



# Food addiction and obesity: do macronutrients matter?

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## A commentary on

### Obesity and the brain: how convincing is the addiction model?

by Ziauddeen, H., Farooqi, I. S., and Fletcher, P. C. (2012). *Nat. Rev. Neurosci.* 13, 279–286.

An article published in April 2012 by the Nature Reviews Neuroscience (Ziauddeen et al., 2012) calls for cautiousness in applying the addiction model to obesity. This scrupulous review described the highly consequential results from B. Hoebel's lab concerning binge-like eating behaviors of rats (Avena et al., 2008, 2009; Bocarsly et al., 2011). Referring to these results, Ziauddeen and colleagues concluded that the binge behaviors relate to the palatability of the foods independently of their macronutrient composition. Earlier, also basing on the works of Hoebel and colleagues, I have been able to draw quite a different conclusion – fat *per se*, although highly palatable, is not as addictive as carbohydrates and is not obesogenic (Zilberter, 2011). In yet another paper (Peters, 2012), A. Peters interpreted results of Avena et al. (2008) as a proof that “sugar addiction” fails causing obesity. Here, I take a closer look at the Hoebel's model of addiction (Avena et al., 2008, 2009; Berner et al., 2009; Avena, 2010; Avena and Gold, 2011; Bocarsly et al., 2011) while keeping in mind the role of macronutrients.

## FOOD ADDICTION

An opinion exists that rather than an observational link, a causality exists between food addiction and obesity (Gold, 2004; Liu et al., 2006; Corsica and Pelchat, 2010; Johnson and Kenny, 2010). Another opinion is that such a causality does not exist (Peters, 2012) or even that a mere link between them should be considered with caution (Ziauddeen et al., 2012). The caution notwithstanding, it has been shown (and is discussed by Ziauddeen et al., 2012) that drug addiction and food addiction have similar effects, e.g., on the dopaminergic system (Volkow et al., 2008; Gearhardt

et al., 2009; Stice and Dagher, 2010) where they “overlap” (Avena et al., 2012). In human subjects, food addiction has been associated with similar patterns of neural activation as substance addiction in anterior cingulate cortex, medial orbitofrontal cortex, and amygdala (Gearhardt et al., 2011b). “Common hedonic mechanisms may therefore underlie obesity and drug addiction,” concluded Johnson and Kenny (2010). Addiction liability is being discussed inline with development of obesity pharmacotherapy (Greene et al., 2011).

## CARBOHYDRATE ADDICTION

Carbohydrate (CHO) bias in brain's control of energy homeostasis (Zilberter, 2011) reveals itself in several well known ways including the phenomena termed “positive reward,” “hedonism,” “wanting,” “liking,” etc. (Berridge et al., 2010; Gold, 2011). The “sweet-addiction” comparable by magnitude with alcohol addiction (Kampov-Polevoy et al., 2003) and drug addictions (Stoops et al., 2010) is well documented. Gold (2011) argued that deficit in “reward” is coupled with obesity and this coupling is common for sugar, cocaine, and heroin addictions.

Gearhardt et al. (2011b), referring to the aforementioned work of Johnson and Kenny, argued that only “hyper-palatable” foods rich in fat and sugar can cause addiction. Indeed, the combination of fat and sugar resulted in a “reward dysfunction associated with drug addiction and compulsive eating, including continued consumption despite receipt of shocks” (Gearhardt et al., 2011a). A link between food addiction and obesity has also been explicitly postulated (Avena et al., 2009; Corsica and Pelchat, 2010; Gold, 2011).

## FAT ADDICTION?

Studies from B. Hoebel lab suggest that access to CHO produces different addiction-like behaviors compared with access to fat (Avena and Gold, 2011; Bocarsly et al., 2011; Avena et al., 2012). Nutrient specificity in control of eating behavior was also shown

