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Research report

Inhibitory control effects in adolescent binge eating and consumption of sugar-sweetened beverages and snacks ☆

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ABSTRACT

Inhibitory control and sensitivity to reward are relevant to the food choices individuals make frequently. An imbalance of these systems can lead to deficits in decision-making that are relevant to food ingestion. This study evaluated the relationship between dietary behaviors – binge eating and consumption of sweetened beverages and snacks – and behavioral control processes among 198 adolescents, ages 14 to 17. Neurocognitive control processes were assessed with the Iowa Gambling Task (IGT), a generic Go/No-Go task, and a food-specific Go/No-Go task. The food-specific version directly ties the task to food cues that trigger responses, addressing an integral link between cue-habit processes. Diet was assessed with self-administered food frequency and binge eating questionnaires. Latent variable models revealed marked gender differences. Inhibitory problems on the food-specific and generic Go/No-Go tasks were significantly correlated with binge eating only in females, whereas inhibitory problems measured with these tasks were the strongest correlates of sweet snack consumption in males. Higher BMI percentile and sedentary behavior also predicted binge eating in females and sweet snack consumption in males. Inhibitory problems on the generic Go/No-Go, poorer affective decision-making on the IGT, and sedentary behavior were associated with sweetened beverage consumption in males, but not females. The food-specific Go/No-Go was not predictive in models evaluating sweetened beverage consumption, providing some initial discriminant validity for the task, which consisted of sweet/fatty snacks as no-go signals and no sugar-sweetened beverage signals. This work extends research findings, revealing gender differences in inhibitory function relevant to behavioral control. Further, the findings contribute to research implicating the relevance of cues in habitual behaviors and their relationship to snack food consumption in an understudied population of diverse adolescents not receiving treatment for eating disorders.

Introduction

Adolescent obesity has more than tripled over the past 30 years (Ogden, Carroll, Kit, & Flegal, 2012). In the United States, over 18% of youth between the ages of 12–19 are obese (Centers for Disease Control and Prevention [CDC], 2013). Obesity in youth is associated with numerous negative health effects and an increased probability of being obese as an adult (CDC, 2013; Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007; Jasik & Lustig, 2008; Li et al., 2009). While a range of snack foods contribute to this trend, this study focused on sugar-sweetened beverages (SSB) and sugary snack consumption in adolescents but also included a comparison of salty/fatty snacks. These sugar-sweetened snacks and SSBs are nutrient poor, have high sugar content, and are commonly consumed by

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adolescents (Harrington, 2008; Jahns, Siega-Riz, & Popkin, 2001; Keast, Nicklas, & O'Neil, 2010).

Although a range of influences affecting the rise in obesity among youth has been explored, differences in neurocognitive processes underlying behavioral regulation over sweet snack food consumption are understudied processes in a general adolescent population not currently receiving treatment for obesity or other eating disorders. The subsequent sections address some key neurocognitive processes relevant to diet behavior in this population, associative processes in habit formation, and resultant cue effects in behavioral regulation and decision-making.

Neurocognitive processes and dietary behavior

The functioning of different but interacting neural systems and their influence on behavioral regulation of appetitive behaviors has been a recent focus of neuroscience. One realm of neural systems focuses on individual differences in prefrontally mediated inhibitory control and sensitivity to reward (mediated by subcortical systems), relevant to the food choices individuals make daily (Grigson, 2002; Kelley, Schiltz, & Landry, 2005). Some neurocognitive control functions are protective in regulating behavior when encountering such risks as high availability of sugary snacks and sugar-sweetened beverages. On the other hand, an imbalance of regulatory systems can lead to deficits in decision-making and control over impulses that may exacerbate food consumption (e.g., overeating or binge eating). Bechara and colleagues have argued for a distinction in functioning between response inhibition (mediated by prefrontal systems) and affective decision-making (mediated by prefrontal and subcortical systems), which are both relevant to behavioral control ability (Bechara, 2005; Bechara, Noel, & Crone, 2006; Bechara & Van der Linden, 2005). Both of these regulatory/inhibitory processes are important, specific aspects of higher order executive control functioning (Winstanley, Eagle, & Robbins, 2006).

