A Review of Visual Cues Associated with Food on Food Acceptance and Consumption

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Abstract

Several sensory cues affect food intake including appearance, taste, odor, texture, temperature, and flavor. Although taste is an important factor regulating food intake, in most cases, the first sensory contact with food is through the eyes. Few studies have examined the effects of the appearance of a food portion on food acceptance and consumption. The purpose of this review is to identify the various visual factors associated with food such as proximity, visibility, color, variety, portion size, height, shape, number, volume, and the surface area and their effects on food acceptance and consumption. We suggest some ways that visual cues can be used to increase fruit and vegetable intake in children and decrease excessive food intake in adults. In addition, we discuss the need for future studies that can further establish the relationship between several unexplored visual dimensions of food (specifically shape, number, size, and surface area) and food intake.

Keywords: portion size, number, visual cues, food, variety, color
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We live in a world where we are constantly bombarded with food and food images either through media or through the proliferation of eating locations that advertise and sell large portions of palatable, energy-dense foods. So it is not surprising that efforts to reduce the incidence of obesity have been largely unfruitful. According to the World Health Organization, about 1.4 billion people were overweight and nearly 500 million people were obese in 2008. In the United States alone, about 35% of adults and 17% of children were obese from 2009 to 2010 (Ogden, Carroll, Kit, & Flegal, 2012). If the current trends in obesity continue, it is expected that almost half the American population will become obese by 2030 (Finkelstein et al., 2012).

The simplest cause of obesity is an increase in energy intake or a decrease in physical activity. Since physical activity has not changed much in the past two decades (Finkelstein, Ruhm & Kosa, 2005), most of the research is now focused on energy intake as a plausible target for obesity prevention and treatment. Several internal and external food cues act independently, additively, or interactively to affect food intake. The focus of this review article, however, is on external cues directly associated with the food and its effects on food intake.

Although many people cite taste as the most important factor affecting their food intake (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998) in many cases the first sensory contact with food is through the eyes. In fact, the mere sight of food can facilitate the subjective desire to eat the target food (Cornell, Rodin, & Weingarten, 1988; Hill, Magson, & Blundell, 1984; Marcelino, Adam, Couronne, Koster, & Siefferman, 2001) and activate brain areas and neural pathways associated with reward (Beaver et al., 2006; LaBar et al., 2001; Morris & Dolan, 2001; Stoeckel, Cox, Cook III, & Weller, 2007). In addition, before a food is consumed, the
appearance of the meal provides expectations about the taste quality, flavor, and palatability of
food which may ultimately affect food acceptance and consumption (Hurling & Shepherd, 2003).

1.1 Why Are Visual Cues From Food Important?

Visual exposure to a novel food before consumption is shown to be particularly effective
in introducing new foods to children. Neophobia or the “fear of something new” is an adaptive
trait that typically peaks between two to five years of age and can decrease the consumption of
fruits, vegetables, and meats (Cooke, Carnell, & Wardle, 2006; Cooke, Wardle, & Gibson, 2003;
Pliner, 1994). Visual exposure to a novel food can reduce neophobia and facilitate acceptance.
When children were exposed to novel food pictures or actual foods before trying them, children
showed a greater willingness to try those foods than those not visually exposed (Birch, McPhee,
Shoba, Pirok, & Steinberg, 1987; Houston-Price, Butler, & Shiba, 2009). Similarly, children
presented with a visually similar, familiar fruit before a novel fruit showed a greater willingness
to try the novel fruit than those exposed only to the novel fruit (Dovey et al., 2012).

Second, not only can visual exposure increase willingness to try a novel food, but
enhancing the visual appeal of a novel food can also encourage consumption. Jansen, Mulksens,
and Jansen (2010) enhanced the visual appeal of a novel fruit by presenting it in an attractive
fashion (i.e. pieces of fruit were pierced with a toothpick and displayed on a watermelon slice).
They found that children ate more of the visually appealing fruits than a simple mix of fruits
served on a white plate (Jansen et al., 2010). In addition, Zampollo and colleagues (2012) found
that children preferred to have more food items, empty space, and variety of foods and colors on
their plates than adults, showing that a varied, attractive meal are important determinants of
Third, arranging foods on a plate can affect our expectations and ultimately, liking of the food. For example, strawberry-flavored mousse placed on a white plate was judged to be more flavorful, sweeter, and palatable than the same food presented on a black plate (Piqueras-Fiszman, Alcaide, Roura, & Spence, 2012). The authors hypothesized that the color-contrast produced with the food on the white plate may have enhanced expectations about the taste, increased perceived flavor intensity, and facilitated acceptance of the food (Piqueras-Fiszman et al., 2012). Similarly, arranging the foods on a plate in an orderly way can enhance intake. When meal ingredients were presented in a neat and orderly fashion, subjects liked the taste of the meal more than when meal ingredients were presented in a random, messy way (Zellner et al., 2011).

Even “balancing” i.e. perceived heaviness of the ingredients on a plate can affect intensity ratings and liking of a food. A multi-colored “balanced” food plate was rated higher in attractiveness than a single-colored, balanced plate (Zellner, Lankford, Ambrose, & Locher, 2010).

Fourth, visual exposure to food elicits the physiological release of saliva and other regulatory peptides required for digestion. For example, the mere sight of food (or food pictures) and smell stimulates the physiological release of saliva (Christensen & Navazesh, 1984; Klajner, Herman, Polivy, & Chhabra, 1981; Wooley & Wooley, 1973). The release of saliva is the first step in the digestive process as it contains key enzymes required for the breakdown of nutrients before complete digestion in the stomach (Pedersen, Bardow, Jensen, & Nauntofte, 2002). Blood insulin levels also peak when exposed to the sight and smell of food in response to an anticipatory increase in blood glucose following food consumption (Johnson & Wildman, 1983; Sjostrom, Garrelick, Krotkiewski, & Luyckx, 1980; Woods, 1991). Woods (1991) argued that this anticipatory increase in insulin levels (called the cephalic phase insulin response) may be an
adaptive response to protect the organism from drastic changes in glucose levels and to maintain homeostasis. In addition, the sight of food can increase subjective sensations of hunger and appetite which are partially responsible for initiating food intake (Bossert-Zaudig, Laessle, Meiller, Ellgring, & Pirke, 1991).

Fifth, varying the appearance of a portion of food can affect perceptions of variety in a meal, and ultimately affect energy intake. Seeking a variety of foods may be an adaptive trait to protect the organism from nutritional deficiencies (E.T. Rolls, 1981). Levistky, Iyer, and Pacanowski (2012) for example, varied the presentation of a vegetable-stir fry and pasta meal by presenting the ingredients of these meals either separately or mixed together. The results showed that when the ingredients were presented separately, subjects ate more than when the ingredients were mixed together. The authors suggested that segregating food into discrete units increases energy intake by increasing the perceived variety of foods available for consumption (Levitsky et al., 2012).

