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Optimizing Food and Beverage Product Development: From the Past to the 21st Century and Beyond

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Abstract: Psychophysics is the oldest branch of experimental psychology, devoted to understanding the relation between physical stimuli (e.g., ingredients, processes) and subjective response. When applied to developing food products for commercial use, psychophysics takes on a new role, as a center point in an evolving ecology of many unrelated but relevant disciplines and professions. We present a short history of the application of psychophysics to the world of food product design, and the ecosystems which grew around it, evolved, changed, and had to be reengineered to be relevant for the 21st century.

Keywords: *Ecosystem, Psychophysics, Experimental psychology and Psychology.*

1. Introduction-Innovation

Until recently, perhaps until the beginning of the 21st century, the development and marketing of foods and beverages may be considered to have been in a blissful world of minimal competition. The adage that 'people always have to eat' lulled many managers in companies to feel that they need only follow current 'best practices' to ensure the success of their products, and coincidentally the safety of their jobs. This complacency was endemic in the world of fast-moving consumer goods, mostly in the domains of knowledge workers, those involved in the acquisition of knowledge from consumers.

The reality of the world of food and drink was quite different, however, from the blissful ignorance that best practices bestowed upon the willing followers. Methods such as Stage-Gate and the procedures of market research from need assessment at the beginning to STM (simulated test market) at the end often predicted success that simply did hold up [1,2]. 'Off the record' professionals in the food industry talk about very high, double-digit failures in the introduction of food products, although there are always excuses about the specifics, such as the introductions are not new products, but new flavors of the same product.

A lot of these failures can be attributing to faulty knowledge, the wrong knowledge, and the siloed nature of the knowledge-worker in the food or beverage company. The adage applies here, 'success has many fathers, but failure is an orphan'. The reasons for any product failure can be traced to single causes, but more often to a combination of causes, most of which are beyond the ability of the developer to correct. There are issues regarding fast moving markets, incomplete knowledge, faulty advertising, faulty pricing, faulty promotion.

There is rarely, if ever, an acknowledgment of the collapse of the infrastructure leading to success, such collapse resulting from the abandonment of common-sense 'homework' needed to make the product a success [3,4]. The picture of the food and beverage industry just painted led to a standardization of approaches, and a slow-moving industry, where risk aversion ruled the day, and where testing evolving to a world of, rigorous, expensive, and slow-moving best practices. The funds for experts on consumer and sensory work were allocated, the professionals were in place, often for many years at the same company, the 'supplier' or 'vendor' was selected, and the processes of development/testing/introduction proceeded at a relaxed, leisurely pace. The cadences of work reflected 'professionalism of process,' rather than business and market sensitivity.

A great deal of the slow and majestic pace of food companies came from the fact that the feedback loops were slow, there were relatively few small companies competing with the large companies, and the quality of store brands, private labels, were not high. A great of effort was expended by companies to build brands, and to make sure that the quality of the foods being sold in the store was maintained. And, perhaps the most important thing of all was the fact that there was relatively little imagination, so-called 'thinking out of the box'. Technological advances were at the level of ingredient substitutions, either to deliver sweetness, saltiness, more 'authentic flavors', with fewer side problems, such as calories, health issues (e.g. blood pressure) or safety. The absence of imagination was not so much manifested in the lack of innovation, for there was always a dazzling array of flavors, but rather the lack of small companies ready to try something new, something risky.

1.1. What Consumers Can Tell You, and What They Cannot

The traditional methods, dating back decades, has been to identify a consumer need, create some products, test these products, and then rolls out the testing. The approach has tended to be haphazard, done as a collection of siloed efforts, usually over a long time period, with careful attention to the precision of measurement, to the proper use of statistics, and generally to a defensive position in the research in order to avoid exposing one's work to criticism.

