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Caloric restriction in the presence of attractive food cues: External cues, eating, and weight

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ABSTRACT

A growing body of research on caloric restriction (CR) in many species of laboratory animals suggests that underfeeding leads to better health and longevity in the calorically-restricted animal (e.g., see [[34]. J.P. Pinel, S. Assanand and D.R. Lehman, (2000). Hunger, eating and ill health. Am Psychol, 55, 1105–1116.], for a review). Although some objections have been raised by scientists concerned about negative psychological and behavioral sequelae of such restriction, advocates of CR continue to urge people to adopt sharply reduced eating regimes in order to increase their longevity. Yet very few people are even attempting to reap the benefits of such restriction. The present paper explores one factor that may deter many humans from drastically reducing their food consumption—the presence of abundant, attractive food cues in the environment. Research on the influence of food cues on food-related behaviors is reviewed to demonstrate that the presence of food cues makes restriction of intake more difficult.

Experiments studying the effects of caloric restriction (CR) have demonstrated a variety of physiological benefits for animals whose caloric intake is severely restricted (i.e., consuming only 60–70% of ad lib [AL] intake). Among other things, these benefits include increases in longevity and improved general health, delayed onset of disorders such as cancer, heart disease, and diabetes [34], and slowed age-related declines in cognitive functioning [33]. The apparent success of caloric restriction in animals has encouraged speculation that humans could live longer, healthier lives if they, too, severely restricted their food intake (e.g., [7,49]). The present paper will review the evidence concerning the efficacy of CR for extending life in humans, and will attempt to show that although CR may be easy to achieve in isolated animals kept in cages and fed measured, restricted diets, it is not clear that this can be extended to humans because of crucial differences between the situations/environments of caged animals and free-living humans. Specifically, we will argue that the ubiquity of food cues in human environments makes it particularly difficult for humans to practice CR successfully. We will present the literature on food cues, which indicates that people are highly responsive to the presence of such cues, eating more in their presence than in their absence.

1. Paucity of voluntary human CR practitioners

Despite the fact that knowledge about the "CR for longevity" (CRL) movement is entering the mainstream, it does not appear as though large numbers of individuals are practicing long-term CR. No estimates of the prevalence of this practice have been published; however, some researchers have alluded to the difficulties of following CR, concluding simply that "so few people have attempted caloric restriction…that for most people, quality of life seems to be preferred to quantity of life" [31, pg. 9]. Limited research has been conducted comparing physiological outcomes for individuals practicing CR with healthy controls. In a study on the effects of CR on atherosclerosis, a total of 18 practitioners of CR were recruited from the Caloric Restriction Society [13]. The results indicated that CR practitioners had a "remarkably low" blood pressure and ratio of total serum cholesterol to high-density lipid cholesterol [13, p. 6660]. Fontana and colleagues concluded that CR has a protective effect against atherosclerosis. Similarly, Meyer et al. [27] report that CR has beneficial effects on cardiac function, with CR practitioners exhibiting better diastolic function than did healthy controls. Although the limited research does suggest that CR can have physiological benefits, this research is short-term, in addition to being constrained by self-selection biases occurring with CR participants (i.e., people who choose to undertake CR may be healthier to begin with). Furthermore, there is not yet any evidence that CR can extend lifespan in humans. It should be noted that the main proponent and practitioner of CR, Roy Walford, who claimed that CR was capable of extending the lifespan of humans to 120 or even 160 years, died in 2004 at the not terribly advanced age of 79.

2. Questions about the efficacy of CR for humans

Despite the well-established benefits of CR in the animal laboratory, some researchers question whether such benefits would

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accrue to humans, especially those living outside of a laboratory environment (e.g., [22,45]). Vitousek et al. [46] reviewed the literature and noted that in animals subjected to caloric restriction, some physical functions are impaired, including growth, reproductive development, and resistance to some stressors. Although these problems seem minor in comparison to the potential benefits of CR, the authors point out that in humans, there are other deleterious effects of CR that can be expected. Vitousek et al. list a number of negative physical side effects of CR such as cold intolerance, higher levels of stress hormones, lower levels of sex hormones, and postural hypotension, as well as psychological sequelae including hunger, obsessive thoughts about food and eating, irritability, social withdrawal, and loss of interest in sex. Many of these side effects were documented in the World War II Minnesota human starvation experiment [21], which examined CR in a group of conscientious objectors who agreed to lose 25% of their body weight. After refeeding, and once food was again freely available, these participants also exhibited the behavioral symptom of binge eating. As Vitousek et al. [46] point out, people experiencing all of these symptoms would generally be seen as unwell, but the outcomes of importance in CR studies are simply longevity and freedom from disease. Because CR animals excel on these measures, they are seen by proponents as being in superior condition, and the negative effects listed above are not discussed.

Vitousek et al. [46] also discuss the fact that the deck is stacked in favor of laboratory-reared CR animals compared to humans attempting a similar restrictive lifestyle. As they put it,

> Under the pressure of hunger, the underfed animal—unlike the free-ranging human—cannot make poor food choices or break down and overeat. In addition, the research context eliminates not only the extraordinary stresses that generally accompany privation in the natural environment but the ordinary perturbations of daily life at liberty. Laboratory animals are typically isolated in individual cages, protected or exempted from germs, temperature variation, work, fatigue, social interaction, parenting and competition. In effect, their only job is to cope with CR, so that all of the meagre energy supplied by their otherwise optimal diets can be put straight to that purpose (p. 285).