Good inhibitory control functioning reflects the ability to actively stop a pre-potent behavioral response, such as binge eating or overeating, after it has been triggered (Braver & Ruge, 2006; Logan, Schachar, & Tannock, 1997). Individuals with weakened or overwhelmed regulatory control functions in prefrontal systems have a tendency to act more impulsively. The Go/No-Go, a valid test of response inhibition, is a commonly used task for assessing suppression of pre-potent behavioral responses (Aron & Poldrack, 2005) and has been used extensively among varied populations ranging from youth to adults (Casey, Giedd, & Thomas, 2000; Durston & Casey, 2006; Simmonds, Pekar, & Mostofsky, 2008). Several studies have shown that relative to female college students with better inhibitory control ability, female college students with poorer control consume more food (e.g., Guerrieri, Nederkoorn, & Jansen, 2007; Guerrieri et al., 2007; Guerrieri, Nederkoorn, Schrooten, Martijn, & Jansen, 2009; Nederkoorn, Guerrieri, Havermans, Roefs, & Jansen, 2009), and are more often overweight if they also have an implicit preference for snack foods (Nederkoorn, Houben, Hofmann, Roefs, & Jansen, 2010). Several studies that evaluated body weight differences in youth and response inhibition with Stop Signal Tasks found obese youth showed decreased response inhibition relative to leaner youth (e.g., Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006; Nederkoorn, Jansen, Mulkens, & Jansen, 2007; Nederkoorn, Coelho, Guerrieri, Houben, & Jansen, 2012; Verbeken, Braet, Claus, Nederkoorn, & Oosterlaan, 2009). One study by Pauli-Pott, Albayrak, Hebebrand, and Pott (2010) used the Go/No-Go task to evaluate response inhibition in overweight and obese youth ranging in age from 8 to 15. Inhibitory control was correlated with body weight in this study; that is, less control was observed in youth with higher body weight (Pauli-Pott et al., 2010).

Adequate affective decision-making reflects an integration of cognitive prefrontal and affective subcortical systems and the ability to optimally weigh short-term gains against long-term losses or probable outcomes of an action. This function is most commonly assessed with the Iowa Gambling Task (IGT), with higher scores revealing more adaptive affective decision-making (Bechara, Damasio, Damasio, & Anderson, 1994; Bechara et al., 2006). For example, a prediction related to food and the IGT is that overeating of foods high in sugar that are known to have short-term reinforcing effects (but longer-term negative consequences to health) should be less likely among individuals who score higher on the IGT; that is, they are more able to inhibit immediate gratification. The bulk of research investigating impaired decision-making (and sensitivity to reward) with the IGT and body weight has been in adult populations with eating disorders; however, one of the first studies to investigate affective decision-making in eating behavior in healthy adult females ranging in weight found the overweight females in the sample to have impaired decision-making. Further, the deficits in decision-making on the IGT were greater than those found in some studies with drug dependent individuals (Davis, Levitan, Muglia, Bewell, & Kennedy, 2004). In another study, Davis, Patte, Curtis, and Reid (2010) found impaired decision-making, assessed with the IGT, in obese adult females as well as among females with binge eating disorders relative to normal weight females. Decision-making deficits did not differ between the females in the obese and binge eating disorder groups (Davis et al., 2010). Verbeken, Braet, Bosmans, and Goossens (2014) evaluated inhibition or delayed gratification with the Hungry Donkey Task, a child version adaptation of the IGT, in children and younger adolescents ranging from healthy weight to overweight. They found impaired decision performance on the task among the overweight youth when compared with healthy weight youth (Verbeken et al., 2014).

The functional distinction between response inhibition and affective decision-making processes comes from extensive clinical observation and research with patient populations with damage in areas of the frontal lobe (Bechara & Van der Linden, 2005) as well as imaging studies that delineate key neural substrates of each function (Lawrence, Jollant, O'Daly, Zelaya, & Phillips, 2008; Simmonds et al., 2008). The importance of these neurocognitive processes in behavioral regulation has been demonstrated across numerous studies and a wide range of populations (Brand, Labudda, & Markowitsch, 2006; Dunn, Dalgleish, & Lawrence, 2006; Simmonds et al., 2008). The present study extends research on response inhibition and affective decision-making by evaluating these processes in a seldom studied, relatively older general adolescent population, ranging in weight from lean to obese.

Cue effects on behavioral regulation and decision processes

The importance of cues in triggering automatic/habitual behaviors is well recognized in basic behavioral sciences spanning neuroscience (Knowlton, Mangels, & Squire, 1996; Yin & Knowlton, 2006a), memory (Nelson & Goodmon, 2003; Rescorla, 2008), and research on appetitive behaviors (LaBar et al., 2001). Yet, most approaches to understanding adolescent risk behavior do not incorporate cue effects and their link to habit formation. A framework for understanding the loss of ability to resist natural (e.g., sugary foods) as well as non-natural (e.g., drugs of abuse) rewards and the development of habitual behaviors can be explained by associative learning/memory models of appetitive behaviors (Stacy, 1997; Stacy, Ames, & Knowlton, 2004; Yin & Knowlton, 2006b). Similar key neural systems (dopamine dependent systems) are critical for motivational effects across a range of rewarding/reinforced behaviors (e.g., natural rewards like sugary foods; Kenny, 2011; Olsen, 2011; drugs of abuse; Chiara et al., 1999; Everitt & Robbins, 2005; Robbins & Everitt, 1999; Wise & Rompré, 1989). Dopaminergic activity reinforces the repetition of behaviors, such as the consumption of sugary snacks, and supports the encoding and processing