Lastly, the food portion served on a plate may serve as a visual benchmark or guide to determine the appropriate amount of food to consume. These visual benchmarks or guides are referred to as “consumption norms” that can dictate the amount of food consumed in a meal (Wansink & Van Ittersum, 2003b). For instance, without the empty bowl as a visual cue to stop eating, subjects ate about 70% more soup than those who were able to view the empty bowl. These results show that people use the emptying of food from a bowl or plate to make decisions about the quantity of food to consume (Wansink, Painter, & North, 2005).

Since the appearance of a food can determine the amount of food consumed and eating behaviors, the purpose of the present review is to identify the various visual cues associated with food and its effects on eating behaviors. While previous reviews have addressed the effects of
the sight of food on physiological processes (van der Laan, de Ridder, Viergever, & Smeets, 2011; Mattes, 1997), no review article has addressed the effects of sight of food on the amount of food consumed. Here, we provide an extensive review on several visual cues such as proximity, visibility, color, height, number, shape, surface area, size, number, variety, and portion size and their effects on dietary behaviors in children and adults. Table 1 summarizes results from studies on visual cues from food and their effects on food acceptance and consumption.

1.2 Sources of Review

Studies included in the review were obtained from Medline, Psycinfo, Nutrition, and Marketing databases and included those conducted on both children and adults. We used a combination of dietary intake and visual cue keywords to generate scientific, peer-reviewed articles on the relationship between visual cues and food consumption. “Energy intake”, “dietary intake”, “food intake”, “eating behaviors”, “taste”, “food”, “amount of food”, and “food quantity” were keywords used for dietary intake and “sight”, “seeing”, “perception”, “view”, “eyes”, “visual appeal”, “vision”, “visual cues”, “visual exposure”, and “appearance” were those used for visual cues. Visual cues identified from this search (proximity, visibility, color, variety, portion size, height, shape, surface area, size, and number) were then used as keywords to generate articles on their independent relationships with food intake.

Studies excluded from this review were those that did not show a relationship between visual cues and the amount of food consumed. In addition, studies relating visual cues with neurological and/or physiological biomarkers were excluded because reviews on this topic can be found elsewhere (van der Laan, de Ridder, Viergever, & Smeets, 2011; Mattes, 1997). We incorporated rat and primate studies for cues that were largely overlooked in human ingestive behavior studies. Studies on rats were included because rats, like humans, are mammals, share
ancestral origins, and have an omnivorous pattern of feeding (Rozin, 1976). Primate studies were included because they are closest to humans in the phylogenetic tree and respond optimally to visual properties of foods (Harlow, 1958 in Dewsbury, 1992; Menzel, 1961).

1.1.1 Proximity and Visibility

Increasing visibility of a food can promote food consumption. For example, Johnson (1974) found that more sandwiches were consumed when wrapped in transparent than opaque packages. However, the effects of visibility of food on food consumption may be dependent on the visual appeal of the food. If a food is visually appealing, then increasing visibility of that food will result in greater energy intake than one that is unappealing. Consistent with this idea, Deng and Srinivasan (2013) found that subjects ate more from transparent than opaque packages when given a visually attractive, multi-colored food (fruit loops) (Deng & Srinivasan, 2013) and less from transparent than opaque packages when given vegetables. Since vegetables are not as appealing as Fruit Loops in palatability, the authors suggested that presenting less palatable foods (vegetables) in transparent packages may increase salience of the less palatable food, and ultimately decrease consumption (Deng & Srinivasan, 2013).

Although visibility of a palatable food can increase energy intake, results for eating in the absence of visual cues or under low visibility conditions are mixed. For example, some studies showed that blindfolded subjects decreased their caloric intake by 22-24% compared to sighted subjects independent of weight status and portion size (Barkeling, Linne, Melin, & Rooth, 2003; Burger, Fisher, and Johnson, 2011b; Linne, Barkeling, Rossner, & Rooth, 2002). Similarly, Ross (1970) found subjects consumed less food when eating under dim lighting conditions than when eating under brightly lit conditions (Ross, 1970). Perhaps, subjects who ate in brightly-lit conditions were able to visually monitor their food consumption more effectively than those who
ate in the dark (Barkeling et al., 2003; Burger et al., 2011b; Linne et al., 2002; Ross, 1970). On the other hand, Scheibehenne and colleagues (2010) found that restaurant patrons ate more food in the dark than under lighted conditions and Kasof (2002) found that college students consumed more food when eating in dim than brightly-lit rooms. However, in Kasof’s (2002) study the effects of lighting on eating behaviors depended on the eating pathology of the eater i.e. while restrained eaters ate more under low lighting conditions, the food intake of unrestrained eaters were unaffected by lighting variations.

The effect of visibility of food on food consumption is also mediated by personal preferences for food. Subjects who preferred a stronger cup of coffee drank more coffee under bright than dull rooms, whereas lighting had no effect on those who preferred lighter coffee (Gal et al., 2007 in Spence, Harrara, & Piqueras-Fiszman, 2012). In addition, visibility of food on the intention to consume is mediated by the degree of familiarity with the target food. Wansink, Shimizu, Cardello, and Wright (2012) manipulated the ambiguity of a food product by withholding or providing product information and observing its effects on food consumption in lighted or dark conditions. They found that for highly familiar foods (crackers), acceptance of the product remained the same under both lighted and dark conditions, even when product information was absent. However, when eating the more ambiguous food (beef enchilada), subjects reported less likelihood to consume the food in the dark when product information was absent than present (Wansink et al., 2012).

Visibility of how much food has already been eaten also affects food intake. Diners ate more chicken wings when seated at a table where the empty bones were removed from sight than those seated at a table where the bones were allowed to pile up (Wansink & Payne, 2007).

Similarly, when pistachio shells were removed from sight, subjects ate 18% more than when the
shells were not removed (Kennedy-Hagan et al., 2011), showing that subjects tend to use foods leftover on the plate as visual reminders of the amount of food consumed to terminate further food intake.

A food is also more visible when nearer to the consumer than when far away. Therefore, increasing proximity to a food source can also increase food intake. College students were more likely to consume dessert when seated closer to the dessert station, than those seated further away (Vanata, Hatch, & de Palma, 2011). Similarly, more desserts were consumed when placed at the front than in the back of a cafeteria (Meyers & Stunkard, 1980) and more foods and beverages were purchased and consumed when placed within arm’s reach that when placed further away (Engell, Kramer, Malafi, Salomon, & Lesher, 1996; Meiselman, Staddon, Hedderley, Pierson, & Symonds, 1994; Musher-Eizenman et al., 2009; Wing & Jeffery, 1979).