It has long been thought that an insightful interviewer can pull out unknown needs from a consumer, with the interview conducted either with one person (in-depth interview) or with a group of consumers who chat with each other and with a

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skilled moderator (focus group.) This is not the venue to discuss the degree to which this research, qualitative research, accelerates the development process. The methods are popular, appear to work, and are the staple of the very early stage of development, when one wants to 'learn about the product and the category'. When the developer creates one or more prototypes, the early stage interview, this qualitative step in development provides valuable feedback about the way the consumer responds to one or a few instances of a product [5].

Beyond the qualitative research there was a world of testing. Often the testing would be done in the development facility by in-house researchers, so-called the sensory evaluation group, who often promoted their use by appeal to being local, and the lowest budget provider of knowledge whether it was the in-house group or the external research supplier, the so-called vendor, the pattern was fairly similar. The product developer would submit one or two products, prototypes, variations of the new products that were thought to be ready for testing. The research vendor or the sensory group would then assemble a panel of 25-100 respondents, test the products, either one at a time (sequential monadic) or head to head (paired comparison). The data would tell the developer just what seemed to be ok with the product, and what seemed to be wrong.

These product tests were reasonably fast, provided little in the way of 'actionable' of immediate use to the developer. The studies revealed egregious problems with the prototypes, but often the direction for further development could not be obtained beyond the simplest, most obvious flaws in the product, flaws needing correction. The problem was that the developer submitted only one product, requiring the respondent to do all the work. Methods such as the JAR, just about right scale, and the ideal product, developed by author Moskowitz [6], could not show the formulation level, unless the developer was able to create the products following a systematic plan, an experimental design.

Nonetheless, often just having the information about the problem of the product (e.g., too sweet not natural tasting) often was good direction, and satisfied the product developer, although just knowing the problem did not reveal the solution. That direct solution was often left to the developer, with the off-hand statement 'the developer knows how to use these results'. The off-hand statement may have been true but seems never to have been demonstrated in a repeatable fashion.

1.2. Enter the World of Psychophysics and the Emerging Ecosystem Around it

The opportunity to create an ecosystem of knowledge for product design and development comes, surprisingly, not from the most modern of techniques but rather from the oldest field of experimental psychology, psychophysics. Psychology today is a broad field, ranging from dealing with personality and its problems (clinical psychology, personality psychology), all the way to studies of the brain, and the function of various parts of the brain in behavior (neuropsychology). Psychophysics, a sub-specialty in the broad word of experimental psychology, comprises the systematized study of the relation between physical stimuli and subjective responses. Psychophysics got its start almost two centuries ago, in the psychological laboratories of some famous German scientists, such as Herman Helmholtz. The notion was a philosophical issue, namely relate what we think we experience to the physical stimulus driving the experience.

In the history of experimental psychology, the early studies in psychophysics were crude, abstract, and from our point of view today (2019) somewhat relevant, but just how and why? The researcher would present a stimulus and instruct the respondent to react as quickly as the stimulus was sensed (or its quality recognized). This was called reaction time. Or the researcher might diminish the physical intensity of the stimulus, either in a straightforward manner or in in irregular manner to hide the pattern, and wait until the respondent answers 'I detect' or 'I recognize', respectively. This approach generates the threshold, the lowest level of a stimulus that the respondent could sense. These studies were a start but gave only a slight hint of what was to come, and how these early stages heralded a new opportunity for business, and business eco-systems to develop.

The world of modern psychophysics, the psychophysics of TODAY, and topic to engage us in the rest of the paper, looks for relations between physical stimuli and subjective responses. These responses encompass the range of what people can judge, subjective responses being ratings of the sensory intensity such as sweetness, or ratings of hedonics, the liking of the sweetness, or in the more general case, liking overall. In some cases, the rating scale has no relation at all to a sensory or hedonic response, but rather may reflect a more complex cognitive aspect, such as 'caloric'. The goal of modern psychophysics is to discover lawful relations, equations, not just correlations. For example, it is one thing to show that the rating of sweetness correlates with the rating of sugar in solution. That is straightforward, easy to demonstrate, but not of particular use. What is far more important is the mathematical nature of the relation, the regression model. When the researcher shows an equation, and even plots it out, that demonstration heralds a new opportunity for developing ecology of disciplines in the service of product design and development.