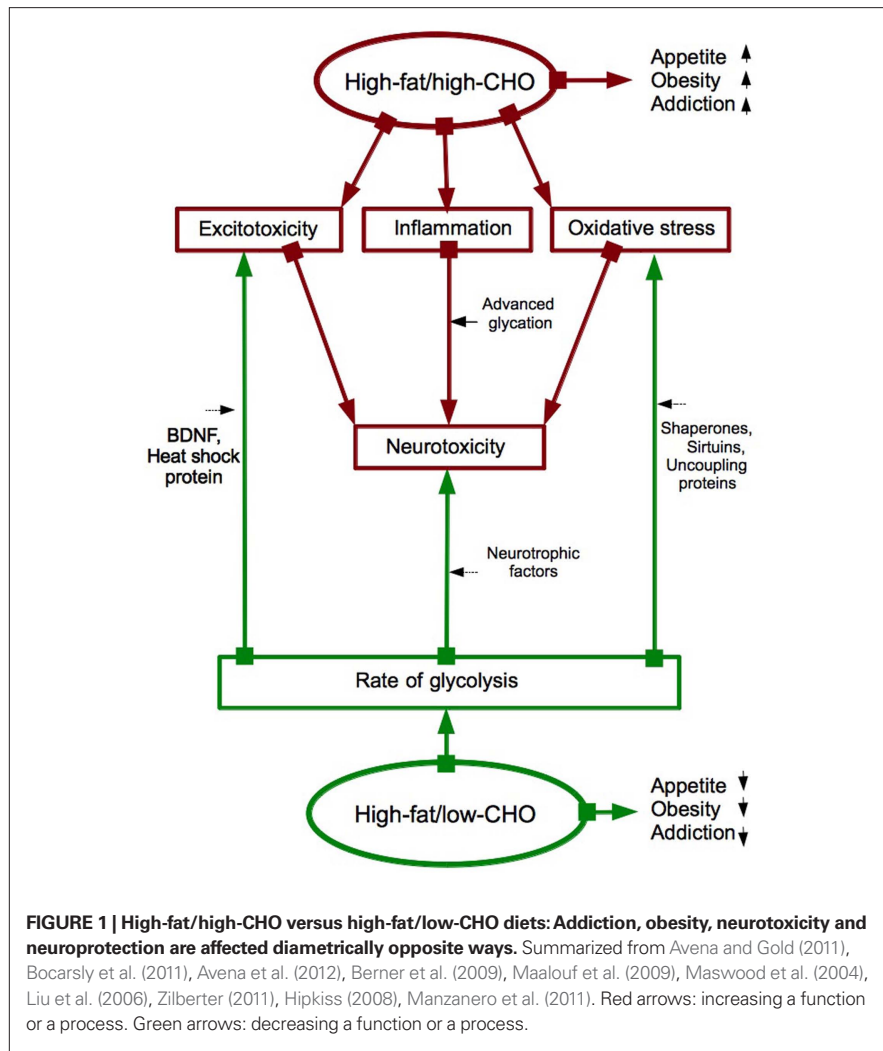
in this lab (Berner et al., 2009). During the “sweet-chow” feeding protocol, rats compensated for the increased sucrose or glucose calories by decreasing chow intake. The authors (Avena et al., 2008) suggested that the increase in sugar intake, while not resulting in obesity, lead to an upregulation of affinity for opioid receptors, which in turn leads to the vicious circle of sugar abuse and might contribute to obesity.

In a later study (Avena et al., 2009), when rats were given intermittent daily access to “sweet-fat” food, they voluntarily restricted their intake of standard chow, similar to what has been reported with “sweet-chow” food (Avena et al., 2008). However, this time rats did become overweight unlike in the “sweet-chow” experiment. Authors concluded: “fat may be the macronutrient that results in excess body weight, and sweet taste in the absence of fat may be largely responsible for producing addictive-like behaviors.” Yet pure fat, unlike the CHO-fat combination, lacks obesogenicity (Dimitriou et al., 2000). Fat combined with limited CHO content failed to cause overeating and weight gain, while excess CHO in high-fat diets caused obesity and metabolic impairment (Lomba et al., 2009).

Metabolic studies show that CHO restriction in high-fat diets exerts neuroprotective effects (Figure 1) via induction of heat-shock proteins (Maalouf et al., 2009), growth factors (Maswood et al., 2004), and mitochondrial uncoupling proteins (Liu et al., 2006). Naturally, CHO excess has neurodeteriorating effects as discussed in Zilberter (2011), Hipkiss (2008), or Manzanero et al. (2011).

## CONCLUSION

Taking into account the well-defined metabolism-related features of a diet can help avoiding ambiguity in definition of diet types and aid in data interpretations. From this standpoint, macronutrients play a crucial role in determining diet's behavioral and metabolic consequences.



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