Appetite 93 (2015) 75–84

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Teaching children to like and eat vegetables

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ARTICLE INFO

Article history:
Received 2 January 2015
Received in revised form 18 June 2015
Accepted 24 June 2015
Available online 26 June 2015

Keywords:
Vegetables
Flavor-calorie learning
Flavor-flavor learning
Children
Conditioned preferences

ABSTRACT

Higher vegetable intake has been related to lower risks of diabetes, cardiovascular disease, several cancers and obesity. Yet children consume fewer than the recommended servings of fruits and vegetables set forth by the USDA. Exposure to vegetables has successfully improved children's liking for and consumption of vegetables particularly for children younger than two years. In contrast, associative conditioning seems necessary for older children, especially with bitter vegetables. We review studies using both exposure and associative conditioning to teach children to like vegetables, including flavor–flavor learning and flavor–calorie learning. Recognizing these different processes helps reconcile discrepant literature and may provide techniques for increasing preferences for vegetables in children. Associative conditioning and exposure can be used by parents and others to enhance children's liking for and consumption of vegetables.

A higher fruit and vegetable intake has been associated with a decrease in the risk of cardiovascular disease, adiposity/obesity, and cancer (Birt, Hendrich, & Wang, 2001; Ledoux, Hingle, & Baranowski, 2011; Ness & Powles, 1997). Despite these health benefits, more than 90% of 2- to 18-year-old children from 2007 to 2010 failed to eat the recommended servings of fruits and vegetables (CDC, 2014). Promoting the consumption of fruits and vegetables particularly in children is important because eating habits established in childhood persist into adulthood (Kelder, Perry, Klepp, & Lytle, 1994). Thus, interventions that aim to increase the consumption of fruits and vegetables in children may help to lower the risk of developing chronic diseases later (Klepp et al., 2005).

Increasing exposure to vegetables in childhood can lead to greater liking for them in adulthood. Wadhera, Capaldi Phillips, Wilkie, and Boggess (2015) asked college students to recall their childhood food experiences up to the age of ten and their current liking for the same foods. They found that subjects who recalled eating vegetables even occasionally in childhood showed a greater current liking for those foods, as compared to those who never ate them. Even vegetables that college students disliked in childhood were currently liked if the students recalled being exposed to them in childhood, as compared to never having been exposed.

Ahern et al. (2013) reported that exposure to vegetables at home was negatively correlated with children's age, such that parents served vegetables less frequently to older than younger children. As a result, younger children (6 to 12 months) liked, were more familiar with, and ate more vegetables than older children (2- to 3-year-olds). Because parental decisions about the types of foods served at home are partly influenced by children's food preferences and intake (Ahern et al., 2013; Campbell, Crawford, & Hesketh, 2007), Ahern et al. (2013) argued that the older children's reluctance to consume vegetables may result in fewer exposures to foods at home, and this may ultimately result in lower vegetable intake for them. In addition, the authors argued that the onset of neophobia may also prevent the 2- to 3-year-olds from consuming new foods such as vegetables (Ahern et al., 2013). Food neophobia is defined as the reluctance or avoidance of foods that are novel and tends to peak between 2 to 5 years of age (Dovey, Staples, Gibson, & Halford, 2008). Rozin (1976) theorized that neophobia may be an adaptive trait that protects organisms from accidentally consuming potentially harmful foods in the natural environment. Thus, food neophobia coupled with a lower exposure to vegetables at home may ultimately decrease intake of vegetables particularly in children who are at the peak of neophobia. Increasing children's preferences for vegetables may motivate caregivers to make these foods frequently available at home, thereby increasing children's exposure to vegetables, lowering food neophobia, and consequently, enhancing intake.

Other studies tracking children over larger time frames have also found similar decreases in vegetable consumption as children grow older. For example, Lytle, Seifert, Greenstein, and McGovern (2000) collected dietary data using 24-hour recalls from children when they were in the third, fifth, and eighth grades. The results showed that fruit and vegetable intake decreased by 20 and 40%, respectively, as children grew older. Similarly, a large longitudinal study that tracked eating habits of children at the age of 10 and then again as adults (19–28 years) found that frequency of consumption of vegetables decreased by one to three times per week from childhood

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http://dx.doi.org/10.1016/j.appet.2015.06.016
0195-6663/

to adulthood (Demory-Luce et al., 2004). Interestingly, Lien, Lytle, and Klepp (2001) found that, while overall vegetable consumption decreased from the age of 14 to the age of 21, individual eating patterns remained fairly consistent from adolescence to adulthood, suggesting that eating habits that are developed in adolescence tend to be maintained in adulthood. Because eating habits developed in childhood can persist into adolescence (Kelder et al., 1994) and adulthood (Campbell & Crawford, 2001; Wadhera et al., 2015), developing preferences for healthy foods in children is critical to maintaining long-lasting, healthy eating patterns.

Taste preferences and liking were the most important determinants of vegetable consumption in children and adolescents (Bere & Klepp, 2005; Blanchette & Brug, 2005; Brug, Tak, te Velde, Bere, & de Bourdeaudhuij, 2008; Cooke et al., 2004). In particular, vegetables were among the least preferred foods by 3-year-old children (Nicklaus, Boggio, Chabanet, & Issanchou, 2004). Vegetables are rejected for several reasons such as their bitter taste, unpleasant texture (Zeinstra, Koelen, Kok, & de Graaf, 2007) and low energy content (Gibson & Wardle, 2003). But the bitter taste of vegetables is often the most influential factor that deters their consumption (Drewnowski & Gomez-Carneros, 2000). As most natural poisons are bitter-tasting (Glendinning, 1994), humans are predisposed to reject bitter tastes (Birch, 1999). An unintended consequence of this bitter rejection response is the avoidance of healthy foods that are naturally bitter, like vegetables. Thus, improving the palatability of vegetables may be an important method in promoting their consumption in children.

