

# Consumption of Sweeteners: An Evolutionary Analysis of Historical Development

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## 1. Introduction

*“The economic growth over the past two hundred years is unprecedented. So, too, is the growth of demand, i.e. real per capita consumption. Economic theorizing has been eager to discuss why and how a growing output can be maintained. It has shown little interest, however, in the role of the exceptional growth of demand. Only one necessary, yet certainly not sufficient condition for a sustained growth of demand... is usually acknowledged: per capita real income must be rising.”* (Witt 2001: 31)

In this paper, the demandside conditions which are usually neglected in growth theories are highlighted. Starting from the consideration that the occurrence of innovations is not restricted to production processes (Saviotti 1996) the question raises how consumers cope with novelty. To answer this question in the framework of standard economic theory is for epistemological reasons impossible. It is true that Lancaster’s (1966a, 1966b, 1971) “new demand theory” avoids the epistemological problem by means of a modification, the indirect utility approach. New goods are conceived to be just more efficient technologies which produce characteristics that are conceived to be the actual objects of consumer preferences (for a discussion of this approach see Ruprecht 2001a). Since the content of novelties, by definition, has not revealed yet, however, maximizing efficiency makes no sense.

Unless no vicarious entrepreneur is presumed who knows exactly what consumers want, it has to be analysed explicitly how consumers wants are shaped and how consumers establish cause-effect relations, given that objectively true knowledge of cause-effect relationships is impossible.<sup>1</sup> The present paper approaches these questions theoretically as well as empirically. A positive approach of how humans cope with the epistemological problem is presented in section 2. In order to illustrate the usefulness of this approach, in section 3 a case study on the historical development of the markets for sweeteners is presented.

## 2. A Positive Approach to the Consumer’s Epistemological Problem

Hayek (1979) proposes a strategy on how to investigate quality that has some relevance in the present context: *“So long as it was naively assumed that all the sense qualities (or their relations) which different men had in common were properties of the external world, it could be argued that our knowledge of other minds is no more than our common knowledge of the external world. But once we have learned that our senses make things appear to us alike or different which prove to be alike or different in none of their relations between themselves,*

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<sup>1</sup> This issue has been neglected also in the literature on technological change, as e.g. in the technology push demand pull debate (see Mowery/Rosenberg 1979 for a survey).

*but only in the way in which they affect our senses, this fact that men classify external stimuli in a particular way becomes a significant fact of experience. While qualities disappear from our scientific picture of the external world they must remain part of our scientific picture of the human mind. In fact, the elimination of qualities from our picture of the external world does not mean that these qualities do not exist, but that when we study qualities we study not the physical world but the mind of man.*“ (Hayek 1979: 48) Following Hayek’s advice, one can take advantage of an exchange between economics and the discipline that has specialized in dealing with processes occurring in the human mind, i.e. psychology. What have psychological learning theories to contribute to the question how consumers solve the epistemological problem?

In the context of an evolutionary analysis of economic change, it may not surprise that also psychology is approached from an evolutionary perspective. Also learning processes have adaptative functions, i.e. finding rapid solutions to problems encountered in the environment. Evolutionary psychology makes learning compatible with a consilient approach (see Wilson 1998). *“What may be ignored in the argument that reasoning is unique to humans and therefore not open to a comparative analysis is that humans may not have a single unitary reasoning system. They may have several cognitive systems that have evolved to process different forms of information or perhaps even the same information in different ways. According to evolutionary theory these systems are seen as adaptations to specific selective pressures that they face. Speech and logical thinking may be specific adaptations or may reflect the output of several more general adaptations. They involve complex information processing including metacognition, which may include normative components.”* (Baker et al. 1996: 5) They continue: *“But there are other systems that process causal and other covariation information. We must decide when to be nervous or anxious. We must make decisions about when to love, like, or hate a person. If we become ill following a meal we must “decide” which food caused that illness. To make any of these decisions we must somehow process our social or our dietary experience and come up with an answer. Certainly, the process by which this latter decision is made might have more in common with classical conditioning than with philosophical reasoning. It seems odd to us that anyone would argue that the mind that created Hamlet was the same mind that developed an aversion to tainted food.”*

In the subsequent section, I take a closer look at two learning theories, i.e. reinforcement learning and consistency theories. Considering the variety of learning mechanisms that may have evolved during human phylogeny I do not claim completeness.

### **2.1.1 Reinforcement Learning**

*“If a preference revelation experiment was run with mammals, some basic items could therefor be expected to be found as objects of the animals’ preferences - those which have been identified in laboratory experiments with Mammals....as primary reinforcers: air, water, sleep, warmth, nutrition, sexual activity, maternal care, love and affection, physical activity, novelty”* (Witt 1999). Similar wants can be assumed in the genetic endowment of humans that has been shaped during phylogenesis (see Ruprecht 2001a). Some of them are satiable, others not.

Theories of operant and classical conditioning claim, now, that an explanation of the ontogenesis of wants can be built on an explanation of their phylogenesis. The learning process starts from innate reinforcers, e.g. food items, aqueous solutions and the other items

listed above. In a classical conditioning process these reinforcers act as primary reinforcers when they are regularly paired with other items. These items or conditioned stimuli (CS), then, obtain reinforcing potential in their own right. In further processes of operant<sup>2</sup> and classical conditioning they operate as rewarding experiences. During the individual learning history, a spectrum of wants or a “preference order” evolves (Witt 1987: 112-123).

Reinforcement learning may even have an intergenerational aspect. In many consumption relevant fields children do not have the capability and possibility to know what is good. Hence, parents vicariously expose their children to goods they like themselves. By reinforcement processes, wants that are acquired by one generation can be transferred to the next generation. *Ceteris paribus*, this kind of ‘exposure learning’ implies a genealogical process which can be compared with the corresponding processes in biology.

The economist Georgescu-Roegen (1954) has proposed a “theory of wants” which has a remarkable similarity to reinforcement learning. Conditioning theories could, indeed, be interpreted as a behavioristic interpretation of Georgescu-Roegen’s principles of the “irreducibility of wants” (i.e.: the variety of wants cannot be reduced to an aggregate of “pleasure”) and the „growth of wants“ (i.e., there is always a next want). When I compare the “theory of wants” with reinforcement learning theories I do not argue, of course, that Georgescu-Roegen has conceived his theory as a behavioral theory. In contrast to the “theory of wants” the reinforcement theory is a behavioral theory and is able to list conditions under which learning takes place:

- regularity in the effect following the cause;
- temporal contiguity of cause and effect, i.e. the two stimuli.
- local contiguity of cause and effect. (Baker et al. 1996).

Interpreting reinforcement learning as cause-effect learning is certainly wrong. In reinforcement learning there is no knowledge involved about the world that is independent of the particular behavior. It can be argued, however, that in some respect a cause-effect relationship is established. Baker et al. (1996: 1) characterize the result of reinforcement processes as “...*being able to react appropriately to causes...*” as opposed to “...*being able to understand them.*”<sup>3</sup>

Establishing conditions for reinforcement learning to take place, simultaneously imposes restrictions on its explanatory range. When these conditions are not fulfilled reinforcement learning simply will not occur. Witt (1987: 121) has argued that a theory of human behavior that is restricted to associative learning may be incomplete. Such an approach would entirely ignore the forms of intentional behavior that are typical for economic processes. In fact, there are strong indicators for cause-effect learning even in the absence of, let us say, the temporal contiguity of the unconditioned reinforcer and the neutral stimulus. A typical case for a non-immediate cause-effect sequence are goods that are inputs in a production process.

Sofar, psychology has been applied to an economic problem. In order to see how psychology can, in turn, profit from economics, one should recognize that under the experimental conditions in psychological laboratories the availability of reinforcers is given and controlled. In this respect, reinforcement theory is inherently static. Outside of the laboratories, however, the availability of primary and secondary reinforcers cannot be taken automatically for granted. Since reinforcement learning is contingent on the availability of the reinforcers

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<sup>2</sup> Operant conditioning means that behaviors which are already present in the behavioral repertoire are repeated more often when they are rewarded.

<sup>3</sup> The Pavlovian dog, for instance, has established a relation between a bell’s sound and food.

without sufficient availability a regular pairing of the stimuli cannot take place. Due to process innovations, the availability (and amount) of reinforcers can change over time<sup>4</sup> some reinforcers become more, some less available and new items may even become available for the first time. Apparently, technological change can alter the preconditions and the opportunities for reinforcement learning.

## 2.2 (Social-) Cognitive learning of Cause Effect Relations

As consumers, humans can anticipate positive and negative effects, too. For instance, in the case of some pharmaceuticals, e.g. antibiotics, a considerable time-lag between consumption and positive impacts exists. Therefore, it seems to be more convenient just to talk about more or less immediate cause-effect relationships than about consumer and production goods.<sup>5</sup>

The possibility of goods with less immediate cause-effect relationships has a clear implication for psychology. When the condition of temporal contiguity is violated there must be another mechanism which is independent of temporal contiguity that links causes to effects. Seen from an evolutionary point of view, the cognitive acquisition of knowledge about cause-effect relations is another adaptative mechanism. In contrast to reinforcement learning, cognitive learning provides “*knowledge about the world that is not tied to particular behavior*” (Toates 1998: 59). It enables humans to expand the number of goods beyond the range that becomes possible by simple reinforcement learning.<sup>6</sup>

Now, I take a closer look at cognitive learning mechanisms in order to address changing consumer knowledge. Concerning the question where the knowledge about the world comes from I take special interest in social-cognitive learning, i.e. learning that takes advantage of conspecies’ experiences and knowledge. The aim is to highlight how social-cognitive learning about cause-effect relations actually works and under which conditions it takes place. Starting from the truism, that only beliefs that are perceived and get attention can influence actual consumption behavior, the investigation proceeds in two steps: in a first step, perception is analysed,. Central topics are what gets attention and why. In a second step, the question is addressed under which conditions beliefs are transformed into actual behavior, i.e. become ‘tight’ and how these conditions can change.

Considerations about which beliefs find attention and which not can start from the fact that the human capability to perceive and to process informations is bounded (Witt 1987). This implies that consumer attention is a scarce resource. Only a selection of the total amount of informations humans are exposed to can be perceived and processed (Witt 1987: 116).

Using the metaphor of a photo-lens Witt (1989b) distinguishes two ways how attention is focussed:

- The first way is *shifting* the whole focus of attention. Witt calls it the ‘agenda-setting effect’. Because retrieval works sequentially, agenda-setting, e.g. by advertisements, is the more effective, the more often advertising messages are repeated: “...*the more memory is dominated by repetitive messages, the more chances these repetitions stand of being retrieved.*” (Woo 1992: p.97).

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<sup>4</sup> In order to become compatible with reinforcement theory availability must be understood in a physical and not in a monetary sense.

<sup>5</sup> Gary Becker has argued in his household production theory, quite similarly, that consumers can also produce.

<sup>6</sup> Interestingly, this fits to Carl Menger’s distinction between first and higher order goods (see Ruprecht 2001).

- The second way to direct attention - Witt calls it the “refinement effect” - is to *narrow* down the focus to one issue which, in turn, can be perceived in more detail. How the refinement effect works can be illustrated by Woo’s considerations about information storage within the human brain. According to him, humans do not perceive bits of information but rather whole messages. Decentral communication in small groups, e.g. among hobbyists, can contribute to the refinement effect.

Centralized communication and the agenda-setting effect seem to be more relevant than decentral communication in small groups for an explanation of how beliefs diffuse from the micro- to the macro level – given the corresponding technological preconditions to spread informations centrally. In a mass media society that is characterized by 50 different radio and TV channels and information overload, however, it is not so easy to assess who actually sets the agenda. Witt proposes to apply the concept of competition to this issue: a competition between different providers of information for the scarce resource ‘consumer attention’ is going on.

Usually, people do not believe every message they perceive. In this context, Mokyr (1999a: 4) defines tightness as “...*degree of confidence that individuals have in the truth of this knowledge and their willingness to act upon it...*”. ‘Knowing’ or ‘perceiving’ beliefs is explicitly separated from ‘trusting’ beliefs. When ‘objective truth’ cannot be a relevant criterion how do consumers decide which beliefs to trust and which not? Subsequently, it is shown how Mokyr’s tightness concept is related to psychological consistency theories that offer an answer to the question under which conditions people are inclined to trust beliefs.

