From Potato Chips to Shoes: Have We Forgotten the Basics?

Ravindra S. Goonetilleke
Human Performance Laboratory
Department of Industrial Engineering and Engineering Management
The Hong Kong University of Science & Technology
E-mail : ravindra@ust.hk

Abstract

Perceived sensations are predominantly as a result of various stimuli that we experience in our daily life. The psychophysical literature has extensive investigations and models that can be used in the footwear domain. However, most research in footwear has been hampered by the lack of useful stimulus metrics. Once the metrics are established, the subjective perceptions can be modelled quite well statistically or mathematically. In this paper, the author presents information in relation to different senses and uses products from different settings to illustrate how stimulus intensities influence perceptions and products, with a view to understanding the subjective perceptions of footwear.

Keywords: Comfort, Fit, Footwear

1 INTRODUCTION

Catering to individual tastes and likings is the way forward in this decade. Most of such personalizations are based on unique information that solely belongs to one's perception. Many researchers have rejected the notion of understanding the perceived qualities of footwear on the premise that it is too subjective for scientific investigation. However, there is much knowledge that can be gained from many different industries such as the fragrance, food and other consumer product industries. Kellogg's attributes its success of cornflakes to the crunchiness of the grain. Kellogg's Rice Krispies are supposed to snap, crackle and pop when eaten. If not, one may check on the expiry date label on the package to make sure that the product has not exceeded its lifetime. At the same time, Potato chips are marketed as crispy, crunchy and so on. Manufacturers and marketers are always looking to enhance their product by adding on different attributes of a sensation or different sensation. In this paper, the author will argue that the poor understanding of footwear comfort is not because perception is subjective but because there is little information about the objective qualities of shoes and its parts.

The human processing system of perception, processing and responding even though quite complex has been studied extensively, modelled and validated in many aspects [1]. Some of these include the Hick-Hyman law for choice reaction time, Fitts Law for movement time and so on. Such modelling can be viewed as input-output transfer functions where the output can be predicted from the related input. Constant repetition and rehearsing over long periods of time will enable one to not only store the information permanently but also allow one to recall the information based on the encoding used.

2 ASSOCIATIVE MEMORY

Such encoding is used by manufacturers very effectively to market many products. A beautiful spring day has a unique aura about it. Manufacturers have been very successful in marketing this freshness into shampoos, soaps, body foam, cleaners and so on. The underlying principle is the association that we have with the event or the condition on a spring day. Such products will have little meaning to a person, who has not experienced such events. The perceptions may be very quickly identified based on the associations. Such associations can be of help and sometimes can be a hindrance as well. Certain events that we perceive in daily life may be associated with happiness and sorrow. The smell of perfume, the songs we hear, the clothes we see or wear can take us back many years to far away places due to the associative memory capability we possess. Some of these experiences may be terrific while others are just terrible. Our greatest challenge is erasing off those negative experiences and enhancing the positive ones. Product innovation can help achieve such a goal. Thus, it is no surprise that footwear manufacturers constantly drive for innovation whether it be functional or gimmicky as it may help create a new feeling on a consumer rather than allow one to recall the episodic memory of a poorly executed previous product.

3 INTERNATIONALIZATION AND LOCALIZATION

Taste is unique but many of us have our preferences towards certain restaurants, brands, or even certain chefs. Food like other consumer products can be made to suit an international audience or may be made to cater to a local audience. For example, the same meat can be prepared Chinese style, Indian style, American style, Japanese style and so on. That type of preparation gives the international flavour but the subtle differences within a country or region is accomplished through variations of the same or similar ingredients. In statistical terms, such a process can be compared with the mean and the

standard deviation of a variable. Shifts in mean can correspond to the internationalisation aspects while the standard deviations can represent the variations within a given locale. Alternatively, process control charts with lower control limits and upper control limits for ingredients, cooking temperature, marinating time and so on can represent the wide variations that exist among different countries. Even fields such as fluid mechanics and structural mechanics resort to using a similar approach to model systems. In those specialties, such modelling to represent variations is called perturbation theory, which is a study of small disturbances in a physical system. Acoustic disturbances are usually regarded as small-amplitude perturbations to an ambient state. The ambient state of a fluid is characterized by the pressure (p_0), density (ρ_0), and fluid velocity (v_0). These ambient-field variables satisfy the fluid-dynamic equations. When a disturbance is present, the pressure and density can be represented as:

$$p = p_0 + p' \qquad \rho = \rho_0 + \rho' \qquad (1)$$

where p' and ρ' are the acoustic contributions (disturbance) to the overall pressure and density fields. A similar approach can be used to evaluate differences in subjective perceptions among different populations when the fundamental laws are clearly defined.