Since a more proximate food source is also more visible, Wansink, Painter, and Lee (2006a) manipulated both proximity and visibility of food and observed their independent effects on energy intake. Visibility was varied by serving candy in transparent, open containers or closed, opaque containers and proximity was varied by placing chocolate candy pieces on the desk or further away. The authors found that more chocolate candy was consumed when they were visible and nearer to the consumer than when not visible and placed further from arm’s reach, showing that proximity and visibility have an additive effect on energy intake. Even healthy foods are consumed in larger amounts when made more proximate and visible. Privitera and Creary (2012) found that college students ate more fruits when placed in open containers within arm’s reach than in closed, opaque containers placed far away. Therefore, both proximity and visibility of a food can additively affect food selection and consumption.

1.1.2 Color
Once a food source is visible, one visual cue from food is its’ color. Since there are many review articles addressing the effects of food color on flavor acceptance (see Spence, Levitan, Shankar, & Zampini, 2010 for detailed review), this review will discuss some studies on color of food and its effects on food acceptance and consumption. Before ingestion, color can influence judgments of acceptability of a product by affecting expectations of palatability of foods which can ultimately dictate food choice and consumption (Koch & Koch, 2003; Spence et al., 2010; Walsh, Toma, Tuveson, & Sondhi, 2001). For example, Morrot, Brochet, and Dubourdieu (2001) found that white wine was described with more red wine-related adjectives when colored red, than when left uncolored.

Color can also affect the odor intensity of solutions when ingested. Zellner and Kautz (1990) and Zellner and Whitten (1999) found that subjects rated colored solutions as more intense in odor than an identical, uncolored solution. The effect of color on the perceived intensity of odors, however, is also dependent on the route of administration of the odor. Odors are detected either directly when volatile odor compounds from food contact olfactory receptors in the nose (called orthonasal olfaction) or indirectly while food is masticated (called retronasal olfaction) (Comeau, Epstein, & Migas, 2001). Odors presented orthonasally (i.e. through the nose via sniffing) were rated higher in intensity than those presented retronasally (i.e. through the mouth via ingestion) when colored than when left uncolored, showing that color’s effect on olfaction may be mediated by the route of administration of the odor (Koza, Cilmi, Dolese, & Zellner, 2005).

The type and intensity of color can also affect the perceived taste of a solution. For example, red-colored solutions were rated sweeter than green or uncolored solutions (Johnson, Dzendolet, Damon, Sawyer, & Clydesdale, 1982; Kostyla, 1978; Lavin & Lawless, 1998;
Pangborn, 1960; Strugnell 1997) and dark red solutions were rated sweeter than light-red solutions (DuBose, Cardello, & Maller, 1980; Johnson & Clydesdale, 1982; Lavin & Lawless, 1998). In addition, color affected perceptions of flavor intensity of a product. Subjects rated brown-colored candy labeled “dark chocolate” as more “chocolatey” than green-colored candy labeled “milk chocolate” showing that both color and labeling of a food product can additively affect flavor perceptions (Shankar, Levitan, Prescott, & Spence, 2009).

Tastes mixed in solutions are also more easily discernible when colored than uncolored. Adding red color to a clear solution significantly increased detectability of sweetness (Johnson & Clydesdale, 1982) and adding green significantly increased detectability of sourness (Maga, 1974). The association of red color with sweetness and green with sourness is perhaps due to our learned color-flavor associations that redness indicates ripeness or maturity of a fruit and green color indicates rawness or immaturity (Alley & Alley, 1998; Koch & Koch, 2003; Maga, 1974).

Adding colors to a solution can also aid in flavor identification especially when atypical color-taste combinations are presented. For example, DuBose et al (1980) and Zellner, Bartoli, and Eckard (1991) found that flavored solutions mixed with an atypical color (i.e. a color that is not naturally associated with that flavor such as a cherry-flavored beverage that is colored green) were harder to identify than those mixed with a typical color (i.e. cherry-flavored beverage that is colored red). Therefore, prior experiences with flavors have an influence on the accuracy of flavor-color identifications.

Accuracy of flavor-color identifications, however, occurs outside of conscious awareness. Even when told to ignore color to identify flavor, subjects were more accurate in flavor identification when colored than uncolored, showing that using color as a visual cue to identify a flavor may be an automatic process (Stillman, 1993; Zampini, Sanabria, Phillips, & Spence,
Typical and atypical color-taste combinations influence judgments of palatability of a product. Typically-colored solutions can enhance aroma intensity, flavor intensity, and overall acceptability of foods and beverages more than atypically colored or colorless ones (Christensen, 1983; Du Bose et al., 1980).

In addition to the color of food, the color of the plate or bowl in which food is served can also alter food palatability ratings and intake. For example, a pink-colored food presented on a white plate was judged to be more flavorful, sweeter, and palatable than the same food presented on a black plate (Piqueras-Fiszman et al., 2012). Similarly, hot chocolate served in red cups was liked more than hot chocolate served in white cups (Piqueras-Fiszman & Spence, 2012) and beverages were rated to be more “thirst-quenching” when served in blue glasses than red, green, or yellow glasses (Guegen, 2003). Food intake may also be altered when served on colored plates. Genschow, Reutner, and Wanke (2012) found that subjects consumed less when pretzels were presented on a red plate rather than on a white or blue plate. The authors hypothesized that red color’s frequent association with danger, avoidance, and warning may have translated to food avoidance, and therefore reduced food intake (Genschow et al., 2012). All together, these studies show that color can affect perceived flavor, odor, and taste intensity of foods which can then affect food intake.

1.1.3 Variety

The presence of foods varying in appearance, texture, taste, and flavor can also affect intake. Varied flavors and foods both within a meal (within-meal variety) and across several meals (across-meal variety) were shown to increase energy intake more than monotonous ones in rats (Estornell, Cabo, & Barber, 1995; Louis-Sylvestre, Giachetti, & Le Magnen, 1984; B.J. Rolls, 1979) and humans (Berry, Beatty, & Klesges, 1985; Brondel, et al., 2009; Bucher, Van der
Horst, & Siegrist, 2011; Meiselman, de Graaf, & Lesher, 2000; Norton, Anderson, & Hetherington, 2006; B.J. Rolls, Van Duijvenvoorde, & E.T. Rolls, 1984; Raynor & Epstein, 2001; Spiegel & Stellar, 1990; Zandstra, de Graaf, & Van Trijp, 2000). For example, rats given access to a cafeteria diet (i.e. a variety of palatable, energy-dense foods and flavors) ate more and gained more weight than those given access to plain laboratory chow (Esteve, Rafecus, Fernandez-Lopez, Ramesar, & Alemany, 1994; Louis-Sylvestre et al., 1984; Prats, Monfar, Castella, Iglesias, & Alemany, 1989; B.J. Rolls, Rowe, & Turner, 1980b; Rothwell, Saville, & Stock, 1982; Rothwell & Stock, 1982; Shafat, Murray, & Rumsey, 2009; Treit, Spetch, & Deutsch, 1983). Similarly, humans given varied sandwich fillings, yogurt flavors, and pasta shapes, ate more than those given a single sandwich filling, yogurt flavor, or pasta shape (B.J. Rolls, Rowe, Kingston, Megson, & Gunary, 1982; B.J. Rolls, Rowe, & E.T. Rolls, 1982).

