counterproductive in the majority of individuals (Mann et al. 2007; Pietiläinen et al. 2012; Siahpush et al. 2015). Most individuals who practice restrictive diet regimes regain more weight than they lose, increasing their risk of obesity in the long term. From the food-insecurity perspective, this makes sense. By following a restrictive diet, individuals are intentionally exposing themselves to restricted food availability. Thus, it is very likely that the effect of dieting episodes is to provide the mechanisms governing weight regulation with cues of food insecurity (Nesse 1984; Williams & Nesse 1991). Under the IH, weight gain as soon as food becomes available again is the predicted result.

7.3. Understanding anorexia nervosa

Although obesity is a major public health concern in affluent countries, about 1% of young people in these countries (mostly women) significantly impair their survival chances by maintaining low body weight in anorexia nervosa. Anorexia is defined by a low body mass index, as well as the sufferer imposing a low body mass target on themselves, above which they dread going and feel it would be inappropriate to do so (Bulik et al. 2005). Although a full discussion is beyond the scope of this article, the IH is potentially relevant to anorexia in two ways. First, in terms of aetiology, the hypothesis predicts that anorexia will occur where the person's estimate of their food security is unusually high. That is, if an individual has developed the perception that shortfalls will never occur, he or she should favour an extremely lean body and be motivated to maintain it. We have not been able to find any epidemiological studies of food insecurity in relation to anorexia, but we would predict that anorexia sufferers will be at the high-security end of the spectrum, diametrically opposite the obese. Some support for this prediction comes from the evidence that anorexia risk, in contrast to obesity risk, is highest in families of relatively high socioeconomic position (Goodman et al. 2014). Note that the IH is agnostic about why individuals might have unusually high perceptions of food security; thus, the hypothesis is not incompatible with a neuropsychological literature investigating general decision-making deficits in some anorexia sufferers (Danner et al. 2012). Given that anorexia shows substantial genetic heritability (Bulik et al. 2006), it could be that genetic factors affect the formation of food-insecurity estimates. The hypothesis merely predicts that low perceived food insecurity might be an important psychological mediator between anorexia risk factors and anorexia symptoms.

A second potential area of relevance is in anorexia treatment. If perceived food insecurity is causally important in promoting weight gain, as the IH asserts, then inducing some food insecurity, for example, by randomly varying feeding routines, might be useful in combating low body weight. This is a contentious proposal, because anorexia patients are at considerable risk of starving themselves to death, and the understandable caregiver response is to try to provide all kinds of foods at all times in the hope that the person will eat them. However, it might be that making at least some kinds of food unavailable at least some of the time is a better strategy for motivating long-term gains in body weight. Given that anorexia tends to have a chronic and disabling course, with a tendency of patients to defend and return to their weight-management practices (Abbate-Daga et al. 2013), the food-insecurity perspective deserves further, if cautious, exploration.

8. Implications of the IH

We conclude by considering the implications of the IH. Despite abundant research on human obesity, there is rather little evidence for effective, scalable interventions that prevent obesity or lead to weight loss that is maintained in the long term (Glenny et al. 1997). The IH does not in itself change this situation, of course. However, it ought to change our framing of the problem. If (adult female) obesity results from the psychological mechanisms posited by the IH fulfilling their evolved function, then there is no reason to expect simple information giving, food labelling, or explicit exhortation to be able to override them. Certain interventions, such as restrictive dieting, in fact look potentially counterproductive. Indeed, the IH suggests that the interventions most likely to work are the very antithesis of restrictive dieting: In the words of Dietz's original paper, the IH suggests that "the prevention of obesity in impoverished populations may require increased food supplementation rather than food restriction to achieve a more uniform pattern of food consumption" (Dietz 1995, p. 767).

Perhaps the major virtue of the IH is summed up in the following oxymoron. The IH is a hypothesis about individual decision-making mechanisms, but it ends up pushing the focus in terms of explaining obesity away from individual decisions and onto society. Surely, the key question is why, in countries of historically unprecedented affluence, there are millions of people who feel they might not have enough to eat. These people need not less food, but more: Better food access and less uncertainty in their lives. If the IH has any merit, then tackling these societal problems should lead to a melioration of the obesity epidemic.

Supplementary Material

To view supplementary material for this article, please visit https://doi.org/10.1017/S0140525X16000947.

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Open Peer Commentary

Eating and body image: Does food insecurity make us feel thinner?

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Abstract: Body image distortions are common in healthy individuals and a central aspect of serious clinical conditions, such as eating disorders. This commentary explores the potential implications of body image and its

distortions for the insurance hypothesis. In particular, we speculate that body image may be an intervening variable mediating the relationship between perceived food scarcity and eating behavior.

In the target article, Nettle et al. integrate different domains of research from epidemiology, animal studies, and human psychology to explain eating behavior in humans. We are especially intrigued by the speculations the authors make about the implications of the insurance hypothesis for understanding the etiology of eating disorders, particularly anorexia nervosa. Here, we wish to highlight research from the field of body representations, which we believe has interesting connections with, and implications for, the insurance hypothesis.