4 OUR SENSES

Our sense of smell, touch, taste, sight and sound helps identify danger and helps invoke a feeling of pleasure if the stimulus is appealing. One's senses and internal state will determine one's preference towards an item. Non-smokers can get the slightest indication of smoke even though a smoker is relatively far away. We sniff food that has been lying for a long time in a refrigerator in order to determine whether it is edible. Our sense of smell helps us to avoid eating rotten food and keep us away from danger. Many items that we purchase in a grocery store go through a sniff-feel and sometimes pinch test [2]. Sour, bitter, sweet and salty have been identified as the basic categories of taste [3][4]. Sweetness and bitterness may be further subdivided into several sub categories using psychophysical procedures. However, other factors may add on top of these four categories. Consider the case of potato chips. They are relatively easy to make but, the crispiness, crunchiness, shape, size, contraction or expansion, sogginess and other properties give the chip its unique identity and are heavily dependent on the manufacturing process. Thus, a one-to-one mapping is needed from the process variables to the perceived qualities of the ultimate product in order to achieve an exciting product.

Marketers have exploited and continue to exploit our weaknesses in our visual system by marketing what isn't there but what we think is present as they attempt to deliver optimal visual satisfaction. A recent study found that comfortable as well as uncomfortable shoes have good aesthetics [5]. In other words, the buying decision is heavily dependent on visual satisfaction. Some of these vision related aspects might also be linked to individual differences. Extraverts have been found to prefer primary and secondary colours, while introverts prefer the "earthly" colours such as browns, olives, beiges, and so on [6]. Colour has three important attributes. They are hue, saturation and brightness. These three dimensions have been used to construct an isohedonic chart showing lines of equal preference [7][8].

Yet, many researchers seem to think that subjective perceptions cannot be modelled and understood quantitatively. The same argument comes up over and over again in many different fields. Authors such as Carritt [9] maintain that beauty is entirely dependent on the observer (that is, subject related or subjective) while others believe that the judgment of beauty is purely a characteristic of the object [10]. Alexander [11][12] and Eysenck [13][14] on the other hand take a more reasonable view when they consider beauty to be part subjective and part objective and something that occurs in a person purely as a result of the characteristics of the object. Perfumes and fragrances work when the odorant molecules bind to the receptor membranes and change the mood of a person (Figure 1). These events are known as the "3Ms" of perfumery [15] clearly indicating that the process is part subjective and part objective.

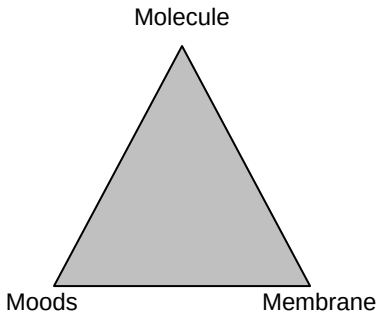

Figure 1. The 3Ms of perfumery (adapted from [15])

This part-subjective-part-objective viewpoint makes it very clear as to what is needed in order to understand the so-called "subjective" perceptions. Firstly, the underlying objective characteristics should be well known and thereafter a number of experiments/studies may be needed to uniquely identify the preferences in relation to each characteristic. Here are two examples from the perfume industry and the food industry. The Chypre family of perfumes uses the following distinct categories to give its odour: citrus, musk, woody, balsalmic, mossy, animal, floral, aldehydes and spicy. The exact percentages of the ingredients that are used give the perfume its unique smell. For example, pimento oil, nutmeg oil and isoeugenol give the perfume its spicy component. Similarly, other ingredients in various proportions give the perfume its unique smell. Freshly roasted coffee has 670 odorants from different chemical families [16]. The number of constituents and the chemical families are shown in Figure 2. There are 108 furans and these furans give coffee its unique flavour and play a key role. Thiols, on the other hand have exceptionally low threshold values and exist at around 10 to 550 parts per million million (ppt or parts in 10^{12}). These thiols give the aroma of fresh coffee. As the concentration of thiols increase above 500 ppt, the aroma becomes less pleasant and at around 1-10 ppb (parts in 10^9), it gives the unpleasant, sulphurous, rancid odour of stale or over-percolated coffee [16].