One explanation for the variety effect is the development of sensory-specific satiety. When a meal is consumed to satiety, pleasantness of that meal decreases relatively more than those uneaten (Guinard & Brun, 1998; Nolan & Hetherington, 2009; B.J. Rolls, E.T. Rolls, Rowe, & Sweeney, 1980a; Smeets & Westerterp-Plantenga, 2006). Therefore, when given a variety of foods and flavors, the usual decline in pleasantness after consumption of a single meal is disrupted, resulting in a delay in the development of sensory-specific satiety and an increase in energy intake. Sensory-specific satiety can occur rapidly i.e. within two minutes of consumption and can persist over a 20 minute period (Guinard & Brun, 1998; Hetherington, B.J. Rolls, & Burley, 1989; B.J. Rolls et al., 1980a).

Sensory-specific satiety however, is not limited to the taste sense. Several studies also showed a decline in pleasantness of the appearance of eaten foods relative to uneaten foods, called appearance-specific satiety. Rolls et al (1980a) found that subjects who ate one of four
foods (crackers, cheese, sausage, or water) showed a greater decline in pleasantness of the eaten food than those uneaten and this decline in pleasantness extended to the visual aspects of the meal (Rolls et al., 1980a). Similarly, the magnitude of decline in pleasantness was greater for a color of food eaten to satiation than the color of an uneaten food (Rolls et al., 1982). Even when the shape of a food was varied in successive courses, energy intake increased. Rolls et al (1982) showed that when subjects were offered three shapes of pasta, the magnitude of decrease in pleasantness for the eaten shape was greater than the uneaten food shape. Appearance-specific satiety, however, is relatively short-lived because it occurs rapidly (2 min) after consumption, and does not persist after that (Hetherington et al., 1989).

To observe the effects of variety on food intake, however, the foods must be sufficiently dissimilar in several dimensions. For example, Rolls et al (1981) found that when offered three different flavors of yogurts varying in appearance and texture (hazelnut, blackcurrant, and orange), subjects ate more than when offered only one flavor. But, this so-called variety effect attenuated when the color and texture of yogurts were held constant. In a subsequent experiment, Rolls et al (1981) found that when subjects were offered strawberry, cherry, and raspberry-flavored yogurt (all pink in color), yogurt intake was not different from those given only a single flavor of yogurt, showing that only varying the flavors of a meal (while keeping the color of the food constant) is not sufficient to increase energy intake. Therefore, presenting foods varying in appearance, texture, odor, and taste of foods may be important to observe the effects of variety on energy intake.

The *perceived* variety of foods can also affect energy intake by changing perceived quantity estimations. When the ingredients of a pasta and vegetable stir-fry meal were presented separately, energy intake increased more than when the ingredients of both foods were mixed
together (Levitsky et al., 2012). The authors suggested that segregating food into discrete units increases energy intake by increasing the perceived variety of foods available for consumption. In addition, Redden and Hoch (2009) showed that a varied set of abstract colors and shapes of non-food objects are perceived to be lower in quantity than one that is homogenous. The authors argued that when people see a homogenous set of items, they are able to group them into a single, unified whole making them appear more numerous. This perceived variety effect on quantity judgments also translates to food serving behaviors. Redden and Hoch (2009) found that when subjects were asked to pour enough candy into a bowl to match the quantity in another bowl, subjects given varied colors of candy poured more candy than those given same-colored ones. The authors hypothesized that subjects underestimated the number of multi-colored candy resulting in more candy being poured into the bowl, than when given only single-colored candy.

Segregating a meal into discrete colored units can also provide subtle visual cues to interject “mindless” eating. To demonstrate this idea, Geier, Wansink, and Rozin (2012) gave subjects a tube of either yellow-colored chips (unsegmented) or one with a red-colored chip inserted at regular intervals (segmented). They found that subjects given the segmented snack ate about 50% less than those given the unsegmented snack perhaps because red-colored chips served as visual “stopping points” during the meal that interrupted further food intake. In addition, partitioning a food into discrete lines and shapes can also change the size of bites taken from them. Sobal and Wansink (2007) suggested that chocolate bars partitioned with several lines may be used as visual references to determine the amount of food to be consumed in one mouthful.

### 1.1.4 Portion Size


One visual cue known to affect the appeal of a food is portion size. Portion size is one of the major contributors of energy intake and Body Mass Index (BMI) in both children and adults (Duffey & Popkin, 2013; McConahy, Smiciklas-Wright, Birch, Mitchell, & Picciano, 2002; Young & Nestle, 2002). Participants rated large portions to be visually more appealing than smaller portions and expressed a greater desire to eat large than smaller portions (Burger, Cornier, Ingebrigsten, & Johnson, 2011a). In addition, people eat more if large portions of food are served rather than smaller portions. In both laboratory and real-life settings, children and adults ate more when snack foods, beverages, sandwiches, and pasta entrees were given in larger portions (Diliberti, Bordi, Conklin, Roe, & Rolls, 2010; Fisher & Kral, 2008; Fisher, Liu, Birch, & Rolls, 2007; Fisher, Rolls, & Birch, 2003; Flood, Roe, & B.J. Rolls, 2006; Jeffery et al., 2007; Levitsky & Youn, 2004; B.J. Rolls, Morris, & Roe, 2002; B.J. Rolls, Roe, Kral, Meengs, & Wall, 2004a, B.J. Rolls, Roe, Meengs, & Wall, 2004b; B.J. Rolls, Roe, & Meengs, 2006a, 2006b, 2012; Wansink & Kim, 2005).

Portion size effects on energy intake, however, are mediated by age. B.J. Rolls, Engell, and Birch (2000) showed that five-year-old children showed proportional increases in energy intake with incremental increases in macaroni and cheese portions, whereas three-year-old children were unaffected. The authors hypothesized that perhaps young children rely heavily on their internal hunger and satiety signals rather than external (visual) cues such as an empty plate to terminate eating.

Portion sizes of foods may also influence food intake by changing the microstructure of eating. People take large bites when served larger portions of food (Fisher & Kral, 2008). Taking large bites lead to gorging. Gorging on food does not allow sufficient time for the release of regulatory peptides required for the development of satiety resulting in reduced feelings of
fullness, increased desire to eat, and increased food intake (Bolhuis, Lakemond, de Wijk, Luning, & de Graaf, 2011; Burger et al., 2011b; de Wijk, Zijlstra, Mars, de Graaf, & Prinz, 2008; Fisher et al., 2003; Fisher, & Kral, 2008; Kissileff, Zimmerli, Torres, Devlin, & Walsh, 2008; Kral, Buckley, Kissileff, & Schaffner, 2001; Weijzen, Smeets, & de Graaf, 2009; Zijlstra, de Wijk, Mars, Stafleu, & de Graaf, 2009). Second, people eat faster when given large food portions (Fisher & Kral, 2008). Eating fast does not allow sufficient time for the development of satiation leading to decreased satiation and consequently an increase in food consumption (Azrin, Kellen, Brooks, Ehle, & Vinas, 2008; Burger et al., 2011b; Ferster, Nurenberger, & Levitt, 1962; Kissileff et al., 2008; Martin et al., 2007; Melanson, 2004; Spiegel, 2000; Spiegel, Wadden, & Foster, 1991).