A common feature of consistency theories is their postulate of an innate human need for consistency between the elements of the cognitive system like attitudes and norms. Since discrepancies between relevant attitudes and the perception of own behavior cause a feeling of discomfort humans are motivated to reduce this discomfort. There are several ways to cope with cognitive dissonance (Zimbardo 1992: 589). For instance, the relevance of a new information for the own behavior can be ignored or the information source can be brought into discredit. Consistency theories can be divided into theories holding for the post-decision phase and others holding for the pre-decision phase (Lauer 1996: 165). When an innovation is understood as “...*an action that has not been carried out earlier...*”. (Witt 1993: 92) the latter category is relevant in the context of innovative adoption. A representant of this category is Ajzen’s (1988, 1991) ‘theory of planned behavior’. In his preface Ajczen (1988) describes his theory as a research field to which the two distinct traditions of personality theory and social psychology are converging.

In diffusion literature, often personality factors are highlighted as well, in order to explain interindividual differences in the inclination to be innovative. Different types of adopters, e.g. early adopters, late adopters, or laggards are identified (Rogers 1995). The pursuit for consistency, now, brings in an additional conservative aspect since the novelty is required to ‘fit’. However, consistency theories do not imply that innovative actions are not considered; they specify only the conditions under which that may take place.

For the present purpose, the message of Ajzen’s theory can be summarized as follows: people execute a certain behavior when, firstly, they themselves value it positively, secondly, when they have the confidence to perform it, and, thirdly, when they consider important other people to think they should execute it (Lauer 1996: 155). The connecting point to Mokyr’s (1999b:4) tightness concept are the social influences on planned behavior which come in by subjective norms. As long as the opinion leaders do not change their attitudes, there will

always exist a potential source of cognitive dissonance for the other community members. When they change it, formerly dissonant knowledge becomes consonant. The diffusion of beliefs or better: the transformation of knowledge into actual consumption behavior is contingent on social norms.

Like reinforcement theory, the theory of planned action has a static component, seen from the point of view of evolutionary economics. This can be argued since it contains different strategies to solve the feeling of discomfort that is caused by dissonance but is not capable of explaining the transition from cognitive dissonance to cognitive consonance. To put it in Mokyř's terminology: how beliefs which used to be not tight become tight and vice versa is unexplained. For answering these questions nothing else is required than a dynamic theory of tightness. When tightness is a matter of social norms as Mokyř suggests, we would just have to combine the theory of planned action with a theory of changing norms (see e.g. Witt 1989c) in order to get there.

### 2.3 Contingency of Learning

Since an evolutionary theory of consumption raises questions that are different from the questions psychology is interested in, certainly, the theoretical considerations on dynamics in consumption are not psychological per se. In order to become useful in the context of an evolutionary theory of goods reinforcement theories and the theory of planned behavior had to be modified and to be complemented by socio-economic concepts. Hence, it may be more appropriate to say that the proposed theory is consistent with psychological concepts.

The qualified concept of a good entails with 'availability' and tightness/social norms two elements which psychology assumes as givens. From an evolutionary economics perspective, reinforcement theory and the theory of planned behavior can be both considered to be inherently static since they are not interested in the variation of availability and social conventions over time. It has been argued that the diffusion of beliefs is contingent on adequate social conventions while conditioning learning is contingent on a sufficient availability of reinforcers. Emphasizing these contingencies makes psychological theories fruitful for the analysis of historical economic processes: Learning can be seen as a historical event.

Here, a parallel can be drawn to evolutionary biology which is also a historical science. A characteristic feature of evolutionary models in biology is its historicity at the variation as well as at the selection level.<sup>7</sup> The theory of differential adaptation to a selecting environment by the survival of the fittest is known as Darwin's theory of natural selection (Payson 1994). The argument for historicity at the selection or dissemination level, is as follows: *"Once a novel genetic variant has occurred its further success or failure in terms of dissemination depends on the current state of its environment. Apart from the physical conditions, the other variants of life which are already present (and which stem from the preceding stages of evolution) and the traits these variants have are crucially important, too. The influence of this well-known „occupancy effect“ on the evolution of the species can be acknowledged in general terms, but its actual impact cannot be traced without careful studies of the historical and geographical contingencies...Historical contingency is an evident complication in tracing the causal structures in evolutionary processes....In such an exploration, the question of generation must be kept separate from the question of causation...."* (Witt 1996a: 710-11)

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<sup>7</sup> For the historicity at the variation level see Schlicht (1997)

Likewise, both types of learning have revealed to be contingent. While reinforcement learning takes place only when certain environmental conditions are given (a sufficient availability of both stimuli), social-cognitive learning is contingent on the social environment.

### 3. The Historical Development of Sweeteners Consumption

In the present chapter, the usefulness of both contingent learning mechanism for the investigation of historical economic change is illustrated by a case study on the historical development of sweeteners consumption. What is the intention behind selecting a food item as the object of this case study? The consumption of food is a repeated activity and is, for this reason, particularly well-suited for the study of learning. It is true that the need for food is satiable in the literal sense. Engel's law predicts an ever decreasing relative share of expenditures for food items from overall consumption expenditure. However, it does not tell anything about the consumption structure within the food sector. In a historical perspective, this structure is permanently changing. Some food items increase their relative weight tremendously while the share of others decreases. Within the class of food items, sweeteners are particularly suited for the purpose of an evolutionary analysis. With the exception of honey, they are comparatively new items, at least in Europe. Their introduction and diffusion is well-documented because of sugar taxation.

A further advantage of choosing food as the object for my case study is that I can benefit from approaches developed by nutrition science, the discipline which deals with this kind of consumption items. In nutrition science, sweeteners have been a popular research topic. Humans are omnivores. They are able to adapt to very different environments and are independent from any particular food sources. As a side-feature of this advantage, however, omnivores have to solve the food selection problem. *"The omnivore must discover the various sources of essential nutrients in the environment, consume these in amounts appropriate to nutrient needs, and at the same time avoid consumption of high levels of natural toxins that exist...It is extremely difficult to elaborate a genetic programme that would discriminate edible from inedible entities, since there are no reliable sensory characteristics that could be invoked to make this discrimination."* (Rozin 1989: 206) Solving the food selection problem is nothing else than an act of recognition whether a thing is actually a good.

In order to solve his selection problem, the omnivore is endowed with multiple mechanisms, some of which have a phylogenetic, others an ontogenetic origin. Among the phylogenetic aspects of food selection nutrition scientists mention, there is an innate avoidance of bitterness and an innate liking for sweetness. *"These biases make adaptive sense, since sweetness is an indicator of calories in nature, and bitterness correlates with toxicity."* (Rozin 1989: 207) Tastes have adapted therefore, to a past environment. *"These genetic predispositions evolved over thousands of years of human history, when foods – especially foods high in energy density – were relatively scarce, a food environment dramatically different from that in the United States today..."* (Birch 1999: 57) Not all of the four fundamental taste directions, sweet, bitter, salty, and sour are genetically determined. In the case of the salty taste direction: *"...a post-natal maturation of an unlearned preference..."* is conjectured (Schmidt/Beauchamp 1990: 35).

In view of the selection problem, humans are, in addition, genetically endowed with different learning mechanisms which make them capable of coping with diverse natural endowments. Nutrition scientists distinguish different ontogenetic mechanisms operating in the formation of tastes and the acquisition of likes and dislikes. Firstly, there is reinforcement learning that

can build up on different innate reinforcers. Cabanac (1979, p. 37), for instance, mentions that: “..the pleasantness of various food tastes and smells can be affected by caloric states....”. In this case, “..rapid satiety serves as a Pavlovian unconditioned stimulus...” (Rozin 1989: 215). It is not at all excluded that the ontogenesis of tastes can reinforce their phylogenesis: sugar consumption, for instance, should be additionally reinforced by positive post-ingestive consequences although its caloric density has already played a role in the phylogenesis of the taste for sweetness. Besides of the rewarding experience of satiation, in classical conditioning processes tastes that are already liked – be they innate or learned - can operate as unconditioned reinforcers. An experimental example for this possibility is reported by Rozin (1989: 215): “Subjects sipped a sweet-flavoured drink and an unsweetened drink with a different flavour. After many samplings of each beverage, there was an enhanced liking for the sweet-paired flavour, even when both flavours were served in the unsweetened form ....”<sup>8</sup>

Also forms of social learning plays an important role in deciding which food items to eat and which to leave. This is why we observe culturally differentiated “cuisines”. By comprising and emphasizing different ingredients and taste directions, cuisines reflect different ways of coping with nature’s parsimony. “Cuisines are sets of practices concerning the basic foods eaten, the flavors added to these foods, the preparation of foods, and special constraints such as taboos...The fundamental factors underlying food selection in omnivores are manifest in cuisine...” (Rozin 1975: 285) “...The characteristic flavorings of a cuisine which are used with most of the foods, have been called flavor principles...These are usually quite simple and include for example, chili and tomato for much of Mexican cuisine, and olive oil, tomato, and oregano for Southern Italian cuisine... Unlike the basic foods which can be easily justified in nutritional terms, the flavorings may serve some “psychological” function...The flavor principles, which seem even more resistant to change than the basic food items, are probably the most conservative aspect of cuisine...” (Rozin 1977: 564-5)

Rozin/Rozin (1981: 8) emphasize that the flavoring of food, i.e. “the deliberate manipulation of food by adding ingredients that will reliably alter the taste”<sup>9</sup> is a uniquely human behavior. Families have an outstanding role as the locus of social learning. “The preparation of foods (flavourings, cooking techniques) is determined by culture, as is the pattern of introduction of foods to children.” (Rozin 1989:208) In early childhood, a particular form of social learning takes place when parents do the food selecting vicariously for their children. These lack of sufficient own experiences in order to decide whether unknown food items are goods. Nutrition scientists have called the childrens capability of learning to appreciate what is available on the menu the “mere exposure effect” which is based on simple reinforcement, too. A side feature of the mere exposure effect is a conservative tendency and inter-generational persistency in taste patterns (Schmidt/Beauchamp 1990) which nutrition scientists call “neophobia“. “By circumscribing a set of acceptable foods and flavors, cuisines become expressions of neophobia...” (Rozin 1975: 285)

In addition to reinforcement learning, of course, also cognitive and social-cognitive learning about the properties of food items takes place (see section 2.2).

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<sup>8</sup> see Hammersley/Reid (1997) for similar evidence about the reinforcing impact of the orosensoric properties of food.

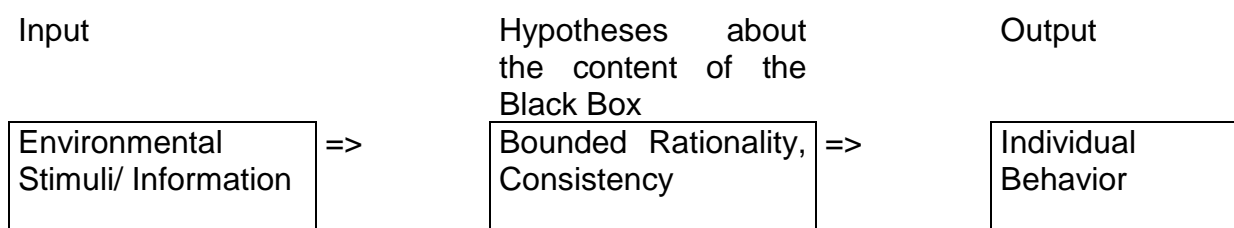
<sup>9</sup> It has to be recognized that the concept of flavor principles is not identical with the common-sense application of the flavor concept as “...a composite sensation of tasting and smelling...” (Bartoshuk 1991).

