HOW PSYCHOPHYSICS CHANGED THE FOOD BUSINESS, AND HOW THE FOOD BUSINESS FOREVER CHANGED PSYCHOPHYSICS

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Abstract

Through a short history of how psychophysics was taken into the bosom of the food industry, this paper shows some of the principles by which one world can learn from another, and promote change in the other.

In 1969, the start of this short history, psychophysics was just taking up the issue of sensory processes in taste, smell, and texture. At the same time, companies, especially those involved with food and drink were discovering that the subjective perception of products was an important 'thing' to understand. And, as it turned out, companies looked around for experts to help them. What happened one pivotal moment of the search, what led up to that pivotal moment, and the impact of that change constitutes the rest of this paper.

The history of psychology has a way of repeating itself in new domains. The world of food is one of these domains. In the late 1800's and the early 1900's, it was all the rage to describe one's perceptions. Put more soberly, the Structuralist School of psychology believed, as did followers of the naturalist Linnaeus, that one could learn a lot by classifying the objects one studied. Taking a cue from Aristotle, it was obvious that good classification would reveal the way the world works. At least that's what it seemed. And so psychologists would instruct observers to introspect, to list their sensations, perhaps in the order that these sensations appeared when a stimulus was experienced.

Scientists in the food industry recognized the value of introspection to foster 'flavor leadership' (a term coined by Cairncross and Sjostrom (1950) of the Arthur D. Little Company, a consulting group in Cambridge). So, in the 1930's and 1940's, decades after introspection had enjoyed its heyday in psychology, you could find panel after panel of dedicated employees, tasting beer, canned food, and so forth, seeking the elusive sensations. As psychologists had done years before, food researchers would now spend inordinate amounts of time refining the lists of terms, identifying which terms were redundant, and of course developing their own language to describe the meta-sensations, the perception that the notes blended together. All this is written up, of course, in many papers and books. Just Google the term 'descriptive analysis in food' to get a sense of the wealth of material and the efforts made. Ah glorious days of full employment, just sensing and talking.

So, as we leave the 1940's and 1950's we note simply that the food business had generally recognized the importance of the senses as drivers of product acceptance. The Great Depression and World War II had come and gone. Food, once rationed and readily accepted at almost any quality as long as it was edible, changed character with the growing affluence of countries. Food now had to taste good. Flavor, texture and appearance had to be 'just right'. Quality was critical. And for the specific tools – they were primarily the aforementioned descriptive analysis which educed the sensory profile of food and acceptance measurement using a 1-9 point scale measuring degree of liking (Pilgrim & Peryam, 1957).

Psychophysics meets the food and drink industry

By the start of the 1960's psychophysicists were working assiduously to understand the relation between physical stimulus and sensory response. Gone were the tedious experiments to determine JND's, and by so doing erect a scale. Those experiments might be fine for Fechner and his followers, but the new spirit of direct scaling was blowing through the different departments of psychology. Stevens and his cohorts were letting people assign numbers to stimuli so that these numbers matched the perceived sensory intensity of the stimuli (Stevens, 1975).

Whether you were in Stevens' camp, against it, or even indifferent to psychophysics and its travails, you had to pay some attention. And they did pay some attention in the food industry. Of course most people in the industry didn't know what to make of it. The world of sensory evaluation, where this 'psychophysics stuff' would properly and eventually reside, was busy trying to do tests of acceptance, tests of difference, and in general answer the questions that came down to '*what do people think about this product*?

Something else was starting to happen, though. As in all worlds of business and science, people liked to meet each other, to discuss issues, and of course to eat and drink together. And so there were meetings in the world of food; some large like the annual IFT meeting (Institute of Food Technologists), and others smaller and more intimate, by invitation only, like meetings about specific topics in nutrition and dairy science. What is important for us here is that among the invitees to these smaller meetings were experimental psychologists, who, no surprise here, focused on the sense of taste and smell. Of course there weren't many of these meetings – one or two a year across all the disciplines of food, but it is important to note that psychologists were invited to present papers on this newly discovered area, hot area, called 'sensory psychophysics'.

So, what interested the people in the business world? Why were these sensory psychologists and psychophysicists invited in the first place? We might start with who they were and how they got there. Those facts alone tell a lot of the story. The food and drink business began to train chemists and other bench scientists in this new world called 'sensory analysis'. These scientists, really developers of a new field, needed guidance. Many of them read the literature, mainly because they had been educated in the sciences and were accustomed to reading literature. Most were BA's and MA's, not Ph.D.'s. These newly emerging 'sensory analysts', as they would call themselves, often attended meetings where they would bump into psychophysicists invited to give presentations on the sensory perception of taste, smell and texture. And so the contacts were made.

Whether through the literature, through meetings, by attending specialized professional groups such as the ASTM (American Society for Testing & Materials), Committee E18 (Sensory Evaluation), the word got out. The game was afoot. Psychophysicists were doing interesting things with chemical stimuli that might apply to foods.