During the formative years of the new psychophysics, from World War II and onward, the luminary of the field was the late Professor Stevens SS. Stevens, born in Utah, studied at Stanford University found himself attracted to the notion of a science of measurement. He enrolled in the 1930's at Harvard, studying with the eminence gris of psychology, historian Edwin Garrigues Boring. It was Boring's early familiarity and interest in sensation and perception that would stimulate Stevens (known to his friends as Smitty), inspiring him in his life's work. That work was to discover and then promote the use of these lawful relations between stimulus intensity and sensory or hedonic response

Stevens methods, painstaking refined, validated, replicated, cross-validated almost to the degree of obsession, allowed respondents (observers following the old German tradition) to rate the intensity of a set of different stimuli of the same type, such as sucrose solutions of different molarity, sounds of different sound pressure levels, lights of different luminance. The exercise, usually done with about 10 observers, all that were needed, would have each observer rate all the stimuli in an irregular order, with the order changed for each person. The result when plotted was a regular graph, a curve. The curve straightened out when plotted in log-log coordinates. Stevens concluded that the underlying relation between stimulus level and response, perception, is a power function [7]. When the rating scale likes the underlying relation in an inverted U-shaped curve. The relation is more like an inverted bowl when there are two variables interacting, and a 'hyper-bowl', hard to envision with three or more variables interacting to drive liking [8].

1.3. Psychophysics as the Center of a Product Design 'Knowledge Ecosystem'

The only way that ecosystems can form 'naturally' is for those in the system to recognize that they get more by cooperating than by isolating. The cooperation may not be 100% but may be what is called 'co-opetition,' cooperating while at

the same time competing. Psychophysics came into the field of product design and development along two paths, the first a painful one with sensory analysis, the second a more welcoming one with market research.

The entry with sensory analysis was difficult, and did not lead anywhere, perhaps because the sensory analysis world of the 1950's-1970's was insular, fighting for its own recognition as a legitimate entity, and therefore was unwilling to be part, or even the center of an ecological system of different disciplines. The sensory 'professional' was fighting for the field to be recognized as a necessary discipline in corporations and undertook very lock-steps procedures to create descriptive panels, i.e., experts. The struggle to achieve professional recognition in the company was waged by the sensory professional adopting a very rigorous testing system, complete within itself, and not receptive to interacting with those outside its own specialty.

Psychophysics would find a more receptive audience among market researchers, not fighting so much for recognition as a profession as fighting to be recognized for their contribution to building a business. Marketing researchers welcomed psychophysics, although most researchers did not understand the science behind. It was important to the market researchers to bring into tools from the outside which could help the business grow. Furthermore, market researchers in the 1970's were socialized to accept the ideas of vendors, outside experts, in contrast to the rather isolationist viewpoint of the corresponding sensory specialist, even in the same company

1.4. Developing the Ecosystem- How to Make the Product

Psychophysics began to create an ecosystem of related groups in the 1970's, with early work done at Pepsi Cola, and work done with Fermco Biochemics, Inc., Pepsi Cola needs no introduction. Fermco Biochemics, headquarters in the Chicago area, held the patent for aspartyl phenylalanine methyl ester, Aspartame®.

The earliest acceptance of psychophysics as a center in product design and development came from R&D, working in tandem with marketing research, and supported by marketing. The beginnings both occurred around 1974. The acceptance of the approach was due to a chain of events, beginning with meetings with Pepsi Cola R&D at the ASTM Committee E-18, the sensory evaluation of foods and materials. The key people to recognize are chemistry Merrick Tibbets, and then in Pepsi Cola Robert Abernathy, Vice Chairman, and Archie Porter, Head of R&D. Lesser known, but also emerging from the ASTM group was the introduction by Kathleen Wolfe and Charles Beck to Fermco Biochemics, Inc., which was just then pioneering the production and testing of Aspartame®.