### 3.1 Some Methodological Remarks

In contrast to other historical work on sweeteners (e.g. Merki 1993, Mintz 1985, Teuteberg 1986a, Grigg 1998) the present study aims to demonstrate how learning processes can be used in order to explain changing historical consumption patterns. The learning framework is used as an alternative to price theory. Since it focuses explicitly on the driving forces, it offers a new perspective on the historical development. In section 2, two learning processes have been distinguished as complementary ways to cope with the epistemological problem. Because of their contingency on availability and social conventions, learning processes are considered to be historical events. Therefore, particular attention is devoted to the conditions under which learning processes are likely to take place.

When the question is raised how psychological learning theories can be applied to the analysis of historical economic change, in some respects, new territory is entered. Recently, there has been an increasing number of approaches to introduce formal learning models into economics (see Brenner 1999 for a taxonomy of learning concepts and a survey of this type of literature). A systematic application of learning concepts to historical economic developments, however, is still missing.<sup>10</sup> To my conviction, a major reason for this lack lies in the methodological uncertainty regarding the question whether and how subjective (reinforcement) learning processes can be observed. With respect to observability, the learning approach seems to have a clear disadvantage compared to approaches explaining changing behavior by changes in relative prices or income levels, both of which are quantities that are usually well documented. Because the direct observation of mental processes is impossible, often, the human mind is considered to be a black box. Hayek has propagated hermeneutics as a method to cope with this problem: *“...think of the archeologist trying to determine whether what looks like a stone implement is in truth an “artefact”, made by man, or merely a chance product of nature. There is no way of deciding this but by trying to understand the working of the mind of prehistoric man, of attempting to understand how he would have made such an implement. If we are not more aware that this is what we actually do in such cases and that we necessarily rely on our own knowledge of the working of a human mind, this is so mainly because of the impossibility of conceiving of an observer who does not possess a human mind and interprets what he sees in terms of working of his own mind.”* (Hayek 1979: 46) Introspection, however, has the disadvantage to replace just one black box by another.

Since even for psychologists looking into the human mind is impossible, the question arises whether hypotheses about the mental states and processes are possible at all. When opening the black box is impossible, however, it may be possible to circumvent it. Although we cannot observe the content of the black box, it is feasible to observe its in- and outputs. Witt (1987, chapter 3) proposes to take the following scheme as a starting point for such a strategy:



In its positivistic tradition, the behavioristic school refrains from any hypothesis about the content of the black box: only observable entities, i.e. individual behavior and environmental

<sup>10</sup> The diffusion literature can be mentioned as an exception. There are approaches (e.g. Lauer 1995) who attempt to give the diffusion process a psychological foundation.

stimuli are recurred to. In contrast, cognitive theories in psychology do not abstain from hypotheses about the mechanisms working in the black box. Witt's interpretation of bounded rationality as scarce attention and consistency theories are examples for such hypotheses. Like the behavioristic school, cognitive psychologists observe the input, i.e. information, and the output of the black box, i.e. behavior. In this respect, the situation of a historian is more comfortable than the situation of the Hayekian archeologist. Often, historical sources contain a lot of information about the in- and outputs of the black box. There can be no doubt that the observation of knowledge diffusion, i.e. social cognitive learning processes is, in principle, possible. There are historical records like newspaper articles, TV programs and other written sources a historian interested in knowledge diffusion (see e.g. Mokyr 2000) can take as input into the black box.

An important advantage over hermeneutics is that psychological learning theories explicitly list conditions for learning to take place. For reinforcement learning to take place the following conditions have to hold: temporal and local contiguity between the conditioned (CS) and the unconditioned stimulus (US) as well as a sufficient availability of the two stimuli in order to allow for a regular pairing of the two stimuli (Baker et al. 1996).<sup>11</sup> Since psychologists do not have to cope with the scarcity problem they take availability usually for granted. In a historical perspective, however, the availability of stimuli is subject to change. In contrast to the experimental situation that implies controlled laboratory conditions, here, the learning processes are regarded as historical events. From the historical availability of certain stimuli it can be concluded that learning may actually have taken place. Therefore, it is a major issue in the present case study to describe in the context of sweeteners how the historical preconditions upon which the two learning processes are contingent came into being. The availability of stimuli may be well documented in written records. Describing social conventions on which the transformation of knowledge into behavior is contingent is equally possible on the basis of written sources. Considering that learning processes are historically contingent it may be more adequate to talk about the interaction between an individual's behavior and its social or physical environment than about inner-subjective processes.

Transferring reinforcement learning into an economic context is by no means a new idea (see e.g. Alhadeff 1982). In a recent paper, Battalio et al. (1991) have transferred the idea of a price system to reinforcement experiments with rats. Two different liquids, quinine and root beer, operating as primary reinforcers are available to the subjects. The pressing of two levers, i.e. the way the subjects can get the liquids are the activities that are operantly reinforced. In the view of their price theoretical interest, Battalio et al. interpret relative changes in the ratio of lever presses necessary to get the corresponding reinforcers as changes in relative prices. In terms of lever presses necessary to get a certain amount of liquid, quinine is made more expensive. Subsequently, some of the individuals increase their relative share of the inferior quinine - in order to ensure a sufficient calory supply taste is sacrificed. Battalio et al. interpret their observations in economic terms as Giffen behavior, i.e. increased demand follows as a paradoxical response to price increases.

The Battalio et al. paper just supports the conjecture that the concept of goods is well-suited for interdisciplinary exchange between economics and behaviorist psychology. My interdisciplinary research strategy, however, is different from Battalio's et al. price theoretical one. I interpret changes in relative prices as indicating changes in the availability of

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<sup>11</sup> Mere availability without tested knowledge about reinforcing impacts, however, is not sufficient: we do not get reinforced by a taste only because it is available. Exposure as we have seen it in the case of intergenerational learning processes is necessary.

reinforcers. Price reductions, hence, imply the possibility of increased reinforcement and vice versa.<sup>12</sup> This is just another interpretation of the same data: One that looks closer at the quality of goods - in psychological terms: the reinforcing dimension, e.g. caloric content in the rat experiment - and less at prices which are considered to be simply indicators of availability. I do not claim that according to some criterion one type of interpretation, be it an explanation recurring to relative price changes or to reinforcement learning, is the correct one. My point is, however, that both stories are consistent with the facts: since the underlying hypotheses refer to non-observable entities, they cannot be falsified. Hence, an economist has no reason at all to apologize for an investigation into learning processes or into what rational choice theorists call preference change.<sup>13</sup>

## **3.2 Sweetness an Emerging Flavor Principle**

### **3.2.1 The Increasing Availability of Sucrose**

There are several types of sugar: fructose (honey and fruits), lactose (milk), sucrose and glucose (honey). The fact that sucrose was the first pure sugar makes its consumption history particularly interesting.

There are two plants which are considered to be the main sources of sucrose. In terms of chemical structure beet sugar and cane sugar are identical substances: both consist of sucrose, which is, like other sugars such as fructose or glucose, a natural organic carbohydrate. Sucrose can be described by quantifiable characteristics as well as by qualitative characteristics: the caloric content of refined sucrose can be quantified with 394 kilocalories per 100g (Grigg 1998:178). Unlike other food items, sucrose is consumed by almost 100% of the world population with the exception of the Inuit population of Greenland, 10% of which suffers from sucrose intolerance (Grigg 1998). The qualitative characteristic of sucrose, of course, is sweetness. According to Hammersley/Reid (1997: 146) the orosensoric properties of carbohydrates in general and sucrose in particular are highly reinforcing. Because of its caloric density and its orosensoric properties, sugar can be part of the basic foods and can simultaneously contribute to the flavor principles mentioned by Rozin.

The chemical identity of the sugars contained in cane and in beet was detected and proved in 1747 by the Prussian chemist Andreas Sigismund Marggraf. Marggraf's student, Franz Carl Achard, got a royal order to explore possibilities how to substitute expensive commodities which had to be imported from other countries' colonies. Hence, the search guiding trajectory - in order to use Dosi's (1982) term - could be described: check the domestic plants with respect to the problem of sucrose production. After conducting various test series in an experimental farm, Achard succeeded in identifying the beet species as the one with the maximum sucrose content.

Even though Achard succeeded in generating the decisive technological knowledge, he failed to find a way of producing beet sugar sufficiently cheap in order to become competitive to

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<sup>12</sup> In a similar way, Scitovsky (1992) has argued that relative price changes in the long run influence tastes. In a reinforcement learning framework, however, it is not prices but availability (and exposure) that influences tastes. In the empirical literature on habit formation (e.g. Houthakker/Taylor 1970: 10/11), there is also something similar. The formation of habits  $c_t = f(c_{t-1})$  formally resembles operant conditioning.

<sup>13</sup> It has been already mentioned above that the reinforcement approach applies only to regularly consumed items like e.g. many non-durables.

cane sugar. Hence, in the beginning, beet sugar was neither a product innovation (because of chemical identity) nor a successful process innovation (because of the more expensive production process compared to cane sugar). It followed a period of trial and error. Here, external political factors played a major role: the first brown-coloured substance prepared on the basis of beet could only be sold in Germany because of the rationing effect of the French continental blockade combined with a British sea embargo. Even though it is documented nowhere, it can be assumed that demand for sugar must have been price inelastic – otherwise such enormous efforts in developing a domestic substitute would not have been undertaken in order to get rid of the dependency on imports of the colonial powers.

After the end of the continental blockade, low taxes for imported cane sugar contributed to the temporary decline of the new German sugar industry which, moreover, suffered from a newly introduced beet sugar tax.<sup>14</sup> Agricultural process innovations in the thirties, particularly the introduction of crop rotation systems and the application of innovative fertilizers, caused production costs for beet sugar to decline (Teuteberg 1986a: 157). The competition between imported cane sugar and domestic beet sugar induced further innovations. By seed refinements the sucrose content of the beet plant could be enhanced: it doubled from 5% in 1800 to 10% in 1900 (Grigg 1998: p.180). Around 1860, Germany turned from an import into an export country. When cereal prices decreased in Germany as a consequence of the introduction of steam boats and railways which enabled massive imports of cereals from the USA and Russia, many German farmers switched from growing cereals to growing beet.<sup>15</sup>

How the availability of sucrose may have increased in the long run all over Europe can be concluded from the real price development in Great Britain.

<b>Table 1:</b> Development of prices for a pound of sugar (in 1960 prices) converted into new pence in England 1400-1960 (source: Johnstone 1976, cit. in Grigg 1998: p. 180)				
1400	1600	1800	1900	1960
875p	210p	70p	17.5p	3.7p

