now had to learn to perform instrumental actions to gain access to the food rewards. For example, they learned to press a left lever in order to gain food pellets, and a right lever to gain a drop of sucrose solution. Finally, to assess the effect of Pavlovian cues on instrumental action, the critical transfer test was conducted. During this test, the animals were once again given the opportunity to freely respond on the two levers, but for the first time the Pavlovian cues (the clicker and the tone) were occasionally presented. As expected, the Pavlovian cues biased responding toward the food that they signaled; in the presence of the clicker, rats increased responding on the left lever, while they increased responding on the right lever in the presence of the tone. Importantly, the Pavlovian cues had never been trained with the instrumental actions – so their effect on instrumental responding is thought to be mediated by the cue-evoked outcome anticipation in an S-O-R associative chain. It should be noted that the transfer test is conducted in extinction (no rewards are actually given) to ensure that direct experience with the outcomes does not influence behavior during the test.

This 'outcome-specific transfer' effect is robust and plays a role in many domains of instrumental action: in animals it has been replicated using different food rewards (and drugs), and in humans it has been demonstrated with rewards such as cigarettes, food and money as well as purely symbolic outcomes. Importantly, several studies provide evidence that the outcome-specific transfer effect is insensitive to motivation. Animal studies have shown that Pavlovian cues for food will bias instrumental actions even when rats have been sated on the signaled food reward (Holland, 2004; Rescorla, 1994) or on their daily maintenance chow (Corbit et al., 2007). Rescorla (1994) first trained rats to expect a food pellet in the presence of a light cue, and a drop of sucrose in the presence of a tone. In the instrumental training phase rats then learned to press a lever for the food pellet and pull on a chain for the sucrose. To reduce the motivational value of one of the food outcomes, either the food pellet or the sucrose was paired with lithium chloride (to induce illness). In the transfer test that followed, the light and tone cues biased responding toward the food that they signaled, regardless of the desirability of that food outcome. In related studies in humans, Hogarth and colleagues (Hogarth, 2012; Hogarth & Chase, 2011) have shown that presenting smokers with pictures of cigarettes while they make instrumental choices for those rewards biases choice toward the pictured outcome. In line with the animal studies, this effect was not reduced by exposure to health warnings about cigarettes (Hogarth & Chase, 2011), nor by a dose of nicotine (Hogarth, 2012). Further highlighting the role of outcome-specific transfer in drug-seeking behavior, cues associated with cigarettes have been shown to prime actual smoking behavior (Hogarth, Dickinson, & Duka, 2010) as well as craving for cigarettes (Hitsman et al., 2013; Hogarth et al., 2010). These cue-elicited effects were observed independently of satiety induced by smoking (Hogarth et al., 2010) or by administration of varenicline – a nicotine agonist prescribed for smoking cessation (Hitsman et al., 2013). It seems feasible that this transfer effect may also play a role in food-seeking behaviors. Interestingly, in two studies (Hogarth, 2012; Hogarth & Chase, 2011), a similar pattern of results was observed for chocolate pictures in a control condition, which also appeared to bias responding independently of current motivation. The aim of the present study is to extend this animal and human research to investigate more thoroughly the role of the outcome-specific transfer effect in the domain of food-seeking in humans.

We investigated whether indirect reminders of food (such as seeing the golden arches of McDonald's in our previous example) would bias instrumental responding independently of satiation. To this end, we adopted a computerized task with the classic PIT design, consisting of separate Pavlovian and instrumental training phases, using two food rewards (Smarties and popcorn), two cues (abstract pictorial cues on a computer screen) and two responses (right and left keyboard presses). Following training, we induced 'specific satiety' for one of the two food rewards by asking participants to consume a large amount of this food. One group of participants was sated on Smarties, the other group on popcorn, and a third control group did not receive the satiation manipulation. Subsequently, participants received a noncued and a cued test. In the noncued test, instrumental choice between the two key presses was assessed in the absence of the Pavlovian cues. We expected performance to be goal-directed during this test, meaning that the Smarties-satiation group should prefer the popcorn key, and the popcorn-satiation group the Smarties key (but no difference in the no-satiation group). In the cued (PIT) test, we expected that occasional presentations of Pavlovian cues would interfere with goal-directed action by eliciting the response for the signaled food reward regardless of specific satiety. To discourage an explicit strategy in the noncued test, we instructed participants to ignore the Pavlovian cues. We also employed a 'nominal extinction' procedure and told participants that they were still winning food rewards but they would find out at the end how many they had won – this kept participants motivated during the test phase while preventing further learning (see e.g., Hogarth & Chase, 2011).

Next to assessing outcome-specific PIT, we also assessed the general motivating effect of the Pavlovian cues on instrumental behavior. In the domain of food, several animal studies (and one human study: Prévost et al., 2012) have provided evidence for this 'general PIT' effect, by showing that a Pavlovian cue for food will invigorate responding generally (i.e. not just for the food-outcome that is signaled). To investigate general transfer, we included two more Pavlovian cues in our design: one for a third food outcome (cashew nuts) and one for no-outcome. Neither of these outcomes was associated with an instrumental response. General transfer would be evident if participants responded more vigorously (on the keys associated with the chocolate and popcorn rewards) during the cashew nuts cue relative to the no-outcome cue. We tested whether satiety