Enter the US Army and the early magic

Let's go back 40 years ago, to the late 1960's to continue the rest of the story, this time from personal observation. Let's see what 'may' really have happened. The word 'may' is

appropriate, because like any story, there are different vantage points. But there seems to be a starting point, some time in the late 1960's. That point coincides with the very strong push by psychophysicists from Harvard and their like-minded colleagues. The research to develop power functions to describe how sensory intensity might co-vary with physical intensity created a hard-to-ignore database of findings. No one, either positively disposed or even downright hostile, could ignore the fact that these psychologists in their laboratories were on to something.

As luck would have it, during the 1960's, the US Army Natick Laboratories in Massachusetts, the former Quartermaster Corps, kitchen to the United States Army, had regrouped after its move from Chicago. The Natick Laboratories in certain ways was industry's link to the food world, both in academia and to industry. The government could afford to hire scientists to do basic research, and hire it did. Dr. Harry Jacobs, a well-recognized scientist in the world of food intake, animal preparations that is, became the chief of the Behavioral Sciences Division, with a mandate to extend the army's knowledge of what foods soldiers liked. This mandate extended to psychophysics. And it was psychophysics with a vengeance. Jacobs hired in quick succession Drs. Linda Bartoshuk, the author, and Herbert Meiselman.

And so began the importation of psychophysics into industry. The food and drink business would never be the same.

Looking back at the secret sauce – Stimulus-Response relations

Hindsight is a great teacher, the great unraveler of what might seem at the time to be mysterious. And so it is the case with psychophysics and business. At Harvard the focus was on the way the senses worked, as revealed by scaling perceived intensity. It was all so clear, so obvious, so interconnected that at the end of the process one didn't know which of the parts of psychophysics would be the most valuable to industry. Would it be magnitude estimation and the creation of a valid ratio scale? Or would it be stimulus-response relations, the kind that led to a power function? Or would it be the actual exponent of the power function, with everything just swept under the rug as standard operating procedures, not worth spending too much time explaining?

The first forays into the business world focused on convincing them that magnitude estimation, the scaling method itself, was the pearl without price that they should admire and adopt. But that was the wrong thing. Certainly in those days not many in the food industry were familiar with magnitude, and all people liked to talk about scaling because, quite frankly, they could pontificate without knowing anything. The magic, instead, as it would turn out, was the relation between stimulus and response. And, furthermore, it would turn out not to be the power function at all. The power function had nothing to do with the magic, and the exponent was irrelevant. Rather, it was the quantitative relation, a curve, showing how sweetness or bitterness, or hardness or whatever of interest changed. Such a simple 'work-product', but with what fascinating consequences.

The 'secret sauce' – focus on liking, not on sensory intensity

If the 'secret sauce' was the relation between stimulus and response, the real magic was this relation, but with the response or rating being 'liking'. You see, business professionals may be interested at a theoretical level of how the sensory system processes the stimulus to convert

it into sensory intensity. It's a 'nice to know' *as a factoid* that the relation between say the amount of sucrose (cane sugar) and sweetness can be described by the power function Sweetness = k(Sucrose concentration)$^{1.3}$. It's a lot more exciting to business to know how liking co-varies with the amount of sucrose. Is the relation a straight line? No. It is more like a parabolic curve, an Inverted U curve, with a peak at about 10%, which coincidentally is the approximately level of sucrose in cola. Now that's news. It's something people in business can use.

So what does this mean? What do we learn? Well, we learn that the magic of psychophysics to business is the 'quantitative relation between level of a stimulus and degree of liking'. That relation makes a great deal of intuitive sense. Business people in the food industry aren't turned on by how we transform sucrose to perceived sweetness or sodium chloride to perceived saltiness. Perhaps those might interest someone. But it's the really practical stuff, the stimulus-liking curve that caught attention, which launched psychophysics in the food industry. The curve was just plain practical. You knew where the product was too sweet, and where the product was not sweet enough. That curve is a factoid for sugar water, but oh so important for a cola or a lemon lime drink.

So what are we to make of this secret sauce and magic? Readers with a penchant to understand the 'why's' and lessons of history might want to ask why it took so long, from the 1950's to the early 1970's, for psychophysical thinking to penetrate the food industry. One answer is that the topic had to be relevant; liking, not sensory intensity. The second part of this answer is that psychophysicists shied away from liking as a dependent variable. There's a Latin proverb, '*De gustibus non est disputandum*', i.e., there's no accounting for taste. To the psychophysicist, and especially to Smitty Stevens, this intractable, person-to-person variability in liking ratings was simply unacceptable. Hedonics were out as a proper subject for psychophysical investigation. The food industry, focusing on products, is very interested in liking, we might say even consumed by it. And, at the same time, professionals in the food industry know that there's a lot of person-to-person variability in liking. That's just the way things are in the world.

Another secret path to the food industry – beyond 'one at a time' thinking

The food and beverage industry didn't just flirt with and then adopt psychophysics because of hedonics, or even because psychophysicists such as Gosta Ekman in Europe and quasi-psychophysicists such as Rose Marie Pangborn in the United States published papers on the intensity of liking versus stimulus concentration. Hedonics may be nice, but it's not the big picture. There's not enough horsepower alone. Perhaps the real breakthrough came when psychophysicists started working in the food industry, investigating problems with multiple ingredients. In other words, real food. Cola is sort of real. Pasta sauce and salad dressing are actually more real.

