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Review

The conditioned satiating effect of orosensory stimuli

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ABSTRACT

Davis, J.D. and G.P. Smith. The Conditioned Satiating Effects of Orosensory Stimuli. PHYSIOL BEHAV 000-000, 2009. Prior to the introduction of sham feeding as a method for studying the controls of meal size, the dominant view was that gustatory stimulation activated the ingestion of palatable diets and postingestional stimulation inhibited it. Early sham feeding studies with rats challenged this view because they showed that, contrary to expectation, rats did not eat continuously the first time they were given a sham feeding test. They ate a larger meal than when tested under normal conditions but stopped eating and showed all the signs of satiety soon after. Only after two or more sham feeding tests did they eat continuously. Subsequent research, reviewed here, established that experience ingesting a diet under real feeding conditions leads to the development of a classically conditioned form of satiation based on an association between gustatory stimulation and some consequence of gastrointestinal stimulation by the ingested food. This conditioned orosensory satiating effect extinguishes when sham feeding occurs repeatedly without intervening real feeding tests. Thus gustatory stimulation both stimulates and inhibits meal size. An experimental implication of this finding is that intake during sham feeding must be shown to be maximal before sham feeding can be used to measure only the orosensory stimulation of the diet. Another implication is that the analysis of a change in meal size produced by some treatment should now include measurement of the potency of the conditioned orosensory satiating effect as well as the potencies of orosensory stimulation and postingestive negative feedback.

Contents

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1. Introduction

Meal size is controlled by the peripheral afferent information produced by orosensory stimulation and postingestive negative and positive feedback of ingested food and its digestive products integrated by central neural networks with a variety of other information, such as the effects of deprivation, diurnal phase, and learning from prior eating experience [1–5]. Orosensory stimulation by unconditioned palatable foods and by foods or other stimuli that have acquired a conditioned acceptance by association with a postingestive nutrient UCS [5] stimulate eating. As ingestion continues, the various inhibitory effects of the ingested food and digestive products accumulating in the stomach and small intestine begin to slow the rate of eating and finally stop it. Since orosensory and postingestional stimuli act concurrently shortly after a meal begins, the relative contribution of each to the size of the meal cannot be assessed during real feeding. This can only be examined by gaining experimental control of orosensory and postingestive stimulation independently and measuring their specific effects on the size of a meal.

The early sham feeding studies in the rat which began to appear in the 1960s and 1970s, showed that meal size of a variety of test diets was larger during sham feeding than real feeding. Further analysis of this robust observation led to three conclusions. First, intake during sham feeding was a concentration-dependent function of the effect of orosensory stimuli on intake [6–12]. Second, the difference in intake between sham and real feeding was a measure of the negative-feedback, inhibitory effect of the postingestional stimulation of the stomach and small intestine by ingested food and its digestive products [11–15]. Third, the inhibitory potency of specific postingestional stimuli in the stomach or the small intestine could be quantified by measuring the inhibitory effect on sham-fed intake by manipulating the volume or nutrients in the stomach or small intestine during sham feeding [15–17]. Thus, for the first time, the contributions of orosensory and postingestional stimulation to the control of meal size could be measured independently, specifically, and quantitatively. These data and measurements have been an important contribution to the ongoing discussion of the controls of meal size in the rat and, by inference to other mammals, for the past 30 years.

One result [13] of the early sham feeding experiments was not consistent, however, with the view that intake during sham feeding was determined solely by the stimulating effects of orosensory stimuli. This result was that intake increased as the animal gained experience sham feeding the test diet which suggested that orosensory stimuli also produced inhibitory effects on intake that decreased over repetitive sham feeding tests. This hypothesis has now been tested in a significant number of experiments and the results have revealed the existence of a conditioned satiating effect of orosensory stimuli developed from an association between orosensory and postingestional stimulation. Given its importance for the interpretation of sham feeding experiments and for their relevance to the controls of meal size, we present a critical review of the literature here.

Three different sham feeding techniques have been used in these studies, esophageal fistula, gastric evacuation and gastric fistula each of which is described with their advantages and limitations in the Appendix. Since the gastric fistula method [18] has become the preferred method, it can be assumed that the study under review used that method unless otherwise noted.

2. Increase in intake with sham feeding experience

The first study [10] to show that the amount of a test solution ingested under sham feeding conditions (esophageal fistula method) increases from one test to the next reported that intake during one-hour tests of water and a series of glucose concentrations increased significantly (about 122 ml in the case of 5% glucose) from the first sham feeding test to the second given 8 weeks later. Since in that study the author's attention was focused on the relative contribution of oral and postingestional simulation to the control of intake, he did not pursue this finding, commenting only, “It seems either that there was a lasting change in S's physiological condition, or that some learning occurred. The data do not permit a decision between these alternatives” (10, p 648–649).

The next study to report an increase in intake with sham feeding experience used gastric aspiration to produce sham feeding [13].

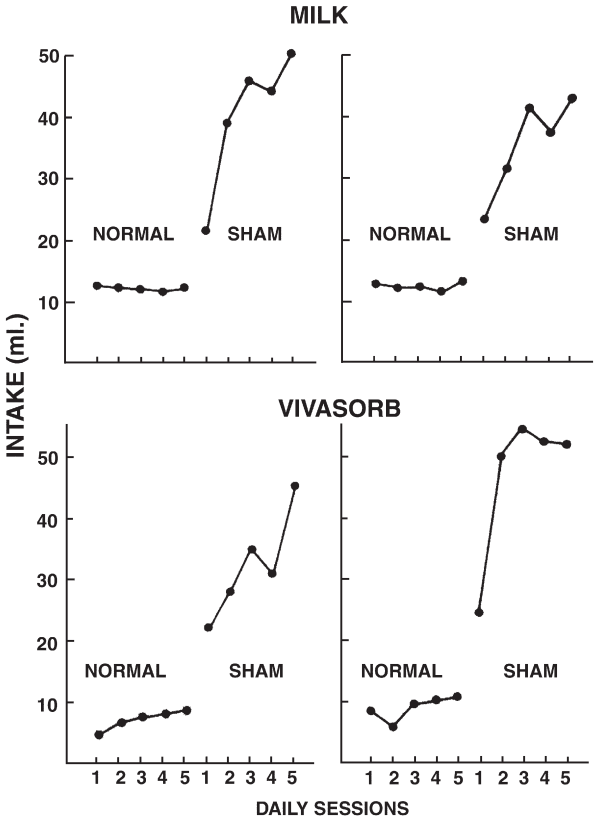

Fig. 1. Mean intake (ml) during five real and the following five sham feeding ones. The two figures on the left are for the first tests with milk and Vivasorb. The two on the right are for the second series where the groups were tested with the alternate solution. From [13] with permission.