What is noteworthy about the early days was that these companies did not focus on formulaic descriptive analysis, and extensive reports by sensory specialists. Rather, they were focused on selling a product, or incorporating an ingredient. The focus was primarily business, and not professional. Such was the case with another early user, Victor V. Studer of Thomas J. Lipton Co., a division of the Unilever Corporation. There were lessons to be learned here about ecosystems, the most important being that an ecosystem had to develop and be ready to try new things. Before the 1980's, ecosystems already were in existence dealing with 'product evaluation' and 'product testing'. Both groups, sensory analysis and marketing researchers, had formed their own ecosystems to do the job. These ecosystems did not, allow for new ways. The efforts were focused on wanting management to accept their results. The efforts were on best practices and standardization, not on demonstrable business success. The various organizations involved in the ecosystems, field services, contract statisticians, advertising agencies, independent consultants, and so forth, simply focused on 'doing the job'. In a sense they were impermeable, static, based upon personal relationships, perhaps because there were no technologies available to them which would create breakthrough performance.

Ecosystems in product development tend to grow larger with success, with breakthrough performance, and with the recognition that the 'world has changed'. In the early 1980's to the mid 1990's, an increasing number of companies began to subscribe to the possibility that this arcane psychological discipline, psychophysics, studying as it was the functional relation between stimulus and perception, could drive product improvement. It was not an acceptance based on acquiring the necessary scientific background. That knowledge was left to the 'technical practitioners'. Rather, the product design and development ecosystem encouraged the use of the tool, as appeared to be satisfied as long as the tool delivered success and was presented in a manner which was clear, not obtuse. The key groups were market research, marketing, and product development.

1.5. How the Ecosystem of How Declined

The use of experimental design in the 1980's and 1990's produced noteworthy products, ranging from beverages (e.g., Tropicana Grovestand® Orange Juice with pulp), Vlasic Zesty® Pickles, Prego Chunky Pasta Sauce, and so forth. The ecosystems around psychophysics-led product develop became larger, as it was embraced by product developers in several companies, by marketers, by top management, and by the trade [9].

During the stressful years of the mid 2000's and beyond, the ecosystem dried up, as new product developers came in, using a variety of other tools. There was a reluctance to make the necessary prototypes, to spend the time and the money for the necessary experiments, and a belief that the experimentation could be replaced by 'analysis,' by 'connecting the dots', or in a sense by avoiding the work altogether, in favor of looking at the array of products 'out there' in the market and deducing (somehow) what was needed in terms of product design and product formulation. There were many failures, but each explained away as an 'aberration'. The attractiveness of 'analyzing our way to the answer' was remarkable, almost seductive. The best analogy to this evolution was the reliance on 'Big Data' and the belief that it was 'all in the data'. It was analysis, not experimentation, which took over.

The power of the ecosystem waned, primarily because the system was cooperative, and not driven from the top in a command and control. Despite the desire of many in companies to have development done from the 'bottom up,' the experience with the ecosystem, membership in which was voluntary, suggested that the ecosystem did not really exist except as a momentary constellation of disparate groups working together. The era of experimental design has never really returned. The ecosystem which had been so productive no longer had the attention and approbation of executives who would push systematic development. Corporate entropy took over, in the absence of strong leadership, and the increasing power of the purchasing department. This pattern occurred at Campbell Soup, Tropicana, Pepsi Cola, General Food/Maxwell House, and other companies which had funded the large-scale studies, had created the necessary ecosystem of marketer, product developer,

statistical and research consultant, field service, and top management. That informal constellation of talent simply dissipated, and never reconstituted.