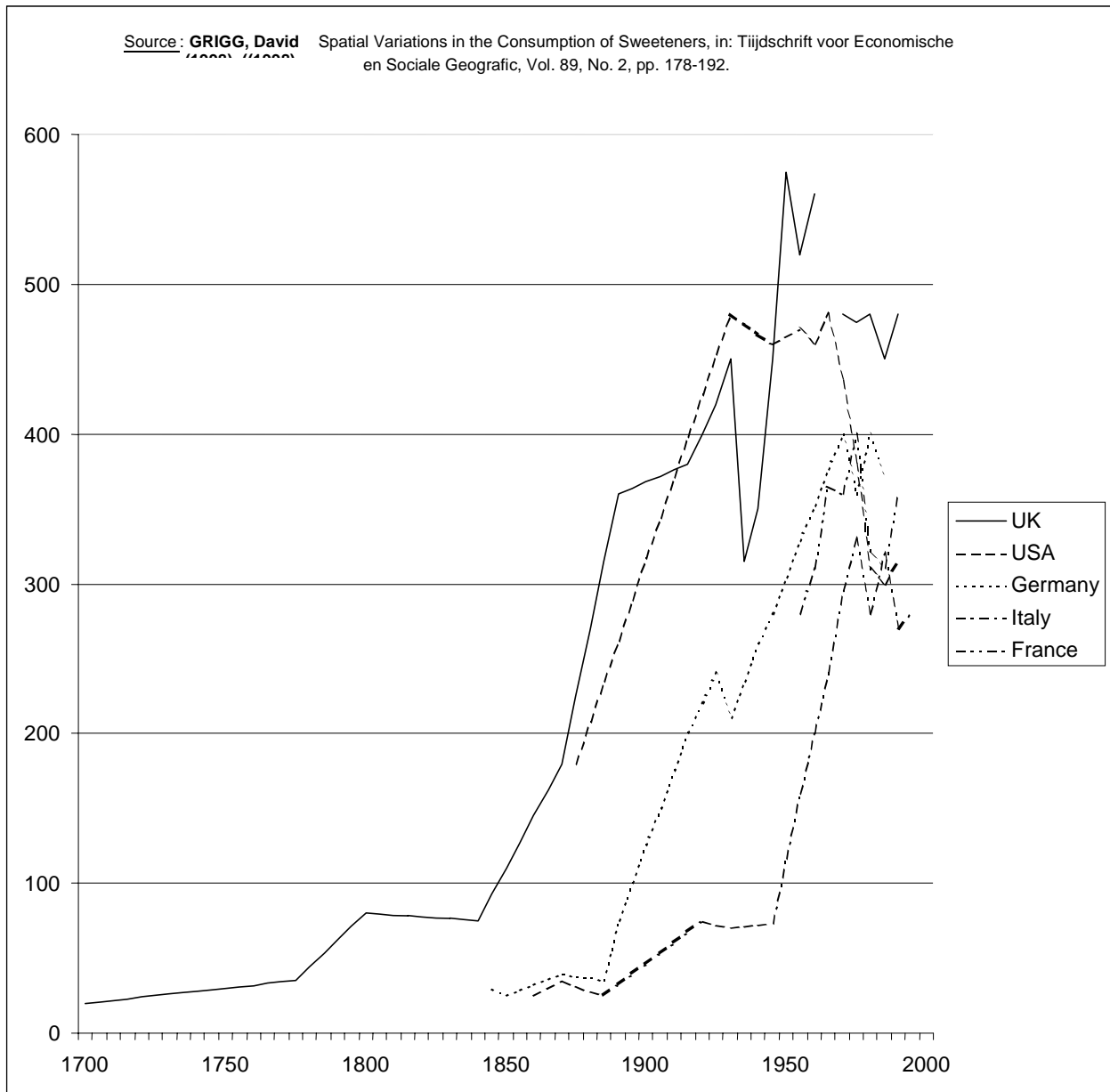
Briefly summarized, it can be stated that sugar is one of the few food items which on average became permanently cheaper during the nineteenth century, i.e. more available, while prices for other items e.g. rye and beef increased (Teuteberg 1986: p. 160). In other words, the speed in which process innovations took place was high compared to other food items.

### 3.2.2 The Indirect Consumption of Sugar

In the late European middle ages in many regions 'sour' was the dominant taste direction and flavor principle in daily food. During the 19<sup>th</sup> and 20<sup>th</sup> century 'sour' was replaced by 'sweet'. Historical evidence from cook books shows that while only 15% of the soup recipes in 16<sup>th</sup> century Rumpolt's cook-book included sweet ingredients, in 19<sup>th</sup> century cook books already 40% of the soups were sweetened. (Wiegelmann 1986: 149) Given the inherent conservatism of flavor principles the question can be raised how and why this change in tastes has taken place.

<sup>14</sup> The tax for beet sugar was propagated by the cane sugar refinement industry which was located in northern Germany.

<sup>15</sup> For a documentation of the increasing area in Germany that was used for the sugar beet cultivation, see Henning (1988: p.78).



**Fig.1:** Consumption of sweeteners in calories per capita per day 1700-2000 in selected countries

As we see in figure 1, the increase in sweeteners' consumption in calories per capita per day seems to be a general trend observable in the industrialized countries in the 19<sup>th</sup> century.<sup>16</sup> Certainly, there are remarkable differences between the single national developments in terms of time structure and overall consumption level : Between the take-off in Great Britain (1850) and the take-off in Italy (1950) there is a gap of 100 years. Moreover, the consumption level of these two countries differs tremendously. Despite of Great Britain having its colonies, international trade should have, in principle, made sugar similarly available to the Italians.

The general trend may be explained by a universal preference for sweetness. Considering the remarkable regional differences, however, a merely genetic explanation may be insufficient. To explain this increase as being an anthropological constant which gets apparent when sweeteners become available is, as I will argue, not false but incomplete.

<sup>16</sup> In this period, sweeteners can be equalized with sugars since artificial sweeteners had not diffused widely yet.

During the last two centuries people in Europe and the US have remarkably changed their food habits and diets (Bennet/Peirce 1961, Teuteberg/Wiegelmann 1986). This development which takes place simultaneously with the diffusion of sugar raises two different questions.

- a) Why have neophob consumers been willing to change their consumption patterns at all?
- b) Another question refers to the historicity of this development: why were European food consumers in the period between 1850 to 1950 able and willing to abandon their traditional diets and cuisines?

The first question can be addressed by referring to the omnivore's problem. Since sweetness has a reinforcing impact, it can contribute to overcoming the innate neophobia humans have for food items they do not know. This mechanism was known already before industrialization: local cuisines added spices to basic food items which had the role of flavor principles (Rozin E./Rozin P.; for empirical examples of regional flavor principles see also Teuteberg 1982 who conducts a comparative historical investigation regional spice consumption in 19<sup>th</sup> century Germany). Neophobia, however, can refer to basic foods, taboos, preparation methods and flavour principles. The sweet taste of sugar signals by reinforcement learning that a new food item or dish can be evaluated positively and helps to overcome the neophobia that is reproduced by the cultural tradition of cuisines.

This leads us to the second question and to the role of the newly emerging food industry in the 19<sup>th</sup> and 20<sup>th</sup> century. The Industrialization of the food sector implied a changing division of labor and new ways of preparing food. According to Rozin's (1977) definition, this was a change in cuisine that caused neophobia. In addition, entirely new basic food items such as cocoa and chocolate, tea, and coffee were in an early state in their diffusion (Wiegelmann 1986). Besides the positive organic properties of sucrose suggesting its application for conservation purposes, the reinforcing impact of sugar was crucial in order to overcome the consumers neophobia regarding the new ways of preparation and the unknown substances. Mainly the latter quality should have induced the food industry to make rich use of it. Fine et al. (1996: p. 85) claim that *"...many of today's taken-for-granted foods and drinks have been invented around sugar as a major ingredient. In this respect a number of food industries, such as confectionary, cakes and biscuits, have developed using sugar as an industrial input..."* Moreover, tea, lemonades, jellies and marmalades, or chocolate can be mentioned.

The upcoming of an industrialized food sector and the rising share of indirect sugar consumption reflects the changing division of labor and the reorganization of the time available to the members of the newly emerging working class. Time uses should have changed away from time spent for food growing and preparation towards time spent for dependent work. Individuals moving from the subsistence sector to the industrial sector had to look for new ways of preparing and getting their food. This argument is supported by Mintz (1985: 130) who suggests that *"...at least in Great Britain of the nineteenth century, food choices were reckoned partly in terms of available time, and not solely in terms of available costs."* The pressure to reorganize time uses caused conservative consumers to look for new opportunities. Sugar has contributed in destroying the old agricultural meal order which centered around the meal that was prepared by and consumed within the family. Sugar was associated with fast food, in the double sense of production and consumption. Considering that the consumption rhythm was dictated by the factories, fast prepared marmelade sandwiches could be fast consumed during a tea break (Merki 1999: 236).

It is interesting to see in this context that the structure between the direct and indirect consumption of sugar has changed: *“In the US three quarters was for household use in 1909-13, but by the 1970s two-thirds was used in food and drink manufacturing ..., and household purchases of sugar have declined since the 1920s....”* (Grigg 1998: p. 180).<sup>17</sup> A look at today’s European meal orders shows that whole meals such as breakfast and the newly established teatime have been shaped by the sweet taste direction.<sup>18</sup> Fine et al. add: *“The major organic property of sugar – sweetness – has been successfully and fully disseminated throughout the British food system as a whole. From sugar and sweetness being a relative scarcity 150 years ago, it is now universal and added or hidden throughout the modern food system.”* (Fine et al. 1996: p. 85). It can be conjectured that the entry of sugar into modern cuisines during industrialization established a new flavor principle which compensated for the new industrial way of food preparation.

The structural change towards indirect consumption reflects both substitution of home produced food items by purchased brands and innovative consumption. The industrialization of food provision and the tendency towards indirect consumption of sugar may have facilitated standardization of tastes and sensual perception. Barlösius’ (1987: p. 375) suspects that industrial producers of sugar and sweeteners take advantage of the reinforcing impact of sweetness by manipulating and directing tastes for their own benefit. In industrial production of food, there is a tendency towards separating the aromatic substances from substances providing mass and caloric intake. This may have facilitated manipulation.<sup>19</sup>

Scitovsky (1976:9) describes the strategy which 19th and 20<sup>th</sup> century producers may have successfully applied in order to conquer the socially reinforced local cuisines. *“Thanks to the technology of mass production, things bought by many people can be produced more cheaply than those bought by only a few. The poor always have the advantage of numbers; those of the poor who all want the same thing can usually have it to a lower price, and that lower price, with respect to that particular thing, offsets their poverty. In the modern economy, therefore, wherever economies of scale lead to important reductions in cost, plutocracy is combined with mob-rule: the crowd’s ability to get those things on whose desirability its members agree. One of the main goals of advertising is to promote such agreement...To render production cheap, the seller must extend his market; he can best do this by catering to desires everybody shares. These desires – beyond that for the essentials of life – consist in the primitive, unsophisticated desires, or variants of desires, which the most simple-minded segment of the consuming public shares with the rest. By catering to these desires the seller fulfils the important economic function of creating the conditions necessary for reaping the economies of scale, cheapening his product, and making that product accessible to all; but at the same time, he also discourages and discriminates against more sophisticated tastes and so pulls down the level of the public’s average taste...”*

This is nothing else than stating a trade-off between a variety of culturally differentiated cuisines and a mass production regime that is based upon economies of scale. It can easily be imagined that the food companies producing for mass markets do not have an interest in individual sophistication and the education of consumer tastes in a similar way as perhaps French cuisiniers. In the case of the taste dimension of food, advertisement is even superfluous in order to get the consumers agreement. Appealing to the reinforcing impact of sweetness is sufficient to overcome neophobia. Once, the new industrially produced food

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<sup>17</sup> see also Fine et al. (1996)

<sup>18</sup> It may be no incidence that the last course of a luxurious three-course-meal, i.e. the dessert, is usually sweet. A reinforcing impact can be conjectured.

<sup>19</sup> See also Fine et al. 1996: 115; or Goodman et al. 1987 on ‘substitutionism’ in the food industry.

items, sweetened with sugar, have entered a family's diet, they can be expected to be transferred to the next generation. The mere exposure effect stabilizes the new nutritional patterns and flavor principle.

In contrast to Scitovsky who is interested in a normative assessment of this development, an evolutionary analysis is rather descriptive. It emphasizes the adaptive processes underlying both regimes, i.e. the large scale industrial regime and the small-scale pre-industrial regime. When the food production was industrialized, one adaptive regime was replaced by another one. While the regional cuisines which were more or less reflecting adaptations to local circumstances and resources and a family-size scale of production technology lost their importance, the adaptation of tastes to large scale production regimes took place.

### 3.2.3 Technological Developments in Caloric and Non-Caloric Sweeteners

Starting from the innate reinforcing impact of sweetness, the role of sugar for the transition of food production from the subsistence economy to an industrialized food sector has been described. However, it is not only human tastes which have to adapt to predetermined environmental conditions. The process can work the other way round as well: by technological means consumption opportunities can be adapted to human tastes.

Indeed, the availability of sweeteners has been further increased by technological developments.<sup>20</sup> Very roughly, two classes of sweeteners can be distinguished:

- The class of caloric sweeteners that is made up by sucrose, glucose and fructose (Bucke 1979: 62), all providing similar amounts of energy, i.e. 16,8 KJ/g sugar (Merki 1993: 25).
- The class of non-caloric or artificial sweeteners, that are not extracted from plants but are produced synthetically.

