

12. Claire N, D'Ugard C, Bancalari E. Automated adjustment of inspired oxygen in preterm infants with frequent fluctuation in oxygenation: a pilot clinical trial. *J Pediatr* 2009;155:640-5.
13. Tan A, Schulze A, O'Donnell CPF, Davis PG. Air versus oxygen for resuscitation of infants at birth. *Cochrane Database Syst Review* 2005;(2):CD002273.
14. American Heart Association, American Academy of Pediatrics. 2005 American Heart Association (AHA) guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiovascular care (ECC) of pediatric and neonatal patients: neonatal resuscitation guidelines. *Pediatrics* 2006;117:1029-38.

Internal Versus External Influences on Energy Intake: Are Disinhibited Eaters Born or Created?

Parents of obese children often describe the child as “always hungry” or that he or she “doesn’t know when to stop eating,” with the implication that there is something awry in the child’s brain or metabolism. The biological conundrum for clinicians is whether such children do indeed have inherently different appetite and satiety signaling, but the practical challenge is how to diffuse frustration and to best help the child and the parents identify constructive strategies around food and eating.

The literature on children’s eating behavior and weight outcome focuses on children’s self-regulation of energy intake and the relation of children’s eating behavior to their weight outcome. Clara Davis performed the pioneering work in this area and, in well-controlled environments with simply prepared foods, demonstrated that young children eat to energy needs by consuming what they like and deferring on less-preferred foods.^{1,2} Additional early work investigating infant response to changes in energy density of formula revealed that infants adjusted the volume of intake to reflect the energy density of the formula, decreasing volume of intake when energy density was increased.³ These results were considered to be evidence of an innate mechanism for self-regulation of energy intake.

Birch et al, in research with single meal protocols in the laboratory, have further investigated the ability of young children to self-regulate energy intake. Their studies have consistently revealed evidence of at least some degree of short-term regulation of energy intake.⁴ However, later work investigating individual differences in self-regulation of energy intake has suggested that the extent to which children show short-term compensation for changes in the energy content of the diet varies considerably and is related to children’s weight status such that children with higher adiposity demonstrate less evidence of short-term energy regulation.⁵ Similar patterns have been noted in school-aged children.⁶

A number of potential influences on children’s ability to self-regulate energy intake have been suggested and, when considered in the bioecological model, these include macro-level influences (ie, community level influences and

the greater food environment) through microlevel influences such as the family environment, parent-child interactions, and characteristics unique to the child (eg, temperament).⁷ Birch et al, through earlier research and from data collected on the Girls’ Needs cohort reported by Anzman and Birch in this issue of *The Journal*, have contributed substantively to this body of work.⁸

Parental feeding practices, particularly parental restriction of children’s access to highly palatable foods, have been reported to have robust relationships with children’s eating behaviors and weight outcome.⁹ Parents who report taking greater control of children’s intake have children who display less evidence of self-regulation of food intake, greater eating in the absence of hunger,¹⁰ and consumption of highly palatable foods after reporting they are no longer hungry.¹¹ Thus, whether parents’ feeding practices cause disinhibited eating on the part of children or whether parents are responding to inborn characteristics of the child is unclear.

The focus of the work by Anzman and Birch,⁸ child temperament as related to impulsivity and inhibitory control, has particular significance for beginning to tease out the sequence or directionality of the association between children’s eating and parental feeding styles. Inhibitory control, as defined by Rothbart et al, denotes an active process of inhibition: an “effortful control” or self-regulation.¹² Inhibitory control emerges late in infancy, continues to develop during the toddler and preschool years, and is reported to have good longitudinal stability.¹³ As such, this aspect of child temperament is considered to be at least partly biological and developmental in nature. Parent-child interactions, such as the degree of parental control, have been posited to contribute to the growth of children’s inhibitory control and its converse, impulsivity.¹⁴ Longitudinal study of the development of children’s self-regulation suggested that the extent to which parents were responsive and provided cognitive stimulation related to their children’s ability to delay gratification. These studies of children’s development of inhibitory control form the basis for the study by Anzman and Birch.

See related article, p 651

Anzman and Birch hypothesized that children's inhibitory control would relate to their self-regulation of energy intake and thus would be a predictor of children's weight status.⁸ Children who, by temperament (in this case postulated to be a biological predisposition), demonstrate lower inhibitory control would be less likely to self-regulate energy intake and would therefore be more likely to gain weight at an excessive rate with time. In agreement with earlier literature relating parent-child interactions to the development of inhibitory control, they further hypothesized that restrictive feeding practices would exacerbate children's struggles with inhibitory control. Their data impressively support these hypotheses in that girls' inhibitory control, measured at age 7 years, predicted adiposity at age 9, 11, 13, and 15 years. Further, it was the girls who perceived higher parental restriction who exhibited this relationship most strongly.