1.1.5 Height

Typically, children and adults use height as a cue when estimating liquid amounts (Anderson & Cuneo, 1978; Piaget, 1952; Raghubir & Krishna, 1999). Piaget (1952) found that children perceive taller glasses to contain more liquid than shorter ones, even when the volume in the two liquids was identical. He attributed this overreliance on height cues to centration bias, a tendency of children to attend to a single dimension to make quantity estimations, while ignoring the rest.

Incorrect quantity estimations due to height biases may in turn, affect the amount of food served and consumed. Wansink and Van Ittersum (2003a) found that subjects poured more liquid into short, wide glasses than tall, narrow ones due to an overestimation of the height of the glass as an indicator of liquid amounts. Height biases in food quantity estimations can affect our expectations of fullness from the food, and ultimately energy intake. Raghubir and Krishna (1999) found that adults perceived a taller glass to contain more liquid than a shorter, wider
glass. This overestimation of liquid when given the taller glass resulted in lower perceived volume consumption, lower post-consumption satisfaction, higher actual consumption, and more requests for refills than when given the short, wide glass. The authors hypothesized that when a subjects’ expectations do not match actual volume consumed (i.e. liquid in tall glass was overestimated), subjects consume more to compensate for the perceived lower volume consumed (Raghubir & Krishna, 1999).

1.1.6 Shape and Surface Area

The shape of a food can affect the perceived volume of a food (Raghubir & Krishna, 1999). Krider, Raghubir, and Krishna (2001) asked college students to determine if a square or circular pizza was larger. More than 70% of the participants perceived the square pizza to be greater in quantity than the circular pizza. Similarly, the shape of food pieces can also affect food quantity estimations. Wada, Tsuzuki, Kobayashi, Hayakawa, and Kohyama (2007) found that subjects overestimated the weights of foods cut into fine strips and accurately estimated weights of foods cut into blocks.

Shapes of food pieces can also affect liking of foods. For example, children liked pictures of vegetables served in the shape of stars than when cut into slices or sticks (Olsen, Ritz, Kramer, & Moller, 2012) and adults preferred pictures of meats cut into pieces than slices (Reisfelt, Gabrielsen, Aaslyng, Bjerre, & Moller, 2009). However, food cut into various shapes had no differential effect on snack food consumption. Children showed no greater intake of snack foods cut into fun shapes (animals, hearts, or hands) than those served in normal shapes (Boyer, Laurentz, McCabe, & Kranz, 2012; Branen, Fletcher, & Hillbert, 2002).

The area of a plate occupied by food can also influence judgments of the amount of food consumed. Food served on larger plates or bowls may be displaced away from the edge of the
plate, resulting in a significant underestimation of food (called contrast effects) and foods served on smaller plates may spread to the edges of the plate, resulting in a significant overestimation of food (called assimilation) (Van Ittersum & Wansink, 2011). These assimilation and contrast effects, as mentioned earlier, occur due to an optical illusion called the Delbouef illusion and is based on the idea that the presence of one circle may change the perceived size of another circle (Nicolas, 1995). This visual illusion affects quantity estimations and the amount of food served and consumed. Van Ittersum and Wansink (2011) found that subjects poured less soup into a smaller than larger bowl due to overestimation of the diameter of the smaller bowl. This overestimation of foods served in smaller bowls, may also explain why the amount of food served in smaller bowls is less than the amount of food served in larger bowls, resulting in less energy intake from smaller than larger bowls (Van Ittersum & Wansink, 2011; Wansink, Van Ittersum, & Painter, 2006b).

1.1.7 Size and Number

In addition to shape and surface area, the size of food pieces can affect liking of a food. Both rats and nonhuman primates show a preference for larger than smaller food pieces (Boysen, Bernston, & Mukobi, 2001; Menzel, 1961; Menzel & Davenport, 1962; Menzel & Draper, 1965; Yoshioka, 1930). Yoshioka (1930) found that rats preferred larger over smaller sunflower seeds even though the larger seeds contained less food overall. Moreover, Yoshioka (1930) found that this preference diminished when seeds were eaten in darkness, showing that size is an important visual cue used to regulate food intake in rats.

Varying the size of food pieces have been shown to affect energy intake in humans. Spiegel, Shrager, and Stellar (1989) developed solid food units (SFU’s), spirals of bread with varied fillings to accurately measure the rate of ingestion of a single, solid food. In this type of
procedure, both obese and normal subjects were instructed to place one SFU in the mouth at a time, so that the amount and rate of ingestion can be measured while keeping bite size constant. The authors found that when subjects were given an unlimited number of solid food units of varying sizes, subjects ate faster and also ate fewer solid food units as the size of the units increased (Spiegel et al., 1989).

A portion of food varying in number and size of pieces can also affect quantity estimations. Consumers in a marketing study judged a snack packet with an image of 15 pretzels to contain a greater number of pretzels than a package containing an image of three pretzels, even though the actual quantity of pretzels in the package were the same (Madzharov & Block, 2010). In addition, Scisco, Blades, Zielinski, and Muth (2012) found that subjects perceived a 16-piece Jell-O portion to contain more food than a nine-piece Jell-O portion.

Varying the size and number of pieces can also affect the amount of food that is consumed. Nisbett and Storms (1972), varied the size and number of food pieces and found that subjects ate more when given four, quartered sandwiches (16 pieces) than the same sandwiches cut into 32 bite-sized pieces. The authors hypothesized that quartered sandwiches may have resembled “meals” that are typically eaten in large amounts, whereas, bite-sized pieces may have resembled “snacks” that are typically eaten in smaller amounts. Similarly, Marchiori, Waroquier, and Klein (2011) found that adults ate more when served 10 large candies, than the same candies cut into 20 bite-sized pieces and that children ate more when served 18 large cookies than those cut into halves (i.e. 36 bite-sized pieces) (Marchiori, Waroquier, & Klein, 2012). Weijzen, Liem, Zandstra, and de Graaf (2008) found that subjects ate six large candy bars significantly faster and in larger amounts than the same amount of candy cut into 66 bite-sized pieces. The authors hypothesized that increased energy intake from the large chocolate
candy bars may have increased the size of bites taken from the food resulting in shorter exposure to food in the mouth. Short oro-sensory exposure to food elicits lower satiation signals, and consequently facilitates an increase in energy intake (Bolhuis et al., 2011; Cecil, Francis, & Read, 1998, 1999; de Wijk et al., 2008; Forde et al., 2013a; French & Cecil, 2001; Kissileff et al., 2008; Kral et al., 2001; Raynor & Epstein, 2000; Weijzen et al., 2009; Wijlens et al., 2012; Zijlstra et al., 2009). Taken together, all these studies show that varying the size and number of pieces can affect food intake either by changing our expectations of satisfaction from the food or indirectly by changing eating behaviors.