Given that it forms the core of the insurance hypothesis, Nettle et al. appropriately focus on the role of food insecurity in shaping eating behavior. However, their model includes one other important variable, which receives less attention, namely, the current fat reserves of the organism. Consider two scenarios. In the first scenario, the probability of finding food equals 0.5, and the organism has substantial current fat reserves (3 units). In the second scenario, the probability of finding food also equals 0.5, but the current reserves are now lower (1 unit). In the model proposed by Nettle et al., these two scenarios would result in a very different eating behavior, even when food insecurity (i.e., the probability of finding food) stayed the same. Thus, to decide whether fat storage is beneficial, an organism must be able not only to predict the food supply, but also to accurately evaluate its current reserves. In other words, to act optimally, the organism needs to know its own body size. It needs a body image.

The distinction between actual levels of fat reserves and the mental representation thereof would be largely academic if body representations were largely veridical. In fact, however, there is substantial evidence for large distortions of body representation in many neurological and psychiatric conditions, most pertinently in the present context in eating disorders such as anorexia (e.g., Bruch 1978; Cash & Deagle 1997), as well as in obesity (e.g., Powell et al. 2010). In the case of anorexia, moreover, body image distortions are a strong predictor of poor prognosis for recovery (Casper et al. 1979) and of relapse following recovery (Fairburn et al. 1993; Keel et al. 2005).

Recent research has suggested that even healthy people maintain highly distorted body representations (for review, see Longo 2017). For example, perceptual abilities such as tactile distance perception (Longo & Haggard 2011; Taylor-Clarke et al. 2004) and position sense (Longo & Haggard 2010; Longo et al. 2012) appear to rely on highly distorted representations of body size and shape. Similarly, distortions have also been found in explicit judgments of body part length (Longo & Haggard 2012) and even in judgments about the spatial configuration of body landmarks (Fuentes et al. 2013; Longo 2015). Further, a clear pattern of body image distortions has been shown in normal-weight adolescent girls, with a tendency to overestimate body width and underestimate body length (Halmi et al. 1977).

Thus, distorted body representations appear to be a normal part of human cognition, as well as being central to serious clinical conditions involving disordered eating. We believe these findings have interesting and important implications for the model proposed by Nettle et al. We speculate that a distorted body image may be an intervening variable mediating the relationship between perceived food scarcity and eating behavior. More specifically, distortions of body image may function to modulate eating behavior: Perceiving oneself as thin may motivate increased consumption, whereas perceiving oneself as fat may discourage consumption.

If both food insecurity and perceived fat reserves (body image) are important contributors to eating behavior, what is the relationship between these two factors? One possibility is that body image and food insecurity are independent of each other, have different causes, and affect eating behavior separately. In this case, body image may modulate the effect of food insecurity influence on fat storage. For example, people who perceive themselves as fat will not eat (or will eat less) even when the food supply is insecure. In the target article, Nettle et al. predict that anorexia occurs when a person's estimate of food security is unusually high, and they propose that introducing food insecurity may promote weight gain in anorexia patients. However, if body image is independent of perceived food insecurity, this proposed treatment may prove inadequate.

Alternatively, body image may be shaped by environmental cues and serve as an intervening variable mediating the relationship between perceived food scarcity and eating behavior. In this case, perceiving the supply of food as secure should lead people to perceive themselves as fat, whereas perceiving the supply of food as scarce should lead people to perceive themselves as thin. In this case, the treatment proposed by Nettle et al. would affect not only eating behavior but also body image. To our knowledge, no research has specifically investigated the relationship between body image and perceived food insecurity. This opens a new possible line of future research and provides a potential way of empirically testing the implications of the insurance hypothesis.

Mapping multiple drivers of human obesity

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Abstract: The insurance hypothesis is a reasonable explanation for the current obesity epidemic. One alternative explanation is that the marketing of high-sugar foods, especially sugar-sweetened beverages, drives the rise in obesity. Another prominent hypothesis is that obesity spreads through social influence. We offer a framework for estimating the extent to which these different models explain the rise in obesity.

The United States is well known as a generally high-income country, but what is less well known is the fact that over a third of Americans are classified as being obese (Ogden et al. 2014) – two-thirds if "overweight" is figured in – with more than 100,000 deaths per year attributed to obesity. Despite the intentions of many to lose weight, the problem has been exceptionally resilient at multiple scales, from individuals who try to change personal habits (DellaVigna & Malmendier 2006) to health or government organizations that address the problem at a population scale (Schroeder 2007). Given their different types and scales of analysis, different social sciences (economics, psychology, anthropology, sociology) tend to favor different explanations for the evolution of dietary habits.

In the target article, Nettle et al. propose a version of the standard evolutionary-psychology hypothesis that modern obesity is a result of high availability of food to Paleolithic hunter-gatherers, who stored calories as fat whenever famine loomed. Nettle et al.'s insurance hypothesis is quite reasonable (Shrewsbury & Wardle 2012) – indeed, storage against food uncertainty is the commonly understood purpose of fat – and falls comfortably alongside numerous other plausible hypotheses for obesity. In community medicine, for example, hypotheses about behavioral change center on information and supply (Guiteras et al. 2015). Regarding sugar, the supply side includes factors such as widespread marketing of inexpensive high-sugar foods, especially sugar-sweetened beverages, that may drive the rise in obesity (Johnson et al. 2007), diabetes (Basu et al. 2013), and heart disease (Kearns et al. 2016). Urban geography, furthermore, can bound food supply, creating high-sugar "oases" within food deserts, causing obesity and diabetes to disproportionately affect the poor.

On the information side is a deluge of food advertising, diet fads, conflicting medical advice, and social-media messaging