The ecosystem which had emerged from the systematized development of products appeared to have dissipated, and in fact it did for 15 years, although it would be resuscitated about 2017. The lesson learned from that hiatus was that the ecosystem was fragile. It also appeared that when the ecosystem emerged from the response to ad hoc situations, e.g., solving a specific development issue, the emergent ecosystem itself was extremely fragile. There was no business formalization of the ecosystem, which became ad-hoc, just like the business problem that the ecosystem addressed. In contrast, more stable ecosystems emerged when the activity had to be done, not as much to solve a problem, as for the daily running of the business, when the activities of the ecosystem resulted in a 'tick' mark, that a required task had been done. Then, and only then, was there enough ongoing flow of money for doing a task to ensure the life of the delicate ecosystem. Solving business problems was not sufficient, being a situation of opportunities rather than standardized tasks to be done.

The story of that part of the eco-system has not been completed. One of the observations about the fragility of the ecosystem was that it required too much ad hoc thinking, too much creativity, and too much effort on the part of the employees in the company. Surprisingly, the employees of the technology-poor companies of the 1970's and 1980's were more positive towards systematics and psychophysics than were professional their counterparts 30-40 years later, today's generation a generation which has grown up with computers. The notion of doing systematic experimental design gave way to the (unfounded) belief that everything was in data that could be purchased. One did not have to do the work of creating prototypes, actual effort. One could somehow 'analyze one's way through the data'. The actual analysis never eventuated, but the ability to divert real effort with product creation and replace it with heavy duty, albeit unfocused and unproductive analytics, became so powerful that the efforts of experimental design were eventually deemed simply 'too effortful'.

1.6. The Situation Today (First Decades of the 21st Century)

Although market researchers, innovation specialists, and even the trade, as well as those writing newsletters feel that today there is a plethora of innovation in foods all around the world, the reality is a bit different. A Harvard study suggested that about 90% of new food products are failing [10]. Whether the rate is 90% or 50% or 30% is irrelevant. What would happen if these statistics were to apply to computers, to washing machines, to medical devices?

The number of failures is higher than it should be. It may well be that those involved in design and development, as well as marketing, continue to use systems which are fundamentally inadequate. If the palates of the consumer keep changing, why are the big, establish companies failing to pick up these changes in tastes and values, and launch the 'appropriate products'.

A great deal of today's innovation in the food and beverage world occurs in small companies, enthusiastic start-ups, which are advocates of a certain lifestyle and values such as organic, vegan and so forth. These enthusiasts often make products for themselves because there is nothing to meet their needs and then sell them to other enthusiasts. These products with their associated values percolate through the layers of consumer acceptance until they become popular. Occasionally, the company is purchased as a strategic move by a bigger company, the latter with its resources not able to do what the smaller company has done, the latter on a 'shoestring'.

Clearly the present systems and methods for product development and innovation systems are severely flawed, hamstrung by processes which do not work. The conclusion must be that were the large food and beverage companies to be doing the right studies, the right experiments, and properly guiding product developments, there would be far fewer failures. The products would be already out there so there would be no need for innovative startups.

1.7. The Slow Rebirth of the Ecosystem for How

One of the earliest harbingers of a newly evolving ecology comes from Design Thinking. Design Thinking, a human-centered approach, has been made hugely popular by Tim Brown from IDEO. Design Thinking has been adopted in one or another fashion by many organizations. The design thinking process solves the challenges through inspiration, implementation and ideation by identifying consumer needs through a serious of immersions, workshops, brainstorming, prototyping, and testing these prototypes. In Brown's words "Design thinking can feel chaotic, the design process is best described metaphorically as a system of spaces rather than a pre-defined series of orderly steps" [11].

Psychophysical thinking contributes the systematized testing of ideas & prototypes through formatted design of experiments to cut through this "design-chaos". The issue with psychophysics in the design world is simply the lack of publicity, coupled with the reluctance to do the mundane but necessary work of creating the prototypes, not so much as part of one's education as a process, but rather as the day-to-day approach. In other words, design thinking and psychophysics must evolve to a 'tick-mark' in the quotidian, rather than an exciting break from a more normal, less disciplined routine.