In the aforementioned studies, however, size varied along with the number of food pieces as the total amount of food was held constant. The portion with the smaller pieces also contained a greater number of pieces than the portion with the larger food pieces i.e. 16 large sandwich pieces were cut into 32 bite-sized ones (Nisbett & Storms, 1972), 10 large candy were cut into 20 small pieces (Marchiori et al., 2011), and 18 large cookies were cut into 36 small pieces (Marchiori et al., 2012). Therefore, number of food pieces is also an important visual cue affecting food intake.

The effects of number of food pieces, independent of size, have been studied extensively in animals. Wolfe and Kaplon (1941) found that chickens ran significantly faster for a popcorn kernel cut into quarters than one left whole, showing multiple pieces of food were more rewarding than a single piece. Similarly, rats ran faster for multiple (4-22) pellets of food than an equicaloric, single pellet of food (Amsel, Hug, & Surridge, 1968; Campbell, Batsche, & Batsche, 1972; McCain, 1969; Traupmann, 1971) and preferred a multiple-piece (four, 75 mg pellets) over an equicaloric, single piece of food (300 mg) in a T-maze (E.J. Capaldi, Miller, & Alptekin, 1989). Humans also prefer and find a multiple-piece portion to be more satiating than
a single piece one. In an unpublished experiment in our lab, we found that subjects preferred and also ate less of a multiple-piece serving than a single-piece one. In addition, food intake following the multiple-piece serving was lower than the single-piece serving.

Since multiple pieces of food are more rewarding than a single piece in both animals and humans, we hypothesized that perhaps the multiple-piece portion was perceived to be greater in quantity as they take up a larger surface area than the single-piece one. This notion was further tested in a subsequent study in our lab in college students, where we varied the surface area occupied by a five-piece chicken portion by scattering the food pieces on a plate or clustering them together. We found that subjects given the scattered chicken portion ate significantly fewer calories from the chicken portion as well as from a subsequent test meal than those given the clustered chicken portion, showing that the spread of a food portion on a plate is an important visual cue that can affect food quantity estimations and ultimately food consumption volumes.

1.2 Future Directions

Most studies largely overlook the effects of visual cues and focus more on taste of food as an important sensory influence on food intake. Although color has been extensively researched in the literature, few studies have measured other aspects of the appearance of a meal. All the research described above show that visual cues such as portion size, visibility, color, proximity, perceived and actual variety, size of food pieces, shape, and surface area occupied by food can all affect food intake either via changes in acceptability of a food and feeding behaviors, perceptions of food quantity, or both.

Despite information about the effects of visual cues on food intake, there are still some unanswered questions in the literature. First, in light of the evidence that large portions of food increase energy intake, the food industry encouraged portion control by selling single-serving
packages of foods. But, the relationship between single-serving food portions and energy intake in the laboratory remains unclear (Hill, 2009). For instance, Stroebele Ogden, and Hill (2009) showed inconsistent effects of 100 kcal versus regular-sized snack packages on energy intake over a two-week period and Raynor, Van Walleghen, Niemeier, Butryn, and Wing (2009) found that consumption from single-serving packages at breakfast was lower than from standard packages in participants recruited for a weight loss program. The amount of food consumed from single-serving packages is also dependent on individual differences. For example, Wansink, Payne, and Shimizu (2011) found that while normal-weight consumers were unaffected by package size, overweight consumers ate about 25% less when given four 100 kcal packages of food versus a single, 400 kcal package. In addition, individuals with greater self-control and lower self-esteem consumed significantly more food from smaller than larger (standard), packages of foods (Arigo & White, 2012; Coelho do Vale, Pieters, & Zeelenberg, 2008).

One important factor affecting food intake in studies investigating single-serving packages is the visual aspect of the food itself. A food portion packaged into single 100 kcal packages eliminates the visual cues used in monitoring food intake when food is eaten directly from the package. Perhaps, 100 kcal packages may reduce intake if served on a plate or bowl so that they can be used as visual references for the amount of food consumed. Future studies should investigate if 100 kcal package foods served on plates are consumed in smaller amounts than when consumed directly from the package. Second, when a package is labeled “100 kcal” it creates a health halo bias that if something is labeled low-calorie or healthy, more can be consumed (Provencher, Polivy, & Herman, 2009). Therefore, providing foods in 100 kcal servings with no labels may prevent the health halo bias and decrease food intake.
Second, manipulations of visibility of food either via changes in lighting conditions or by
blindfolding subjects have shown inconsistent results. Although palatability and familiarity of
food have been shown to interact with lighting and visibility, the moderating influence of other
factors have not been investigated. The type of food i.e. highly palatable or nutritious foods may
also moderate the influence of visibility on food intake. Deng and Srinivasan (2013) found that
while intake of palatable foods increased when packaged in transparent wrapping, the intake of
less palatable foods like vegetables decreased. Therefore, more studies need to investigate the
effects of visibility of food on food intake when the palatability of the target food is varied.

Third, it is surprising that very few studies have investigated the effects of shape of foods
on energy intake. Most studies on portion size have focused on amorphous foods (Fisher & Kral,
2008; Raghubir & Krishna, 1999; Van Ittersum & Wansink, 2011; Wansink et al., 2006;
Wansink & Van Ittersum, 2003a). However, the shape of food cut into discrete sizes and shapes
and the amount of room taken up by food can affect quantity estimations, expectations of
palatability of food, and ultimately food intake (Krider et al., 2001; Olsen et al., 2012; Reisfelt et
al., 2009; B.J. Rolls et al., 1982; Wada et al., 2007). In addition, the shape of a food may also
change feeding behaviors by changing the size of bite or perception of intensity of food in the
mouth. In fact, desserts with added odors were consumed in smaller bites than those presented
with no odors due to the larger quantity of aroma molecules present in larger bites (de Wijk,
Polet, Boek, Coenraad, & Bult, 2012; Ruijschop et al., 2011). Perhaps, then the shape of food
pieces may also change the intensity of tastes and odors experienced in the mouth and ultimately
affect food intake. Future studies should address how the shape of foods affects the
microstructure of eating and ultimately food intake.
Fourth, much of the literature on the effects of surface area occupied by food on food intake used amorphous foods or foods that take the shape of the plate or bowl in which they are served (Fisher & Kral, 2008; Raghubir & Krishna, 1999; Van Ittersum & Wansink, 2011; Wansink et al., 2006; Wansink & Van Ittersum, 2003a). With the exception of our study, no study has determined the effects of the surface area occupied by a non-amorphous portion of food and its effects on eating behaviors and energy intake. Future studies should consider the space occupied by a portion of food and its effects on energy intake in both children and adults.