Among the non-caloric sweeteners, saccharin is the oldest one. By means of "sugar equivalents" different types of sweeteners can be made compatible with respect to the dimension "sweetness intensity". The "sweetness" of saccharin is between 300 times (Heasman 1990: 9) and 550 times (Fine et al 1996: 136) higher than sucrose. i.e. 1 Kg saccharin is 550 Kg sugar equivalent. In contrast to sugar, artificial sweeteners (high intense sweeteners) are usually classified as food additives and not as food item because of their enormous sweetening force (Fine et al. 1996). In the 20<sup>th</sup> century, several other non-caloric sweeteners entered the market. Due to their enormous sweetening force they are characterized as high-intense-sweeteners (HIS).

Artificial Sweetener	Sweetening Force in "Sugar Equivalents"
Saccharin (1879)	300-550
Cyclamate (1937)	30
Aspartame (1965)	200
Acesulfame	130-200
Super-Aspartame (patented)	55,000

The invention of the HIS together with subsequent process innovations increased the availability of sweetness dramatically. Merki (1993: 72) reports that a French company has

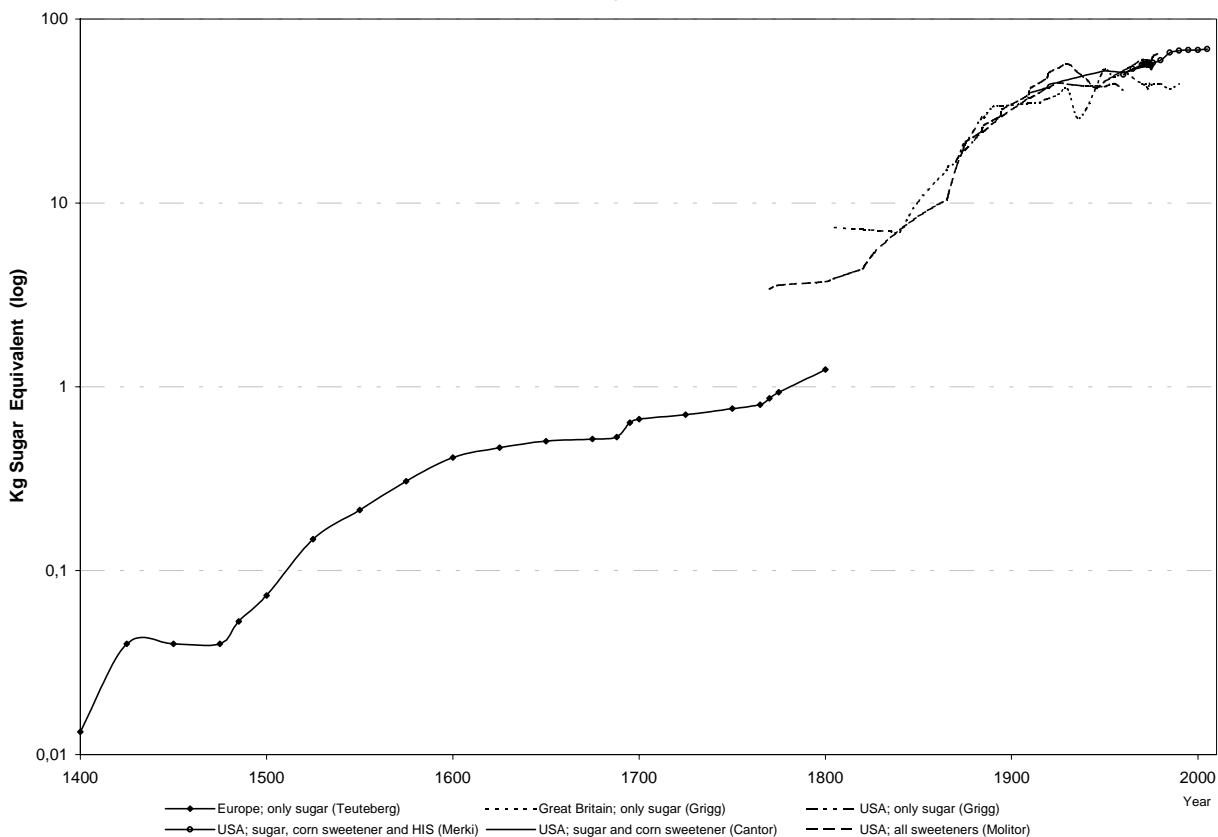
<sup>20</sup> This type of innovation leading to increasing availability of formerly known characteristics is basically described by the Lancasterian framework. In the present framework, however, increasing availability is just a precondition for reinforcement to take place.

patented an artificial sweetener with the enormous sweetening power of 55.000 sugar equivalents.<sup>21</sup>

New developments in caloric sweeteners further increased the availability of sweetness. In the USA, glucose and fructose sweeteners made of sweet corn have been introduced already 1811. Most importantly are high fructose corn syrup (HFCS) and liquid isoglucose both of which are produced to sufficiently competitive costs in order to threaten the position of sucrose. In 1982, it replaced sucrose from the first position in the market for caloric sweeteners and held in 1987 a market share of around 52% (McMinimy, R. 1987: D5).<sup>22</sup>

Availability has been tremendously enhanced in the historical development from cane to beet sugar up to high-intense artificial sweeteners. It is true that in artificial sweeteners, the phylogenetically coded connection sweetness – caloric content is decoupled, but, with respect to their reinforcing impact, there is no difference between sugar and artificial sweeteners (Capaldi/Owens/Palmer 1994).<sup>23</sup> The hypothesis of the innateness of sweet taste is supported by Fig. X, that describes the long term trend in the annual per capita consumption of sweeteners.

Figure 2: Annual Consumption of Sweeteners in kg sugar equivalents per Capita in Selected Regions (1400-2005)

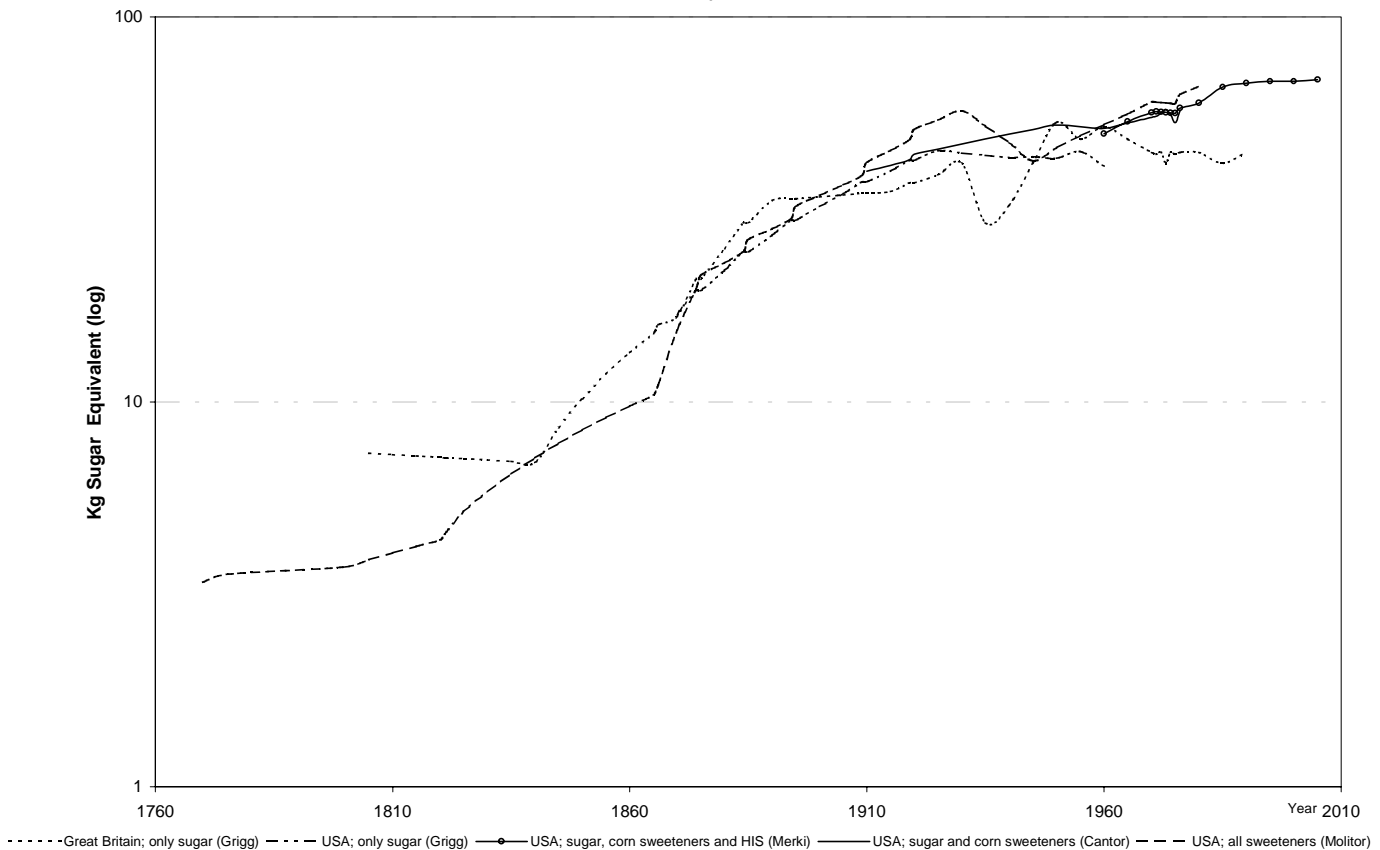


<sup>21</sup> Molitor (1986: D 32) lists 150 substances and their corresponding sugar equivalents. Among them, 17 substances have a sweetening force higher than 1,000 sugar equivalents.

<sup>22</sup> Their main field of application is the fast growing soft drink sector.

<sup>23</sup> With respect to the reinforcement by post-ingestive satiation feeling saccharin may be less reinforcing than sugar. However, like sugar saccharin is seldom consumed in a pure form. Hence, saccharin can be expected to become the object of secondary reinforcement, too.

**Figure 3: Annual Consumption of Sweeteners in kg sugar equivalents per Capita in Selected Regions (1770-2005)**



Figures 2 and 3 survey data about the long term development of the consumption of sweeteners that are taken from different sources. Interpreters should recognize that the long term trend describes the average consumption. Particularly, during the period in which imported cane sugar was an expensive luxury the interindividual variance of sugar consumption should have been high. Because of the many methodological problems that are involved here, I do not argue that these data are correct in detail. I am very well aware of the problem that the different types of sugars are not equally represented here. Fructose and glucose are not equally recorded in statistics since their consumption in pure form is rather seldom. However, both sugars are contained in food items such as fruits.

In his analysis of German consumption patterns that covers the period from 1850 to 1975, Teuteberg (1986b) delivers some more evidence that support the hypothesis of the emergence of sweetness as a new flavor principle. Apart from sucrose, his analysis contains also other sources of sweetness. It reveals that in the period under investigation the increase in sucrose consumption could have been accompanied by a parallel increase of the consumption of other sweeteners: Teuteberg reports an increase in the per capita consumption of honey (fructose and glucose) by the factor 4 (from 0,25 Kg to 1 Kg) while the consumption of fruits (fructose) has increased by the factor 7 (from 15,25 Kg to 121 Kg).

In any case, figures 2 and 3 illustrate the general tendency of an enormous increase of the consumption of sweetness. The fact that this trend holds interculturally as well as intergenerationally, supports the hypothesis that the flavor principle that governs industrially produced food may have genetic underlyings.

### 3.2.4 Sweetness and Whiteness

By putting emphasis on changing availability that enables the regularity of pairing I have neglected the other preconditions of reinforcement learning. Given that at least one stimulus is previously positively evaluated another condition is the spatial and temporal contiguity of the stimuli. When goods are considered to be multidimensional entities, these dimensions are always temporal and spatial contiguous. In contrast to the Lancasterian conception, in a learning framework these dimensions differ with respect to their reinforcing quality: hence, between the single dimensions of one and the same good reinforcement can go on. It is innovative producers who recombine these dimensions and provide temporal and spatial contiguity of stimuli.

It is difficult to prove that interaction has taken place in a way that a formerly neutral characteristic is now positively (or negatively) evaluated. In the above case on the evolution of flavor principles by indirect consumption of sugar, stating neophobia against the industrially prepared food has been crucial for the interaction argument. In the above case of indirect consumption, food items like chocolate were considered to have the dimensions “taste” and “unknown ingredients”. In the combination with sweetness, the latter got a positive connotation.