Vitousek et al. object strenuously to the tendency of CR researchers to ignore the negative effects of CR and focus exclusively on the benefits, especially when using these benefits to recommend CR for humans. They state, “Because CRL specialists are generally animal physiologists by training and inclination, it is unsurprising that they are more struck by the wonders CR works in the systems they favor than by the damage it does elsewhere” (p. 286). Vitousek [47] further decries the failure of CR advocates to even examine behavioral and psychological problems that occur as a result of CR.

In addition, and more disturbingly, there are individual differences in how well restriction is tolerated (especially in primates), with some animals becoming seriously ill on the same restriction that is beneficial for others. Vitousek et al. [46,47] compare organisms undergoing CR to patients suffering from anorexia nervosa (AN); like primates undergoing CR, some AN patients tolerate the caloric deficit better than do others. The ones who do not tolerate it well may subsequently become bulimic, reminiscent of the starved Minnesota conscientious objectors (e.g., [4]) or starved prisoners of war in World War II [37]. Some humans who have attempted CR on their own have developed serious cardiac irregularities, as sometimes happens in AN. Applying CR as developed in the specific, rarified conditions of the laboratory to free-living humans without careful consideration of these different contexts can lead to serious and unexpected negative effects in humans. This concern may be moot, however, given that the evidence suggests (e.g., [46]) that very few humans will be able to maintain CR for long enough to do much damage to themselves, as the psychological costs of such restriction are too high for most people. In fact, even the most ardent advocate of CR, Roy Walford, was unable to maintain the caloric restriction (inadvertently) begun by him and 7 of his colleagues in the Biosphere II project (when their rations failed to meet normal levels), and all 8 quickly regained the weight they lost while in the Biosphere as soon as the project terminated (after 2 years of CR, and despite intentions to try to continue to eat less in order to maintain the weight loss and other improved physiological indices).

3. The presence of food cues during caloric restriction

One reason that CR may be so difficult to maintain for humans, especially as compared to laboratory animals, is the typical environment in which humans live. Most of us are frequently confronted by attractive food cues, on the street, on television, in the subways, pretty much anywhere we go. Humans in developed societies are thus hard-pressed to escape these ubiquitous food cues. CR animals in the laboratory, by contrast, are actually protected from food cues in the sterile, foodless cages in which they are housed, next to other similarly food-deprived animals. As the CR animals are almost invariably housed together, when food does appear, it is probably consumed fairly quickly by all the deprived animals, leaving no residual food cues even from the relatively unattractive laboratory chow. The research literature clearly shows that exposure to attractive food cues increases food consumption in animals [54] and humans (e.g., [10,11]), even when they are already satiated [6,43]. In fact, the presence of food cues (a meal presented to be eaten) can be more potent than signals of satiety [43]. When two severely amnesic patients who were unable to remember events for more than a minute were fed their normal lunch, and then given another lunch 10 to 30 min later after all signs of the first lunch had been removed, they happily ate the second meal, and 10 to 30 min later, began eating a third meal until it was taken away. Without a memory of having eaten, people respond to the presence of food cues by eating, even if they have just eaten a full meal or even two full meals. Thus, free-living humans attempting to restrict their food intake in the face of ever-present food cues face a challenge not faced by laboratory animals undergoing a CR regimen.

There is some limited evidence that the presence of food cues adds to the stress and difficulty of CR in animals. A recent laboratory study of rats on a standard CR regimen [5] deliberately manipulated the presence of food cues to test the effects of the presence or absence of food cues on physiological and behavioral responses to CR. CR and ad lib-fed rats were exposed to attractive, inaccessible food cues (Froot Loops cereal suspended in wire mesh baskets above their cages), during and after 14 weeks of CR, such that both visual and olfactory cues were present. All rats had been given Froot Loops to taste during the baseline period of the study, so the food was familiar and liked. Rats exposed to the food cues had higher levels of corticosterone, higher food intake over 24 h during refeeding, and weighed more during ad lib feeding than did non-cued rats. The CR cued rats weighed less than non-cued CR rats during deprivation, possibly because of the stress of the presence of food cues added to the stress of CR, but then gained weight more quickly when food was freely available so that they soon caught up to (and even slightly outweighed) their non-cued peers. Food cues are thus a stressor independent of caloric restriction, but their effect on CR rats is to make them eat their ration faster and weigh less during the deprivation period but then regain more rapidly. These data suggest that those who try CR and then give it up are likely to overeat and gain weight if they are exposed to food cues, which, in our society, is almost inevitable.

The effect of food deprivation on responses to food cues was investigated in humans. Drobes et al. [9] deprived college students of food for 0, 6, or 24 h and then showed them emotion-inducing pictures and food-related pictures in two studies. There was no effect for the emotional pictures, but both self-reports and physiological reactions to food pictures were affected by food deprivation in both studies. The second study included individuals prone to restricting their eating (in an anorexia nervosa-type fashion) or binge eating (like bulimia nervosa patients). Food-deprived and binge-eating