It would take four more, separate, paradigm-ruffling steps, to push psychophysics firmly into the heart and bosom of the food industry, teaching us that change is not automatic.

1. <u>Multiple variables one time is more realistic</u>: The problem had to have multiple variables, preferably variables which interacted with each other, and which affected different senses. Just think of pasta sauce. You have color, texture, aroma, taste. You don't have sound, but you could. Sound would come later with the texture of potato chips. Once enterprising psychophysicists realized that 'mixtures' of stimuli were where the action would be, they

quickly rushed to these mixtures. You only have to read the literature of the early 1970's to see the burgeoning interest of psychophysics, especially those in taste and smell. So, from a world of uni-variate functions and such nice tractable relations that one might see with the variation in sugar and salt levels, the psychophysicist got into the messy world of mixture. It had to be that way. Nature doesn't confront us with simple sugar solutions, and there's precious little to be learned about our food from these uni-variate relations. Horace Greely might have pontificated 'go to the mixtures, young man, and grow with the opportunity' had he been a research advisor in the 1960's, rather than an American in the 1840's. (Actually the quote is mis-attributed; it was actually from the title of an editorial by John B.L. Soule in the Terra Haute Express!).

2. You've got to test many stimuli: The psychophysicist had to be ready to deal with many different stimuli, systematically arranged by experimental design. This was also no problem. Of course it was a bit more difficult to deal with 45 mixtures of six ingredients, than to deal with six levels say of sucrose. On the other hand, the education of a psychophysicist was in mixtures, especially those researchers who had studied enhancement and suppression. So, in the end, there was no real problem here.

3. But don't be obsessive – use an efficient experiment design because time and effort are money: To those of us educated in classical psychophysics, a good experiment is a full factorial design. That is, if we have one factor or variable, say amount of tomato pieces, we would evaluate five levels. Now add in onion, and we might evaluate four levels. Finally, add in sugar and we have another four levels. The traditional psychophysicist interested in the deep knowledge about pasta sauce would study all 5 x 4 x 4 or 80 combinations. A lot of work, there. Maybe it's acceptable for a Ph.D. thesis on the psychophysics of a food, but it's not acceptable for a business problem, just one problem of many in a typical work week. Statisticians can design a smaller set of combinations. The results won't be as powerful, but they'll do the job.

4. The world as if: Psychophysics looks for equations which ***truly*** capture how sensory processes work. Anyone who worked with Smitty Stevens, those near and dear to him, began to believe in the absolute reality of the power function as the 'true' equation to describe sensory intensity as it co-varies with physical magnitude. Of course there was the perfunctorily dutiful statement '*as a first approximation*', one of Stevens' favorite expressions. But… the reality was that the power function WAS the correct equation, for a variety of reasons too complex and too tendentious to deal with here. Yet the business world would have none of this. It was hard enough to convince them of psychophysics of pasta sauce. A power function was simply out of the question. Especially because it was hard enough to deal with linear and quadratic equations. Since we were dealing with liking, a good old fashioned second order polynomial equation was fine. The polynomial equation would describe the data, and the quadratic term would capture the fact that maximum liking could be in the middle of the range. So much for fundamental functions. Psychophysics was one thing; slavish adherence was another, and business wouldn't abide that.

And so psychophysics came to the food industry

When it comes time for another historian of the food industry to write about the contribution of sensory analysis, no doubt psychophysics will play a role in this history. What type of role remains to be seen. History is written by the winners, by the survivors. Psychophysics might well be seen by these writers as instrumental to the growth of consumer research as key to driving new understanding of foods.

Certainly, however, from our vantage point today in 2009, we can draw at least five lessons from psychophysics and the food business.

1. Ideas take time to grow. Psychophysics wasn't ready for the big time business world until it, itself had matured.
2. People, really evangelists, are critical. Without the active, albeit perhaps not conscious proselytizing by psychophysicists in the 1940's and 1950's, we might not have seen psychophysics enter the food industry. It was people who spread ideas. People like Carl Pfaffmann and Roland Harper.
3. People take what they want, and leave the rest. Psychophysics didn't get imported lock, stock and barrel. It was really psychophysical thinking that was embraced, the notion of lawful relations between stimulus and response. At the same time, the tool, magnitude estimation was examined through and through, and discarded as unwieldy.
4. People will do what they want with what they take. You may not recognize the work-product. It makes no difference what the 'proper' approach may be. Certainly no one begins to go counter to conventional wisdom when borrowing ideas from another field. But it just happens. And perhaps that's not so bad. Borrowing ideas from psychophysics, business builds applications, which makes the psychophysics even more relevant.
5. New ideas spring from old ones, in ways that one least expects. There's no room to go into concept development. But imagine that instead of creating a model for pasta sauce in six physical variables using psychophysical thinking, we create a model for six different types of ideas, using psychophysical thinking, or at least psychophysical inspiration. That's another story. And as Fermat said, the margins are too narrow for the proof. And this paper must be finished now, because there are only six pages allowed.

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