A look at the transition from cane to beet sugar illustrates that there is another case of reinforcement learning where neophobia does not matter. In this case, not chocolate but sugar is considered to be a multidimensional good with “taste” and “colour” as the relevant dimensions. Because of its brown colour, initially, beet sugar was considered to be a surrogate for cane sugar (Teuteberg 1986: 157). Sugar bakeries and conditors clearly preferred white cane sugar over the brown-coloured beet sugar. An association process between the taste and the colour dimensions of sugar can be assumed, since at the end of the century the beet sugar industry successfully invested in a technique that changed the annoying brown colour into white (Teuteberg 1986a: 160). Without recurring to reinforcement learning it is hard to find a reason for consumers preferring the combination sweet and white over the combination sweet and brown.<sup>24</sup> That artificial table top sweeteners are white-coloured as well also indicates that a preference order may have evolved by local learning processes.

### 3.3 Explaining Structural Changes in Sweeteners’ Consumption

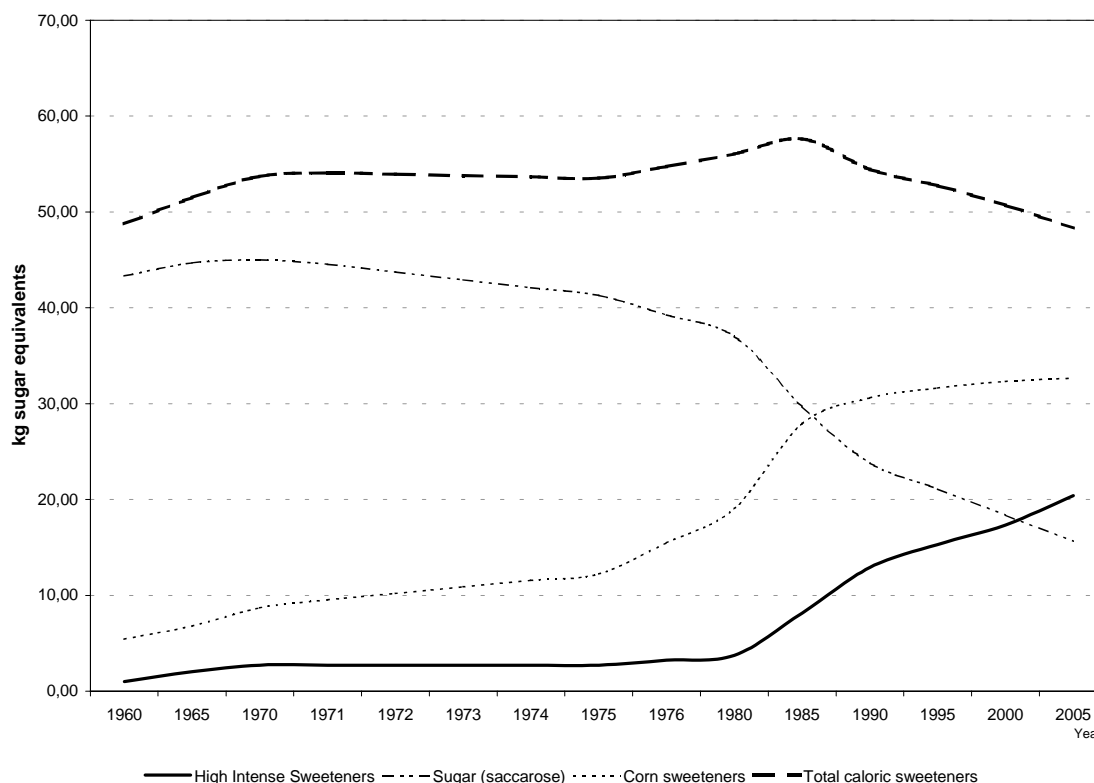
Figure 4 describes the recent structural change in the Us market for sweeteners from 1960 to 2005 (prediction).

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<sup>24</sup> In the economic literature on conspicuous consumption, it is sometimes argued that the consumption of the more expensive good creates an extra value when publicly consumed. However, in the case of beet sugar and artificial sweeteners this argument does not hold since, initially, beet sugar, was the more expensive good (Teuteberg 1986a: 158).

Figure 4: Structural change in the US market for sweeteners 1960 – 2005

Source: Merki (1993)



At the end of the 20<sup>th</sup> century, in the USA and other industrialized countries the income elasticity of caloric sweeteners became negative (Grigg 1998). Inferiority and superiority are relational concepts (Lipsey/Rosenbluth 1971), i.e. income elasticity is dependent on the existence and quality of substitutes). Hence, the economic history of artificial sweeteners can be fruitfully approached by looking at its relationship to sugar (see e.g. Merki's 1993 book). Since saccharin was invented already 1878, the question seems to be just legitimate why it took almost a century until artificial sweeteners got a significant share in the market of sweeteners.

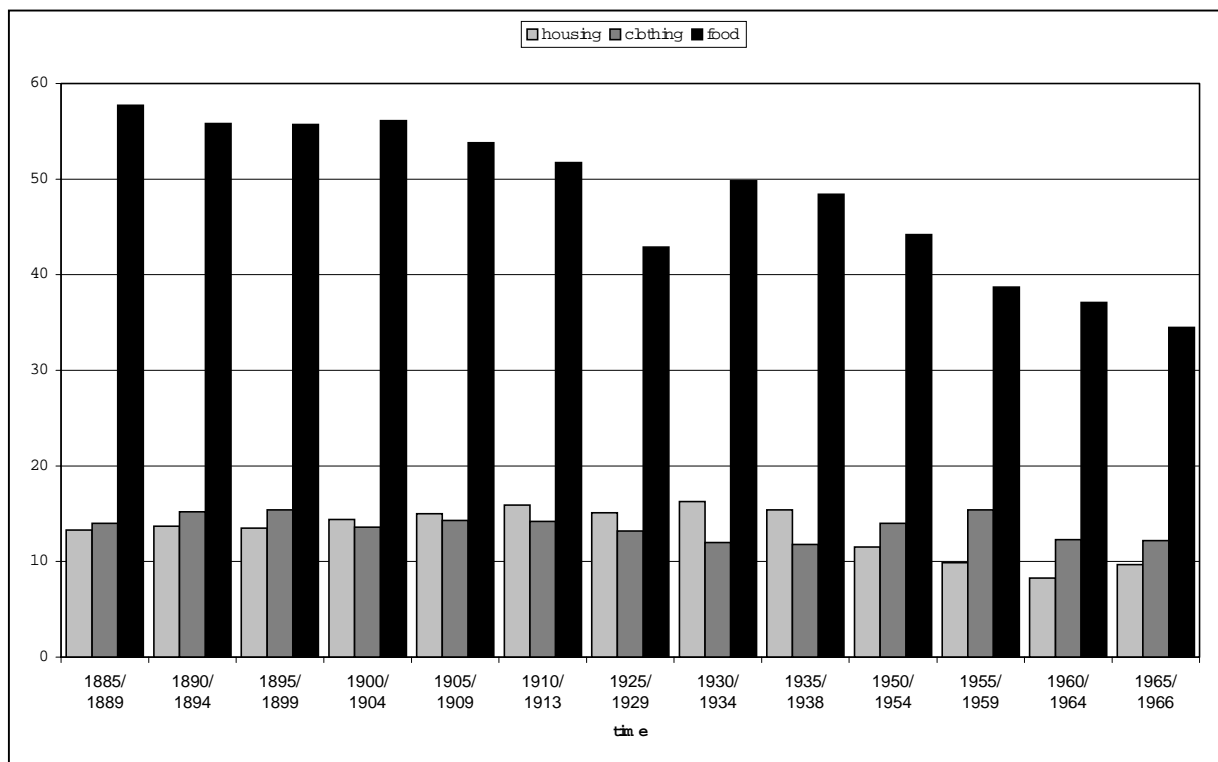
There are two each other complementing explanations of this historical development. While the first one focuses on the genetic level of behavior the second one rather stresses cultural determinants. The historian Wilhelm Abel (1981) has formulated a "*natural law of food evaluation*". It states that in times of food scarcity the nutritional value has priority for consumer choices while in times of affluence the pleasure spending characteristics become dominant. The fact that also animal behavior seems to follow this law (see the experiments of Battalio et al. 1991), supports the conjecture of an underlying genetic cause.

In Lipsey/Rosenbluth's (1971) explanation of changing income elasticity a more general and more precise formulation of the law can be found. Lipsey/Rosenbluth's approach is based on the Lancasterian characteristics framework. It leads changes in income elasticity back to the existence and quality of substitutes. In a two-goods-two-characteristics-framework the consumption technologies differ with respect to their fixed comparative advantages in the production of characteristics. Comparative advantages are defined as follows: "*Good 1 has a comparative advantage over good 2 in the production of characteristic 1 if the quantities of*

*the two goods that produce equal quantities of characteristic 2 yield unequal quantities of characteristic 1, the higher quantity produced by good 1.” (Lipsey/Rosenbluth 1971: 138)*

Starting from this conceptual framework, Lipsey/Rosenbluth construct initial conditions under which a good can become inferior although all produced characteristics are desired. *“If we have a range of commodities all able to produce characteristic 1, demand for which is satiable, and characteristic 2, the demand for which is not satiable, increases in income will cause purchasers to move in the direction of commodities that have an increasing comparative disadvantage in the production of the satiable characteristic.” (Lipsey/Rosenbluth 1971: 143)*

The delayed success of artificial sweeteners can be explained in this framework. In the present case, sugars have a comparative advantage in producing calories while artificial sweeteners have a comparative advantage in producing sweetness. When the food supply increases the need for calories fades because of satiation.



**Figure 5:** German household expenditure from 1885 – 1966 in % - selected consumption categories<sup>25</sup>

Not only in Germany, empirical evidence is consistent with the satiation hypothesis. For the time period following the introduction of saccharin, satiation is indicated by the fact that the share of household expenditure spent for food has significantly decreased. Simultaneously, the diminished requirements for physical labor may have additionally reduced the need for calories.

By admitting the possibility of satiable characteristics, Lipsey/Rosenbluth do not violate the non-satiability axiom which is constitutive for ordinal preference theory. This is because the axiom still holds for goods. Since consumption technologies produce combinations of

<sup>25</sup> Source: Selter (1995: 194)

characteristics, satiation of one characteristic does not imply market satiation. Nevertheless, once the possibility of satiation, a psychological entity, is admitted, the question arises whether the explanation should not be entirely based on psychological entities. This consideration leads us directly to the second explanation of the changing structure of sweeteners consumption, which challenges Lipsey/Rosenbluth's assumption of fixed and objective comparative advantages. In the contingent learning framework that was presented in section 2.2 the completeness axiom is abandoned. Consumer knowledge and preferences become variable.

Starting from the conjecture, that consumer knowledge is a crucial dimension in the competition between caloric and non-caloric sweeteners, I will undertake a short excursion into the history of consumer knowledge about the health-related properties of sweeteners. That particularly health related aspects influence consumer choices is intuitively plausible. Because of the complexity and the time structure of the relation between nutrition and health, a social-cognitive learning process can be assumed – as opposed to learning by own experiences.

The relevance of knowledge for consumer choices is increasingly acknowledged by economic historians as e.g. Fine et al. (1996: p. 119): "*The role of science and technology in recent years in transforming society's understanding of diet and nutrition and the impact of this new knowledge on food supply in advanced capitalist countries is not fully addressed in the foods systems literature...*"<sup>26</sup> This position is, however, only partly consistent with the positive approach on consumer induction that has been presented above. Given the impossibility of objective insight, learning from mass media may be more relevant in the current context than learning from science: because of their agenda-setting power, mass media have an enormous influence on which beliefs are perceived and find attention (Witt 1996b). It is not sufficient to look at the sources and the diffusion of consumer knowledge. The cultural conditions under which consumers are willing to trust new knowledge and under which beliefs are likely to get "tight" have to be addressed. The relevance of new knowledge for actual behavior is contingent on its tightness that is subject to change as well. In this perspective, the question to be answered is: how does lacking caloric content in sweeteners switch from being a dissonant to being a consonant property?