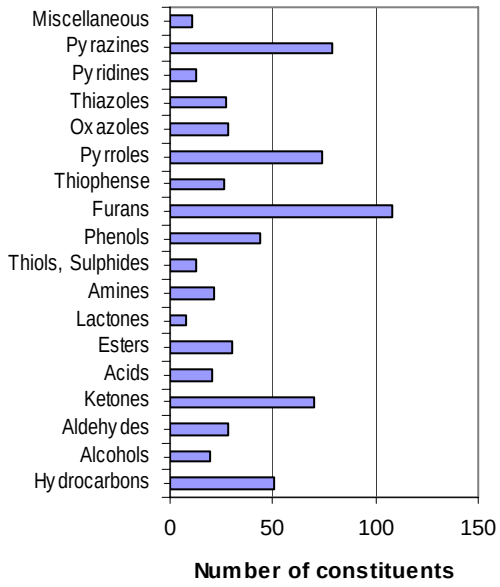

Figure 2. The main chemical families in freshly roasted coffee (adapted from [16])

Both these examples clearly show that there are key–impact–ingredients (KIIs) that give each product its characteristic quality. In the footwear domain, the KIIs may be viewed as the physical properties of the shoe or shoe part. The aforementioned studies also bring out the fact that while some aspects are critical, others, possibly with low thresholds, have to be at optimum levels in order to achieve a likeable (or positive) sensation. All such information is extremely important if footwear perception is to be well understood.

5 SHORT HISTORY OF WOMEN'S SHOES

A quick look at the history of shoes will help illustrate how and why footwear has changed over the years. A good summary is given in [17]. After the Second World War began in 1939, there were strict limitations on shoe designs. The height of high heels was limited to 2.5 cm in the U.S and 5 mm in Britain. Leather was in short supply and poor quality leather with bright hues and cheap materials such as cork, wood and rubber were used for shoes. Shoes had canvas uppers, crepe soles and plastic straps. With the easing off on footwear restrictions, high heels and the peep toes emerged in the early 50s. In the late 50s, the toes became longer, heel heights were lessened and the court shoe became popular. With skyrocketing prices of leather, material used for shoes changed radically in the 60s. Plastics and other synthetic material became popular and were promoted by many fashion designers. The platform shoe started to re-emerge around 1967 after it had gone out of fashion in the 40s. By the mid 70s, platform shoes and boots, and bellbottomed trousers were the most popular. Crepe rubber and leather covered plastics or wood were common materials for the shoe heel and soles. In the 80s, people were most concerned with designer labels and shoes made of materials that could breathe became popular. Platform shoes made another comeback in the early 90s. All such changes over the last century have been driven by fashion and resource limitations and have had little influence on the understanding of people's perception and sensation abilities.

6 THE BASICS OF SENSATION AND PERCEPTION

E. H. Weber formulated one of the first psychophysical laws when he conducted studies to investigate people's ability to perform discrimination tasks. What he found was that discrimination was relative rather than an absolute judgment. His work resulted in a basic psychophysical law that can be expressed as:

$$\frac{\Delta X}{X} = \text{constant (k) = Weber fraction} \qquad (2)$$

Where X is the physical intensity of the stimulus and ΔX is the differential threshold value or the increase of intensity needed to produce a just noticeable difference. The above equation states that the smallest increment that is necessary to perceive a change is a constant proportion (k) of the original intensity of the stimulus. Some example Weber fractions are 1/3 for taste (table salt), 1/4 for the smell of rubber, and 1/7 for pressure [18]. Weber's law is often questioned, as the Weber fraction is constant only in the middle ranges of the stimulus values, but increase at the lower extremes and higher extremes [19][20]. Due to this weakness, Fechner's law (1860) emerged where:

$$S = \ln X \qquad (3)$$

Here S is the perceived intensity of the stimulus while X is the physical intensity. Fechner assumed that the sensation discrimination is uniform with respect to the logarithm of the stimulus magnitude. In the late 50s, S. S. Stevens and colleagues established subjective scales for many different stimuli and established the now popular Stevens' power law:

$$S = a X^{b} \qquad (4)$$

Typical exponents of the power function are 1.0 for visual length, 1.1 for static force on palm, 1.45 for weights lifted by hand, 0.80 for squeezing rubber blocks and so on. Most physical quantities have an absolute threshold (X_0) and the power law relationship is often modified to reflect this threshold as:

$$S = a (X - X_0)^{b} \qquad (5)$$

Our senses adapt to whatever stimulus that exists whether it be smell, sound, taste, touch and sight. In other words, with constant stimulation, the perceived intensity of the stimulus decreases over time. This adaptation can be viewed as a decrease in sensitivity or alternatively as an increase in threshold. The following formulation has been proposed to account for adaptation [21]:

$$S = a (X e^{-ct/X} - X_0)^{b} \qquad (6)$$

7 FOOTWEAR

With such clear formulations between stimulus intensity and perceived sensation, one may wonder why understanding footwear has been so difficult. Consider the two cases of cushioning and fit.