Although exceedingly well-designed and executed and with very little patient attrition, there are some limitations to the study design that limit the generalizability of their findings. First, this study was originally conceived to examine the emergence of early dieting in girls and, as such, there were no boys recruited into this cohort. The literature suggests that girls exhibit higher levels of general inhibitory control and are lower in impulsivity, at least in the early years of life.¹³ In earlier studies on self-regulation of food intake, results have suggested the opposite: that girls show less evidence of compensation or self-regulation than boys.⁵ How the proposed model of the impacts of inhibitory control/temperament relates to boys' adiposity is, as yet, undetermined. This in no way diminishes the findings reported in this study.

The cohort recruited for this study comprised largely of middle-class, educated, non-Hispanic white parents. Whether the same pattern of results could be expected from a more ethnically diverse group of children and families is unclear and is certainly a question open for testing. How feeding practices from other cultures that are more "child-centered" or indulgent or that have different cultural ideals for children's weight interact with child temperament is unclear, but they may result in the same outcome for children's weight. What is clear, both from clinical practice and research, is that there are many paths to childhood obesity and discovering effective parenting strategies to promote children's self-regulation of energy intake may differ for children with different temperaments.

The implications of the study by Azman and Birch can be considered in both the clinical and public health arenas. For the child with high(er) inhibitory control, reliance on the division of responsibility around food and eating—that is, when parents are encouraged to establish the food environment and children are presumed to have reliable internal signals to appropriately regulate intake—is likely to work very well. For the more impulsive child who struggles with control, a focus on increased structure of the home food and mealtime environment may be especially important. These data also raise a cautionary note about body mass index (BMI) percentile reporting outside the clinical context if given without appropriate interpretive guidance. Informed

of a high BMI percentile in their child, well-intentioned parents may respond with overly restrictive approaches directed to the child's eating, a response that could actually exacerbate rather than improve the weight gain trajectory of a child with low inhibitory control. Surveillance of children's BMI trends in a school setting may usefully inform the school's policies related to the health environment; the benefit of transmitting that information to individual families seems less assured. As aforementioned, the directionality of the interaction between a child's level of inhibitory control and parental restriction cannot be discerned from this study. Research that explores the interplay between child temperament and parenting styles brings straight to the fore the age-old questions of nature versus nurture or, in more contemporary language, of gene-environment interactions. This study reminds us to remember and to try to address both. ■

Susan L. Johnson, PhD
Nancy F. Krebs, MD, MS
Section of Nutrition
Department of Pediatrics
University of Colorado Denver
Denver, Colorado

Reprint requests: Nancy F. Krebs, MD, MS, 12700 East 19th Ave, Box C225, Aurora, CO 80045. E-mail: nancy.krebs@ucdenver.edu.

References

1. Davis C. Self-selection of diet by newly weaned infants. *Am J Dis Child* 1928;36:651-79.
2. Davis C. Results of the self-selection of diets by young children. *Can Med Assoc J* 1939;41:257-61.
3. Fomon SJ, Filmer Jr LJ, Thomas LN, Anderson TA, Nelson SE. Influence of formula concentration on caloric intake and growth of normal infants. *Acta Paediatr Scand* 1975;64:172-81.
4. Birch LL, Fisher JO. Development of eating behaviors among children and adolescents. *Pediatrics* 1998;101(3 Pt 2):539-49.
5. Johnson SL, Birch LL. Parents' and children's adiposity and eating style. *Pediatrics* 1994;94:653-61.
6. Johnson SL, Taylor-Holloway LA. Non-Hispanic white and Hispanic elementary school children's self-regulation of energy intake. *Am J Clin Nutr* 2006;83:1276-82.
7. Bronfenbrenner U. Nature-nurture reconceptualized in developmental perspective: a bioecological model. *Psychol Rev* 1994;101:568-86.
8. Anzman SL, Birch LL. Low inhibitory control and restrictive feeding practices predict weight outcomes. *J Pediatr* 2009;155:651-6.
9. Birch LL, Fisher JO. Mothers' child-feeding practices influence daughters' eating and weight. *Am J Clin Nutr* 2000;71:1054-61.
10. Fisher JO, Birch LL. Restricting access to palatable foods affects children's behavioral response, food selection, and intake. *Am J Clin Nutr* 1999;69:1264-72.
11. Fisher JO, Birch LL. Eating in the absence of hunger and overweight in girls from 5 to 7 y of age. *Am J Clin Nutr* 2002;76:226-31.
12. Rueda M, Rosario Rothbart M. The development of executive attention: contributions to the emergence of self-regulation. *Dev Neuropsychol* 2005;28:573-94.
13. Kochanska G, Murray K, Jacques TY, Koenig AL, Vandegest KA. Inhibitory control in young children and its role in emerging internalization. *Child Dev* 1996;67:490-507.
14. Olson SL, Bates JE, Bayles K. Early antecedents of childhood impulsivity: the role of parent-child interaction, cognitive competence, and temperament. *J Abnormal Child Psychol* 1990;18:317-34.