Considering changing tightness, two historical diffusion periods can be distinguished – one lasting from 1885 until the sixties, and the other one from around 1970 until now.

### **3.3.1 The first Diffusion Process of Artificial Sweeteners**

The early diffusion process of saccharin differs, in any case, remarkably from the diffusion of sugar which diffused from the upper classes downwards. It shows a pattern that is typical for a surrogate. In Germany, saccharin initially spread mainly in the countryside, where it made sweetness for the first time available. Around 1900, saccharin cost only half of sugar.<sup>27</sup> Considering that the market for sweeteners was permanently growing– between 1888 and

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<sup>26</sup> With the establishment of a statistics-based nutrition science in Europe and the US in the 19<sup>th</sup> century (Mokyr 1996: 19; 27/28; Merki 1993: 81-82; Ellerbrock 1987) consumer knowledge was systematically produced. It seems to have been not a matter of pure coincidence that the emergence of nutrition science was temporally contiguous with the emergence and growth of an industrialized food sector and the decline of the subsistence economy. The ongoing division of labor should have made the consumer's epistemological problem even worse, since the sofar decentralized knowledge about ingredients and the production process was centralized.

<sup>27</sup> Soon after Fahlberg's invention, the entrance of new competitors intensified the competition at the saccharin market and triggered a couple of process innovations. Between 1887 and 1903, production costs were already reduced by 95%.

1901 per capita consumption of sugar increased by 80% (Teuteberg 1986b) – saccharin’s growth rate was disproportionate to the one of sugar.

Year	Saccharin consumption in tons (sweetening force 550)	Saccharin consumption in tons sugar equivalent	Saccharin consumption in % of sugar consumption
1888	0.15	83	0.02%
1890	0.8	440	-
1892	1.6	880	0.17%
1894	2.3	1,265	-
1896	5.7	3,135	0.52%
1898/99	32.2	17,710	2.54%
1900/01	118.9	65,392	9.17%

**Table 2:** Development of saccharin consumption in Germany (1888-1900) as a share of sugar consumption<sup>28</sup>

The initial success of saccharin was thoroughly observed by the sugar industry. In several European countries, around 1900 an anti-saccharin campaign was initiated. This campaign exemplifies attempts to influence common beliefs about the health effects of a consumption item and the instrumentalization of science by interested parties (see for a detailed description Merki 1993: 81-89). Scientific knowledge about the health effects of food items usually is found among toxicologists and food chemists. In France, the physician Jules Worms reported several cases of digestion problems following the consumption of saccharin in a lecture at the Parisian Academie de Medicin. Nationalistic journals took his talk as an occasion to agitate against the “foreign substance” (Merki 1993: 83). Political authorities that were because of the fiscal importance of the sugar tax a natural ally of the sugar industry (Merki 1993: 73) decided to forbid the import of saccharin.<sup>29</sup> Although it took only one year that the scientific authorities of the ‘Comite de Hygiene’ revised their vote against saccharin (Worm who used to be the physician of two major sugar refiners was accused to have acted unethically), the image and reputation of saccharin had taken damage. The saccharin industry, of course, also started employing experts in order to reject these rumours. However, since this image campaign had to carry the burden of proof, i.e. the impossible task to verify the harmlessness of saccharin consumption, the success was only very modest. The comitee had recommended to use saccharin not as a regular food but as a medicine. Now, representants of the sugar industry argued that a substance the usage of which had to be allowed by a physician simply could not be harmless. In addition, the German sugar industry employed contract research and published critical “scientific” assessment of saccharin’s health impact in order to ruin its reputation (Merki 1993: 84).

When cognitive learning is regarded to be contingent on norms, it can be argued that believing the alleged negative health impact of saccharin was consonant with its low social prestige. An indicator for the latter is the commitment of a domestic servants’ club in Germany not to work for people who sweetened their coffee with saccharin instead of sugar (Merki 1993: 70).<sup>30</sup> The historical development of saccharin purchases in Germany between 1903-1944 provides an indication for the persistent surrogate character of saccharin

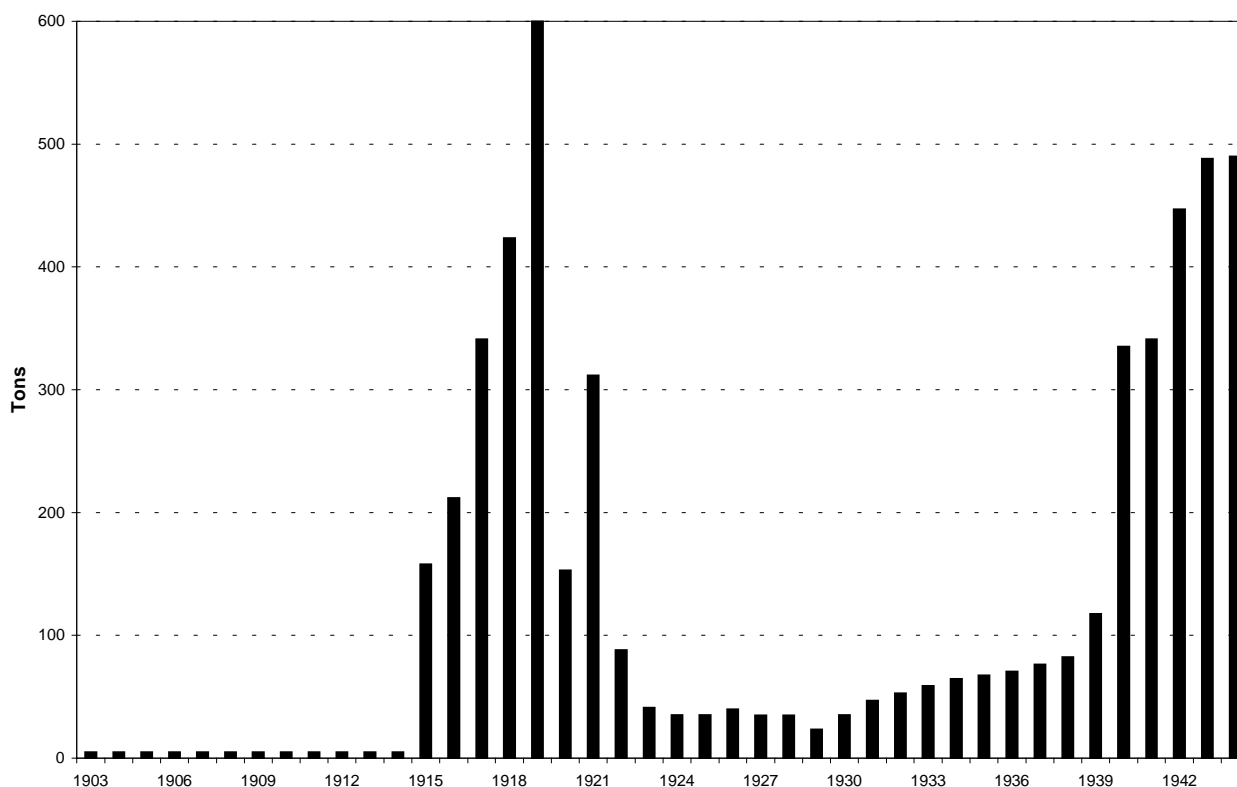
<sup>28</sup> Source: Merki 1993: 60

<sup>29</sup> 1902, saccharin was forbidden by the German government and around the same time in Spain, Portugal and the USA (Molitor 1986: D39). In Germany, it was re-introduced not earlier than 1916.

<sup>30</sup> Besides the low price, the fact that saccharin is synthetically produced and its originally bitter after-taste could have contributed to the low status, too. However, the taste of saccharin improved soon (Merki 1993: 57/58).

Figure 6: Saccharin sales in Germany 1903-1944

Source: Merki (1993)



Since sweetness was already established as a flavor principle, in times of sugar shortage inferior saccharin provided sweetness. As soon sugar was available again consumers switched to the original.<sup>31</sup> Even the saccharin industry seems to have perceived their product to be rather a predecessor than a substitute competing with sugar that would disappear when incomes increased. 1900, in a letter to the Deutsche Reichstag industry representants predicted the following development: *“Die ärmsten Schichten der Bevölkerung ... erhalten jetzt in dem Saccharin ein Gewürz, das ihnen für wenige Pfennige die Möglichkeit giebt, ihre Speisen und Getränke ohne fühlbare Vertheuerung wohlschmeckend zu machen. Das Saccharin erweckt bei diesen Bevölkerungsschichten das Verlangen nach Süße und erzieht ihnen...das Bedürfnis zu einem ihnen bisher unbekanntem Genußmittel an; im gewissen Sinne ist also das Saccharin ein Pionier für den Zucker, und es steht außer Zweifel, daß die gegenwärtig Saccharin konsumierende Arbeiterbevölkerung mit der Verbesserung ihrer sozialen Lage (...) zum Zuckergenuß übergehen wird.”* (see Merki 1993: p. 68) The prediction that saccharin could show the typical development of an inferior good revealed to be wrong.

### 3.3.2 The Second Diffusion Process of Artificial Sweeteners

In the first diffusion process of artificial sweeteners, saccharin failed since it had the image to be a surrogate for people that could not afford the original (see also Merki 1993: 68). The lack of nutritional content made it inferior to sugar which was, then, still a luxury. After all, it did not last until 1970 that the saccharin industry applied the low calorie content of its product as

<sup>31</sup> see also Molitor 1986: D 53 who nicely illustrates the sugar shortage during the wartime; that a similar development has been taken place in the USA can be concluded from a comparison of Stare’s (1975: 242) data on the development of per capita consumption of sugar during the wars with Molitor’s (1986: D 52) data on US saccharin production 1900-1984.

a marketing argument, in addition to the lower price. Already in 1889, Fahlberg's saccharin company intended to sell saccharin to high income groups who were scared of sugar's caloric content. (Merki 1993: 78). In 1932, saccharin was advertised by the slogan: "*Millions want to keep their weight – millions want to save money.*" (Merki 1993: 78). This campaign, however, was not too successful. It can be imagined that saccharin's low social prestige has prevented this message from being transformed into actual behavior.

In order to explain changing consumption behavior by cognitive learning, I will have to address the tightness of consumer beliefs. Subsequently, changes in the preconditions for the transformation of knowledge into beliefs are described. My central point is that due to newly arising beauty norms, obesity became a social stigma. It can hardly be denied that the sufficient availability of food is not only a precondition to get satiated but, additionally, to become obese. There is a positive correlation between caloric intake and body weight. Obesity is, however, a matter of cultural norms and subjective perception.