Lastly, studies investigating the size and number of pieces occupied by food pieces are largely limited. Except for a few studies on the effects of food item size on energy intake, we still don’t know if cutting up foods into small pieces or presenting food in smaller pieces decreases intake in both obese and normal-weight subjects and in restrained and unrestrained eaters.

1.3 Practical Applications

Most children fail to meet recommendations for fruit and vegetable intake in the U.S (Lorson, Melgar-Quinonez, & Taylor, 2009). Consumption of fruits and vegetables is beneficial for the prevention of chronic diseases such as cancer, cardiovascular disease, and obesity (Birt, Hendrich, & Wang, 2001; Epstein et al., 2001; McCrory et al., 1999; Ness & Powles, 1997).

Given that varied visual cues can affect food intake, changing the appearance of a food may be used to both initiate and increase the consumption of fruits and vegetables in children. Zampollo and colleagues (2012) suggested that children prefer varied colors of foods on their plates and Olsen et al (2012) found that children prefer fruits and vegetables cut into different figures to those cut into slices or sticks. Perhaps, parents should try serving foods in attractive ways or cutting fruits and vegetables into fun shapes to increase their intake. Second, neophobia
can prevent children from trying new foods. Neophobia is an adaptive trait that peaks around two to five years of age and is shown to reduce dietary variety, especially the consumption of fruits, vegetables, and meats (Cooke et al., 2003, 2006; Cooke, Pliner, 1994). Although repeated exposure to the taste of food can increase willingness to try them (Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012; Birch & Marlin, 1982; Hausner, Olsen, & Moller, 2012; Lakkakula et al., 2010; O’Connell, Henderson, Luedicke, & Schwartz, 2012; Wardle et al., 2003; Wardle, Herrera, Cooke, & Gibson, 2003), the initial reluctance to try new foods can be eliminated by visually exposing children to the novel foods. This initial visual exposure may then enhance acceptance when offered a second time. Another way to decrease neophobia visually is to discuss with children the similarity of the new food’s taste and appearance with a familiar one similar to the procedure adopted by Dovey et al., 2012. This method can reduce the uncertainty about the taste of the new food and encourage trial.

Research on the size and number of food pieces may be used to increase healthy food consumption and decrease unhealthy food consumption in both children and adults. Since foods cut into pieces are consumed in smaller amounts than those left whole (Wadhera, Capaldi-Phillips, & Wilkie, unpublished), healthy foods (like fruits) should be served whole and unhealthy foods (like cookies, cakes, and pastries) should be served in pieces. Anorexics have been shown to cut their food into smaller pieces and spread their food portion on the plate to make it look like more food (Garner & Garfinkel, 1979). Therefore, recovering anorexics may also benefit from leaving foods whole to increase their consumption of these foods. Spreading a small portion of unhealthy foods (potato chips and candy pieces) on a plate may look like more and therefore decrease intake of these foods in both children and adults. On the other hand,
clustering fruits and vegetables in the center of a plate, may look like less and result in the overconsumption of these foods.

Other ways of decreasing the intake of energy-dense foods is by making them less accessible. Studies on proximity and visibility reviewed here found that foods kept at a distance were less likely to be consumed than those that were placed closer to the consumer. Empty-calorie foods must be stored in opaque containers, away from the desk or in less accessible places to discourage their intake. Similarly, fruits and vegetables should be placed on the table to make them more visible, thereby increasing their intake than when stored in the refrigerator.

1.4 Strengths and Limitations

This review article has some strengths and limitations. Only articles that were published in English were included in the present review. In addition, few studies on color were reviewed here as other reviews have already provided extensive reviews on this topic. Despite these limitations, this review article makes a significant contribution to understanding the effects of visual cues on food intake. Given the importance of taste and smell on food intake, research on vision has often been under-studied in human ingestive behavior studies. This review article summarizes the literature on the sight of food on food intake and revisits research questions that have largely been overlooked. For example, with the exception of a few studies (Barkeling et al., 2002; Burger et al., 2011b; Linne et al., 2002), few researchers have attempted understanding the role of vision on the amount of food consumed. More research should be undertaken to understand how the sight of food itself may impact food intake in normal and overweight children and adults. Additionally, Rolls and colleagues (1980a, 1981, 1982) found that subjects habituate to the appearance of foods, showing appearance-specific satiety. But, most studies investigating variety effects largely neglected the role of the appearance of food on the initiation
of sensory-specific satiety. Future studies must consider the role of vision, in addition to taste, in the development of sensory-specific satiety.

Second, most reviews only include studies that discuss a single visual cue and its relationship with food intake. Although some review articles addressed physiological measures (saliva, brain activations) associated with the sight of food (van der Laan et al., 2011; Mattes, 1997) no review article summarizes research on behavioral (non-physiological) factors associated with the sight of food.

Lastly, we identified the role of some visual cues in dietary choice and intake that have been largely limited and/or absent. For example, many studies in primates have explored the role of various quantitative dimensions of food (number, size, length, orientation, surface area) on food choice (Boysen et al., 2001; Menzel, 1961; Menzel & Davenport, 1962; Menzel & Draper, 1965). Few human studies however, have explored how these visual dimensions of food affect food choices and intake in children and adults.

To conclude, visual cues from food can decrease neophobia in children, improve perceived flavors, change estimations of food quantity, prepare the body for digestion, modify the microstructure of eating, and affect energy intake. Future studies should address the interactive and additive effects of environmental and food-related visual cues on food intake. Identification of the various visual cues and their effects on eating behaviors may be useful for identifying potential targets for obesity prevention and treatment in both children and adults.
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they do: taste, nutrition, cost, convenience, and weight control concerns as influences on
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subjective experience before, during and after the consumption of preferred and less


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Table 1
Summary of results from studies on visual cues associated with food on food acceptance and consumption.