Psychophysics has also begun to enjoy a renaissance, although the progress is slower because psychophysics is not so much a way of 'thinking' in the spirit of the above-mentioned 'Design Thinking,' but an actual process of 'Doing'. As of this writing, the psychophysical approach has started a new phase in the business ecosystem, with new players, experienced individuals outside the company, but with extensive corporate experience. The change in strategy began with the recognition in 2014 that the world had forever changed, that a new generation had emerged which did not understand the value of systematic exploration, and in fact were not even senior enough in their jobs to understand the nature of the product with which they were working. The tenure of jobs was shorter, companies were no longer employing senior people in the name of cost cutting profitability, and most employees were becoming exceptionally risk averse. All of these destroyed the eco-system, which had to be rebuilt in a new fashion.

There was a secondary recognition as well, the prevalence of hope in the concept of 'Big Data'. As noted above, a dual or shadow of the culture of experimentation was the culture of 'connecting the dots,' of 'story-telling,' of 'analysis in place of experimentation'. The advances of computation, the widespread availability of data, the almost frenetic investments in analytics for Big Data ended up sidelining the value of experimentation. The feeling was that it was 'all in there'. The solution simply had to emerge, sooner or later, from powerful statistical analyses and one could then skip experimentation which as the non-glittering t homework, of the dull painful sort encountered in systematic prototype creation. The reconstruction of the product-

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development ecosystem began with the realization that the world of product design and development had changed. Many of the older professionals, those with power to make decisions, had retired, left the company, and in so doing simply disappeared with the experience of the technology gone with them. It was at that moment that the realization emerged that the next stage in the ecosystem had to be re-established on technology, widely used, and not in the hands of a few experts, who could once again disappear for any one of a thousand reasons.

The reemergence of the product-develop ecosystem was predicted on technology, a suite of computer programs, easily and widely available, with extremely low cost. The ecosystem of 30 and 40 years before had grown within the confines of personal relations among the individuals, the awarding of projects, and the lack of interference of the purchasing department. The 1990's and beyond would see purchasing departments, not professionals, often dictating the terms within which a vendor could work with a client. As an unforeseen consequence, eventually the only projects that would be approved were those that were standardized. These experiences would dictate the nature of the new ecosystem, one designed to appeal to smaller companies, where the employees were always aware of the tenuousness of their jobs, and where there were few or no professional fiefdoms to protect.

The new reality was to create a simple suite of programs, and let anyone use it, at very low cost. The effort would still have to be made to create systematically varied prototypes according to an experimental design, a heritage from the psychophysics of 30 and 40 years before. What changed, however, was the elimination of 'people,' 'thinking,' and 'active problem-solving'. It was not that these were unimportant, but rather the talent to do the thinking had been diluted so that the notion of experimental design was truly alien, not matter what the professionals averred. And, at the same time, it was important to circumvent the rigid procurement rules which had been established in the corporation to standardize efforts and save money, but which created a stranglehold on innovative ideas, virtually keeping them out of the corporation because they had no track record with the corporation, and worse, no billing number.

The revised approach was to create a basic set of eight products, no more, no fewer. Each variable could have only two options, A or B, on or off, and so forth. There could be 3-7 independent variables, with the same set of 8 combinations appropriate for each condition. The notion was to make the approach automatically analyzed, and automatically reported in minutes, at a very low cost. The eco-system would evolve from problem solvers at the basic technical level to problem solvers using a set of pre-fixed, 'canned' programs.

1.8. Side Journey-Sensory Segmentation

The early studies in psychophysics of taste and smell focused on the relation between sensory intensity (e.g., sweetness) and the actual ingredient level. Occasionally, an enterprising researcher would change the rating scale so that the rating was degree of liking, not degree of sweetness. The results were startling. As the amount of sugar in the solution increased, i.e. perceived sweetness increased, liking went up, peaked and went down, approximating an inverted U-shaped curve. Of greater importance, however, was the discovery that people differed, that there was no single curve, but rather a family of curves. Some curves continued to go straight up, perhaps peaking at a high level of sweetness, whereas other curves peaked in the middle, and still others peaked at a low level of sweetness and then dropped down with further increases in sweetness. In other words, the simple world of perception of amount fragmented when the perception was not of 'amount' but rather of 'liking of amount'.