7.1 Cushioning

The term *cushioning* is only used to describe those aspects of the foot-floor interface that are concerned with the reduction of the transmitted forces. As a result, the foot-floor interface literature is split into two distinct categories related to injury and discomfort. In the biomechanics literature, injury has been linked to shock absorption. On the other hand, the ergonomics literature primarily focuses on discomfort and has always made reference to the hardness and/or compression of materials. The addition of a visco-elastic insole into a shoe has shown improved comfort while reducing back, leg and foot pain in subjects whose jobs required standing at least 75% of the time [22]. In their experiment, the "lighter" subjects and those with smaller feet were given insoles with a 40/45 Shore hardness rating while the heavier subjects were given insoles with a 45/50 Shore hardness rating. Hence, it is clear that the authors assumed cushioning comfort to be related to the hardness of the insoles (material). Researchers using different materials and some of their characteristics have related them to injury, pain, comfort or discomfort. Such an approach is very tedious and time consuming. It is no doubt an interesting exercise to evaluate commercially available products and to place them on a comfort-compression, tiredness-hardness or similar type of map. However, technological improvements, such as advances in composite materials, can alter significantly the physical or mechanical characteristics of products and alter the position of a product on such a map. Product testing and usability testing are important for product-evaluation purposes and best-in-class assessments, but they do not explain the underlying causes of "good" or "bad" products or perceived feelings of the wearer, which are the most important elements in designing products right the first time. A better procedure will be to develop an acceptable and relevant characterization procedure that can provide a means to improve wearer comfort while reducing fatigue and injury during activity. Such an approach will allow designers and developers of products to understand which particular cushioning characteristics are perceived by humans in any given activity being performed. The material properties contributing to perceived cushioning was investigated recently [23]. The footwear materials were characterized using an impact tester. It was found that the perceived level of cushioning (PLC) during running and standing were related to material stiffness (or compression) and time to peak deceleration. On the other hand, when walking, the magnitude of the deceleration appeared to be a good predictor of PLC clearly showing that perceived sensation can be predicted if the stimulus metric is known. The ideal material will have the desired deceleration as well as the stiffness property. This will not only improve perceived levels of cushioning but will, it is hoped, reduce injury, pain, and discomfort. However, cushioning levels cannot be increased infinitely due to its interacting effects with perceived stability. Hence achieving the optimal level of cushioning without sacrificing stability is of utmost importance for footwear. Having understood the properties that affect sensation, further studies are needed to determine the exponents of the power law so that cushioning perceptions can be clearly formulated.

7.2 Fit

Good fit is known to influence the comfort of footwear. For many consumer products, fit can govern function and is hence an important property. Even though fit ranks as one of the most important considerations in the purchase of a shoe, the quality of fit is poorly assessed. Traditionally, for good fitting footwear such as ski boots, foot width or foot girths are matched with the shoe width or shoe girths to determine the right fit. However, this procedure is not very accurate, as the positioning of the foot within a shoe has to be correct in order for this match to function. In other words, the registration process has to be accurate. These width or girth measures have to be taken at the correct positions. A more recent study [24] has shown that the dimensional difference (DD) plots can be used for predicting footwear fit. Forefoot fit was strongly correlated ($R^2 > 0.8$) with two of the minimums in the DD-plot while midfoot fit was strongly correlated ($R^2 > 0.9$) with the dimensional difference around the arch region and a point on the lateral side of the foot. Again, this study shows that perceived sensation of fit can be predicted when a meaningful metric is selected. The metric selection process is not easy, but is an important way forward if we are to really understand footwear perceptions.

8 CONCLUSIONS

All of the aforementioned studies clearly show that the key to understanding people's perceptions is the determination of a good stimulus metric so that perceived sensations and stimulus intensities can be related. Once that is done, quantifying perceived sensations may not be a difficult task.

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