<table>
<thead>
<tr>
<th>Visual cue</th>
<th>Known Mediators</th>
<th>Results</th>
<th>Effects on Food Acceptance and Consumption</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visibility</td>
<td>Consistent</td>
<td>Increased visibility of food increases food intake</td>
<td>(Barkeling, Linne, Melin, &amp; Rooth, 2003; Burger, Fisher, &amp; Johnson, 2011b; Johnson, 1974; Linne, Barkeling, Rossner, &amp; Rooth, 2002)</td>
<td></td>
</tr>
<tr>
<td>Food type</td>
<td>Consistent</td>
<td>Increases palatable food intake and decreases unpalatable food intake</td>
<td>Deng &amp; Srinivasan, 2013</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>Mixed</td>
<td>Dim lighting increases food intake</td>
<td>(Kasof, 2002; Schebeheinne, Todd, &amp; Wansink, 2010)</td>
<td>(Ross, 1970)</td>
</tr>
<tr>
<td>Preference</td>
<td>Consistent</td>
<td>Bright lighting increased consumption in subjects who prefer darker coffee</td>
<td>Gal et al., 2007 in Spence, Harrara, &amp; Piqueras-Fiszman, 2012</td>
<td></td>
</tr>
<tr>
<td>Familiarity</td>
<td>Consistent</td>
<td>Dim lighting decreases consumption of ambiguous foods</td>
<td>Wansink, Shimizu, Cardello, &amp; Wright, 2012</td>
<td></td>
</tr>
<tr>
<td>Eaten food</td>
<td>Consistent</td>
<td>Reminders of amount of food eaten decreases food intake</td>
<td>Kennedy-Hagan et al., 2011; Wansink &amp; Payne, 2007</td>
<td></td>
</tr>
<tr>
<td>Proximity</td>
<td>Consistent</td>
<td>Foods located closer are consumed in larger amounts than those located far away</td>
<td>Engell, Kramer, Malafi, Salomon, &amp; Lesher, 1996; Meiselman, Staddon, Hedderley, Pierson, &amp;</td>
<td></td>
</tr>
<tr>
<td>Factor</td>
<td>State</td>
<td>Effect Description</td>
<td></td>
<td></td>
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<tr>
<td>------------------------</td>
<td>-------</td>
<td>-----------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximity &amp; visibility</td>
<td>None</td>
<td>Increased proximity and visibility additively increase food intake</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consistent</td>
<td>(Privitera &amp; Creary, 2012; Wansink, Painter, &amp; Lee, 2006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color of food*</td>
<td>None</td>
<td>Affects expected palatability and taste of food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before food intake</td>
<td>Consistent</td>
<td>(Koch &amp; Koch, 2003; Morrot, Brochet, &amp; Dubourdieu, 2001; Spence et al., 2010; Walsh, Toma, Tuveson, &amp; Sondhi, 2001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After food intake</td>
<td>Consistent</td>
<td>Affects intensity of odor from food</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(Koza, Cilmi, Dolese, &amp; Zellner, 2005; Zellner &amp; Kautz, 1990; Zellner &amp; Whitten, 1999)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flavor/food identification</td>
<td>Consistent</td>
<td>Aids in flavor or food identification which ultimately affects palatability and acceptability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color type</td>
<td>Consistent</td>
<td>Red solutions rated sweeter than green or uncolored solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color intensity</td>
<td>Consistent</td>
<td>Dark-colored solutions rated higher in taste and flavor intensity than lighter solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Utensil color</strong></td>
<td>Consistent</td>
<td>Foods served on certain colored dineware rated more acceptable in taste and other properties</td>
<td>(Piqueras-Fiszman et al., 2012; Piqueras-Fiszman &amp; Spence, 2012; Geugen, 2003)</td>
<td></td>
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<tr>
<td>Color of utensil</td>
<td>Consistent</td>
<td>Foods served on red plates consumed in smaller amounts</td>
<td>(Genschow, Reutner, &amp; Wanke, 2012)</td>
<td></td>
</tr>
<tr>
<td><strong>Variety</strong></td>
<td>Actual</td>
<td>Increased variety of foods or flavors increases energy intake in animals and humans</td>
<td>(Estornell, Cabo, &amp; Barber, 1995; Louis-Sylvestre, Giachetti, &amp; Le Magnen, 1984; B.J. Rolls, 1979; Berry, Beatty, &amp; Klesges, 1985; Brondel, et al., 2009; Bucher, Van der Horst, &amp; Siegrist, 2011; Meiselman, de Graaf, &amp; Lesher, 2000; Norton, Anderson, &amp; Hetherington, 2006; B.J. Rolls, Van Duijvenvoorde, &amp; E.T. Rolls, 1984; Raynor &amp; Epstein, 2001; Spiegel &amp; Stellar, 1990; Zandstra, de Graaf, &amp; Van Trijp, 2000; Esteve, Rafecus, Fernandez-Lopez, Ramesar, &amp; Alemany, 1994; Louis-Sylvestre et al., 1984; Prats, Monfar, Castella, Iglesias, &amp; Alemany, 1989; B.J. Rolls, Rowe, &amp; Turner, 1980b; Rothwell,</td>
<td></td>
</tr>
</tbody>
</table>
Perceived

Consistent  Increased perceived variety of foods decreases quantity estimations and increases energy intake (Levitsky, Iyer, & Pacanowski, 2012; Redden & Hoch, 2009)

Portion size


Age

Children younger than 5 years of age are unaffected by portion size (Rolls, Engel, & Birch, 2000)
<table>
<thead>
<tr>
<th>Height bias</th>
<th>Consistent Beverages served in tall glasses are overestimated but consumed in larger amounts than those served in short, wider ones</th>
<th>Anderson &amp; Cuneo, 1978; Piaget, 1952; Raghubir &amp; Krishna, 1999; Wansink &amp; Van Ittersum, 2003a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape</strong></td>
<td>Consistent Square-shaped foods and foods cut into strips are perceived to be larger than circular foods or those cut into blocks. Foods cut into fun shapes were liked but not consumed in larger amounts than those cut into slices or sticks</td>
<td>(Krider, Raghubir, &amp; Krishna, 2001; Wada, Tsuzuki, Kobayashi, Hayakawa, &amp; Kohyama, 2007) (Boyer, Laurentz, McCabe, &amp; Kranz, 2012; Branen, Fletcher, &amp; Hillbert, 2002; Olsen, Ritz, Kramer, &amp; Moller, 2012; Reisfelt, Gabrielsen, Aaslyng, Bjerre, &amp; Moller, 2009)</td>
</tr>
<tr>
<td><strong>Surface area</strong></td>
<td>Consistent Foods covering a larger surface area perceived to contain more food and also consumed in smaller amounts</td>
<td>(Van Ittersum &amp; Wansink, 2011; Wansink, Van Ittersum, &amp; Painter, 2006b; Wadhera, Capaldi-Phillips, &amp; Wilkie, unpublished)</td>
</tr>
<tr>
<td><strong>Size &amp; number</strong></td>
<td>Consistent Foods cut into smaller pieces are preferred, perceived as more food, and consumed in smaller amounts than larger pieces of food</td>
<td>(Madzharov &amp; Block, 2010; Marchiori, Waroquier, &amp; Klein, 2011, 2012; Scisco, Blades, Zielinski, &amp; Muth, 2012; Nisbett &amp; Storms, 1972; Spiegel, Shrager, &amp; Stellar, 1989; Weijzen, Liem, Zandstra, &amp; de Graaf, 2008; Wadhera, Capaldi-Phillips, &amp; Wilkie, unpublished)</td>
</tr>
</tbody>
</table>
Note: * The review on color is only for studies included here. For a detailed review see Spence et al., 2010)
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Contributors: Author DW conducted literature searches, provided summaries of the research studies, and wrote the first draft of the manuscript and author EC contributed to and approved the final manuscript.

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Highlights

- First sensory contact with food is mostly through the eyes
- Seeing food can change feeding behaviors and food consumption volumes.
- Portion size, number, and size are some visual cues that can affect food intake
- Visual cues can be used to increase healthy food intake in both children and adults