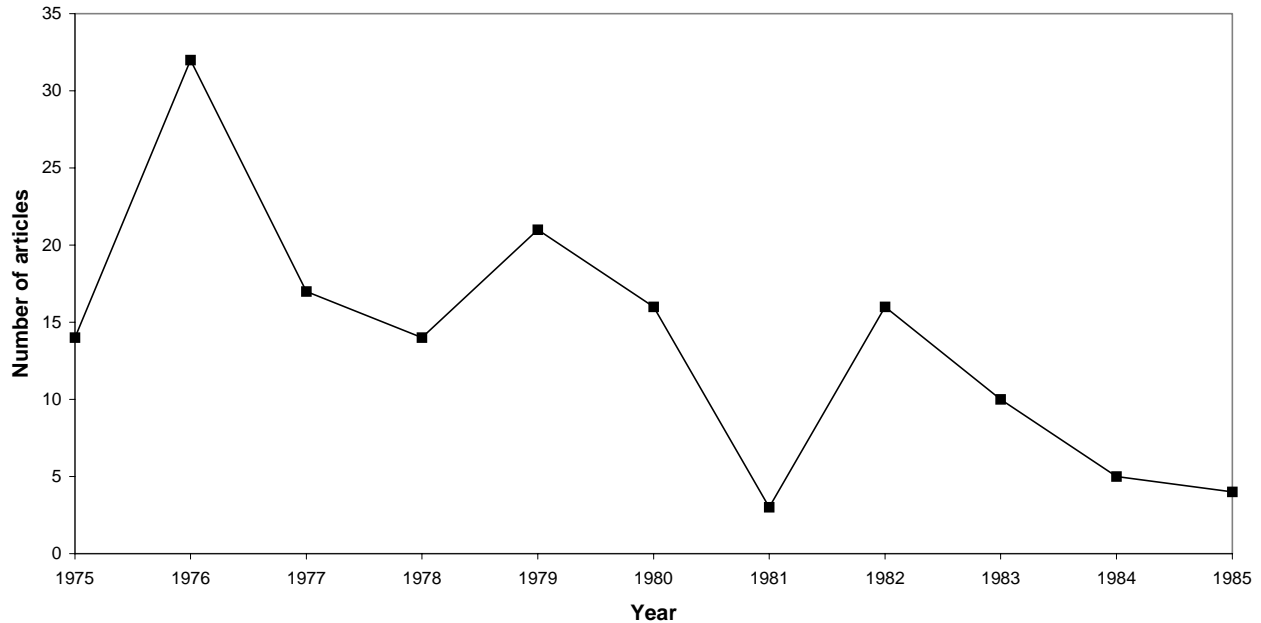
Menell (1986) connects the improved nutritional conditions with social norms when he argues that in Europe the fear to become obese has spread from the upper classes downwards since the 19th century. He stresses rather cultural than medical causes: under conditions of affluence for the upper classes gluttony and body weight as a symbol of social distinction was simply replaced by the opposite (Menell 1986: 407). For this hypothesis he gives some evidence: a comparison of the weight of three generations of British aristocrats shows that the younger generations were lighter although in old age, all generations finally reach the same weight. More sound is the observation that cases of anorexia are disproportionately often among high income classes and widespread in Europe and North America. (Menell 1986: 419).

It may be worthwhile to add in this context, that according to clinical measures nowadays 20-30% of the US population are obese. That, in contrast, 70-80% believe that they are obese shows the difference between the scientific measure and social perception (Merki 1993: 78; Molitor 1986: D54). The fear to become obese has a significant gender bias: by current estimates, 39% of American women and 25% of men trying to lose weight (Drewnowski 1999: 758). Pliner/Chaiken (1990; cit. in Grogan et al. 1997: 20) report that "snacking", i.e. eating outside main mealtimes, is a particular problem for women, who risk social censure for not "eating lightly". That eating was subject to corresponding social norms finds a sound illustration in the label "Du Darfst" that is a famous brand name for light food in Germany. More evidence in favor of the gender bias hypothesis provides Logue's (1995: 271) observation that the winners of American beauty contests got permanently thinner during the last decades. Hence, there are reasons to assume that the fear to become obese may be more relevant than obesity per se in the context of consumption. Moreover, this fear was a new source of motivation. Hence, the cognitive learning approach provides an argument for changing consumption that is different from Lipsey/Rosenbluth's decreasing motivation for the caloric dimension of food items.

In the mid-1970s sugar in the diet had become a major scientific issue in Europe. This was accompanied by considerable public attention. Fischler (1987) surveys the frequency of negative comments about sugar in selected journal in France.

**Figure 7: Number of articles specifically addressing sugar in French press publications, 1975-1985**

Source: Fischler (1987)



For UK, Fine et al. (1996: p. 117) report the following: *"...in a review of a random sample of British regional newspaper cuttings between September 1987 and October 1990 that reported on sugar, diet and health, a total of twenty-five different illnesses, diseases and ailments were associated or linked with sugar consumption..."*. *"These have included dental caries; problems of the stomach (gastric and duodenal ulcers); problems of the large and small intestine; metabolic problems, such as overweight, vitamin and mineral deficiency, diabetes mellitus, cardiac and circulatory diseases; some cancers; and the influence on and alteration of behavior..."* Moreover, between 1974 and 1996 British authorities have published 12 reports giving dietary advice and recommendations including information about sugar consumption. Among these the most important one was the NACNE report from 1983 the bibliography of which included more than 900 references (Fine et al. 1996: 116). It recommended to reduce annual sucrose intake to 20 Kg per person, i.e. to the half of the present consumption.

It has to be recognized, however, that the above cited cause-effect relations of sugar cannot be taken as objective truth. They are rather highly disputed in the scientific clinical literature. In the case of dental caries, however, a direct impact of sugar consumption seems to be confirmed: *"It requires the presence of microflora, notably Streptococcus mutans, in the mouth. It is affected by the presence or absence of fluoride in the water supply and by the dental hygiene practised by the individual. Certainly sucrose is a preferred substrate for S. mutans, being converted into acids which attack the teeth."* (Hugill 1979: 24/25) An evaluation report of the Federation of American Societies for Experimental Biology (FASEB) comes to the following conclusions: *"1. Reasonable evidence exists that sucrose is a contributor to the formation of dental caries when used at the levels that are now current and in the manner now practised. 2. Other than the contribution made to dental caries, there is no clear evidence in the available information on sucrose that demonstrates a hazard to the public when used at the levels that are now current and in the manner now practised."* (cit. In Hugill 1979: 24-5; see for similar statements Stare 1975: 244-5 or Trowell 1975: 161). In

other words: A simple cause-effect relationships between sugar consumption and the emergence of coronary heart disease, diabetes mellitus, or obesity cannot unambiguously be stated. For all three diseases multicausality can be assumed.<sup>32</sup>

More crucial than the scientific evidence or “truth” of the alleged effects is their consistency with social norms. An item that is assumed to cause obesity is easily believed to cause other problems as well.

Industrial food producers have reacted to changing concerns about negative health effects of sugar. When around 1980 publicity of healthy eating was at its height, food and drink manufacturers started supplying sugar-free and sugar-reduced products. This was possible even without abandoning sweetness as the dominant flavor principle since the new HIS had entered the market. The most famous ones are cyclamate, acesulfame K and aspartame.

- Cyclamate was invented in 1937. Being relatively expensive, its sweetening force is 30 sugar equivalents. When medical studies reported carcinogenic effects of cyclamate its use as a food additive was forbidden in the UK in 1969 and in the US 1970.
- Acesulfame K(alium) is 130-200 times sweeter than sucrose.
- Aspartame was invented in 1965. It is 200 times sweeter than sucrose with a similar taste profile. Aspartame has been marketed not only as table top sweetener under the label of NutraSweet. NutraSweet was the first ingredient having a brand name. In 1987 and 1988, the Pepsi and the Coca-Cola companies changed from a aspartame/saccharin blend to 100% aspartame as ingredient for their diet soft drinks. (Heasman1990: 7)

Partly, the status improvement artificial sweeteners experienced can be assigned to the objective technical changes of the product, i.e. the new artificial sweeteners having a superior taste profile compared with saccharin. None of these HIS was a perfect sugar substitute. Liqueurs, for instance, cannot be sweetened with saccharin because consistency changes and and “body” of the liqueurs cannot be achieved (Merki 1993: 62). Aspartame, moreover, lacks long-term stability and cannot be used in foods which have to be baked or heated (Molitor 1986: D44). Acesulfame K is comparatively more stable but has a bitter after taste. These problems, however, can partly be overcome when two or more of these substances are mixed.

But also subjective beliefs improved the consumer valuation of artificial sweeteners. Consumers perceive the substitution of sugar by low-caloric sweeteners as a means to lose weight. Drewnowski (1999: 758) reports that among the most frequent weight loss practices were the use of diet soft drinks (by 52% of women and 45% of men) and of tabletop intense sweeteners (43% of women and 33% of men). Scientific experiments, however, do not unambiguously support his believe. Molitor (1986: D 52) reports clinical experiments for weight reduction in which the test persons’ diets contained low caloric sweeteners without the test persons’ knowledge. The experiments, however, did not lead to the expected result, i.e. weight reduction. To the same topic, more recently Mela (1997: 837) assesses: *“Research...has tended to focus heavily on short term and laboratory based experiments*

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<sup>32</sup> Of course, there are correlations between the increased per capita consumption of sugar and certain diseases. These correlations that reveal at the population level (Mokyr 1996: 22) should not be mixed up with a causal theory. To illustrate this point, I borrow an example by Joachim Schwerin (1999: 54). At the aggregate level there can be a stable positive correlation between the amount of sweets a person consumes and the probability that he or she won’t get divorced. An indirect impact of sugar consumption on obesity can nevertheless, be assumed. As a pure carbohydrate, sucrose is lacking any proteins, vitamins, fibre and fat and other substances that are part of a balanced diet (Merki 1999: 232). Some authors consider obesity to be caused by a general fibre deficiency in the daily diet (Trowell 1975).

*under controlled conditions, but the answers to the questions posed will require greater consideration of the long-term behaviours of consumers consuming real foods under normal conditions.”*

Merki (1993:78) assesses the alleged positive health impact of artificial sweeteners to be a placebo since there is a difference between scientific knowledge and actual beliefs. Given, that the assumed connection between the consumption of low caloric sweeteners and body weight is not falsified yet, I restrain from the placebo notion. Apart from discussing the objective truth or falsity of this relation, it can be conjectured that these broadly spread beliefs had a chance to be transformed into actual consumption behavior not because they were true or undisputed but because their promises were consistent with the social beauty norms.

Artificial sweeteners offer the possibility for a substitution pattern (Heasman 1990) that is rather conservative compared to the substantial changes of the diet structure that occurred in the 19th century: sweetness as a flavor principle is not abandoned.

The empirical evidence of two coexisting markets for sweeteners<sup>33</sup>, a regular one and a light one, confirms the relevance of norms for consumption behavior. Heasman (1990: 11) interprets the coexistence of lite and regular market segments in the following way: *“... the importance of cultural and societal factors in the growth and development of the “lite” market, rather than the simple health messages cannot be overemphasised. Consumers are being influenced by “image” messages rather than being motivated by the strict health message.”* Consumers in the two market segments differ with respect to the question whether they perceive and trust health messages or not. The line between the two market segments is exactly along the same (gender and social) lines as the diffusion of beauty norms that was mentioned above. Fine et al. (1996: 225) report for the period between 1979 and 1989 differences between UK income percentiles with respect to the frequency of sugar consumption. According to Heasman (1990:7) females in the age between 16 and 54 are the primary purchasers of light food and table top sweeteners.

In this light, non-caloric sweeteners seem to be rather a specialization than a sugar substitute in the market for sweeteners. In advertisement campaigns and on packages the attribute “sugar free” is applied as something positive. Artificial sweeteners clearly have lost the surrogate status saccharin had 80 years ago: although the production of artificial sweeteners is relatively cheaper than sugar, consumers are willing to pay the same price for lite products as for the regular product (Heasman 1990). The future will show, however, whether the current state of market segmentation between caloric and noncaloric sweeteners will become permanent or whether it is just a transitory state in a diffusion process.

#### **4. Conclusion**

In this paper, a positive approach on evolving consumer preferences was presented. The proposition of two innate learning mechanisms is consistent with a consilient perspective on human behavior. Since both learning mechanisms have revealed to be historically contingent, the conditions under which learning is possible were given special attention. The usefulness of this approach for the explanation of historical economic change has been illustrated in a case study on the historical development of sweeteners consumption.

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<sup>33</sup> This holds for table top sweeteners as well as for their indirect consumption.

In Europe and elsewhere, the annual per capita consumption of sugar equivalents has extraordinarily increased during the last 200 years. Several technological innovations have made this development possible. During the industrial revolution, sweetness became the dominant flavor principle. For the transition from small scale production of food to industrial mass production the reinforcing role of sugar has been crucial. Since 1970, the consumption structure of sweeteners has been changing: caloric sweeteners are substituted by non-caloric sweeteners. That in times of food abundance the need for calories is diminishing is plausible but only a part of the story: in the developed countries, beauty norms were changing when the food supply improved. The fear to become obese has disseminated particularly among women. Under these conditions, scientific and unscientific beliefs about detrimental health effects of sugar and the weight reducing impact of artificial sweeteners have become tight.

Hence, in the case of changing flavor principles as well as in the case of caloric satiation, the cultural level of behavior seems to have adapted to the genetic level.

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