Learning of food preferences: exposure and associative conditioning

Mere exposure and associative conditioning are two methods of improving liking for and consumption of foods. Each will be explained here before experimental evidence for these processes in children are reviewed.

Exposure

Zajonc (1968) in a series of studies found that, as exposure to a novel stimulus increases, a concurrent increase in positive affective responses toward that stimulus is seen (Bornstein, 1989). In other words, liking increases with familiarity. Repeated exposure can increase liking for a variety of stimuli, including taste (Bornstein, 1989; Hill, 1978).

Pliner (1982) provided the first human experimental evidence for the effects of exposure on liking of foods. In this study, adult subjects showed a linear increase in liking ratings for juice as the number of exposures to the juices increased (Pliner, 1982). One proposed explanation of this finding is that repeated taste exposure to a novel food decreases neophobia (Dovey et al., 2008). Repeated taste exposures to a new food teaches the organism that the food is safe to eat (Birch, 1999) and this learned familiarity increases liking for the food. Birch and Marlin (1982) showed that 50–60% of the variance in food intake of 3- to 4-year-old children was explained by sweetness and familiarity with the food (sweetness is preferred in human infants; Steiner, 1979). Strategies to overcome neophobia in children may include familiarizing children to new foods via repeated exposure.

Associative conditioning

Associative conditioning also involves repeated exposure to a food but, in addition, it involves associating the food with a positive or negative consequence. Associative conditioning follows a classical conditioning procedure in which a novel flavor (conditioned stimulus – CS) is paired repeatedly with calories (unconditioned stimulus – US), a procedure called flavor-calorie learning. Or, a novel flavor can be paired with an already liked, familiar flavor (US), a procedure called flavor-flavor learning (see Capaldi, 1996 for review). The subject learns to associate the new flavor with the pleasurable effects induced by the nutrient and/or the liked flavor respectively, and this learned association eventually leads to liking for the originally neutral flavor. Associative conditioning has been demonstrated extensively in animals using a variety of flavors and macronutrients (Capaldi, 1996).

Flavor-calorie learning

The basic paradigm in flavor-calorie learning is to pair one arbitrary flavor repeatedly with a high calorie substance and another arbitrary flavor with a lower calorie substance. In rats, after conditioning, using as few as four trials (Capaldi & Sheffer, 1992), preference for the flavor associated with the higher calories is seen (Capaldi, Campbell, Sheffer, & Bradford, 1987). Furthermore, this increased preference for the flavor associated with higher calories is greater when rats are hungry, rather than satiated (Capaldi & Myers, 1982; Capaldi, Owens, & Palmer, 1994; Fedorchak & Bolles, 1987). In the animal laboratory, carbohydrates, fats, proteins, and alcohol have all been used as caloric USs to obtain flavor-calorie learning (see Sclafani, 1997 for review). In humans, flavor-calorie learning has been observed in both children and adults using novel-flavored yogurts, milkshakes, desserts, and drinks (Birch, McPhee, Steinberg, & Sullivan, 1990; Brunstrom & Mitchell, 2007; Kern, McPhee, Fisher, Johnson, & Birch, 1993; Mobini, Chambers, & Yeomans, 2007; Shaffer & Tepper, 1994).

Flavor-flavor learning

In flavor-flavor learning, an initially neutral flavor is paired with an already highly preferred flavor (e.g., sweetness). An association between the neutral flavor and the highly preferred flavor is learned, resulting in an increase in preference for the initially neutral flavor even when subsequently presented unpaired. It is important to note here that in order to show flavor-flavor learning separately from flavor-calorie learning, the reinforcer used must have no calories, showing that the preference for the novel flavor is based purely on associations with the taste or flavor of the US and not nutritive content (Capaldi, 1996). Flavor-flavor learning has been demonstrated in animals (Capaldi et al., 1987; Faneslow & Birk, 1982) and humans (Brunstrom & Fletcher, 2008; Yeomans, Leitch, Gould, & Mobini, 2008). Other human studies used a sweet, caloric reinforcer (sugar) to demonstrate flavor-flavor learning (Baeyens, Eelen, Van Den Bergh, & Crombez, 1990; Brunstrom & Fletcher, 2008; Zellner, Rozin, Aron, & Kulish, 1983). However, sugar has both a palatable taste and calories so a combination of flavor-flavor and flavor-calorie learning could have produced preference in these studies, rather than flavor-flavor learning alone.

In most associative conditioning studies in animals, novel and neutral flavors are used as CSs (Capaldi, 1996) although a few studies have used CSs that are unpalatable to rats (such as sour and bitter tastes) (Capaldi & Privitera, 2008b; Forestell & LoLordo, 2000, 2003, 2004). Palatability of sour and bitter tastes is improved if consumption is followed by caloric consequences or if the tastes are mixed with other liked tastes (Breslin, Davidson, & Grill, 1990; Capaldi & Privitera, 2008b; Forestell & LoLordo, 2000, 2003, 2004). Based on these findings in animal studies we would expect liking for vegetables to develop if vegetables are mixed with an already liked flavor or caloric substance. Because vegetables are bitter and lower in energy density and are consequently disliked (Gibson & Wardle, 2003), conditioning methods that improve palatability and/or that elicit associations with nutritional consequences may be optimal for increasing liking for and consumption of vegetables. Conditioning methods have improved liking and consumption of vegetables in some studies (Capaldi-Phillips & Wadhera, 2014; Fisher et al.,