The academic use of this information is great, the business use is greater, especially when the business ecology marries together marketers who want to sell more, product developers who can formulate to fit these newly discovered taste preference groups (so-called sensory segments), and finally technical experts who could analyze the data, to make it reveal the nature of these sensory segments, and how to formulate optimally for each. The acceptance of the notion of sensory segmentation was not immediate. It was offered to one very large global food company, but there were no contacts, and thus no possibility of an ecosystem to support it. It was then offered to Vlasic Foods, Inc., then a division of Campbell Soup Company, where the response was positive.

The early adopters, Dr. Pal Palnitkar, Mr. Cary Monaghan, Mr. William Shaw, and Mr. James Dorsch were all positive to it, as was Mr. John Scales, the president of Vlasic Foods, Inc., The happy result was that the early studies with pickles changed the entire thinking of how pickles should be formulated, generated the most successful pickle in history until then (Zesty), revealed the power of psychophysical thinking to drive segmentation, and in its wake generated 125 million dollars in the first few years. The evolution of this new eco-system around sensory preference segmentation continued, again at a slow pace. Remarkably, wherever the segmentation approach was applied, tied into experimental design and psychophysical thinking, the results were dramatic 'wins' in business, especially in term of the sales of the product, and the return on investment. The second effort, this time with Campbell Soup company itself, driven by marketing research (Monica Wood), and marketing (Kathleen MacDonald), revolutionized the business of pasta sauces, and came up with an array of pasta sauces (especially Prego Chunky), which would make money for decades, and continues to do so. The learning regarding business ecosystems is that the ecosystem must involve decision makers who focus on the business, and not on the demonstration of their own value to the corporation. Had there been blocks in the effort, as there were in so many other places, neither Zesty nor Prego Chunky would ever had emerged.

1.9. Side Journey-Merging Economics with Food Design and Development

At the time of this writing, the introduction of psychology into economics is all the rage. The contributions of psychology to economics suggest different ways of making decisions, the effect of mind-sets and the often-deceptive situations which drive the decision to be incorrect. In the world of psychophysics and product design, the introduction of economic concepts has done the opposite, also successfully. The marriage of psychophysics and economics has created a world wherein one can optimize product for acceptance and image (fit to a concept), s subject to economic variables such as cost of goods, as well as show the joint of effect of product hedonics and price to driving stated interest in purchase. The impact of economics is its application to the psychology of price, and thus the ability to drive development. When the respondent does not want to pay a high price, the cost of goods is constrained, and the product formulation must be changed.

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1.10. Prospects

As we hurtle toward the third decade of the 21st century, the issue is whether the fragile eco-system of product design through psychophysics can evolve to a new generation. The lessons learned from the journey of psychophysics through the world of product design are:

- The ecosystem organically arises to fit a new opportunity
- The ecosystem may emerge from supply (selling a project) or from demand (improving a product)
- It is better to solidify the eco-system as a set of procedures at a lower level in the corporation, rather than have the procedure gain a great deal of visibility. In other words, the ecosystem works together when it addresses a standardized task, rather than a one-off task. In other words, the ecosystem is safer when it is a 'tick mark' in a system, rather than an insight which creates millions, or even billions of dollars of revenue.
- The ecosystem is fragile, especially when built on thinking, rather than on rote process. A thought-driven ecosystem can be readily blocked from within a corporation. In fact, as Maurice Maeterlinck (poet, dramatist, Nobel Laureate) famously opined: Each progressive spirit is opposed by a thousand mediocre minds appointed to guard the past.

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