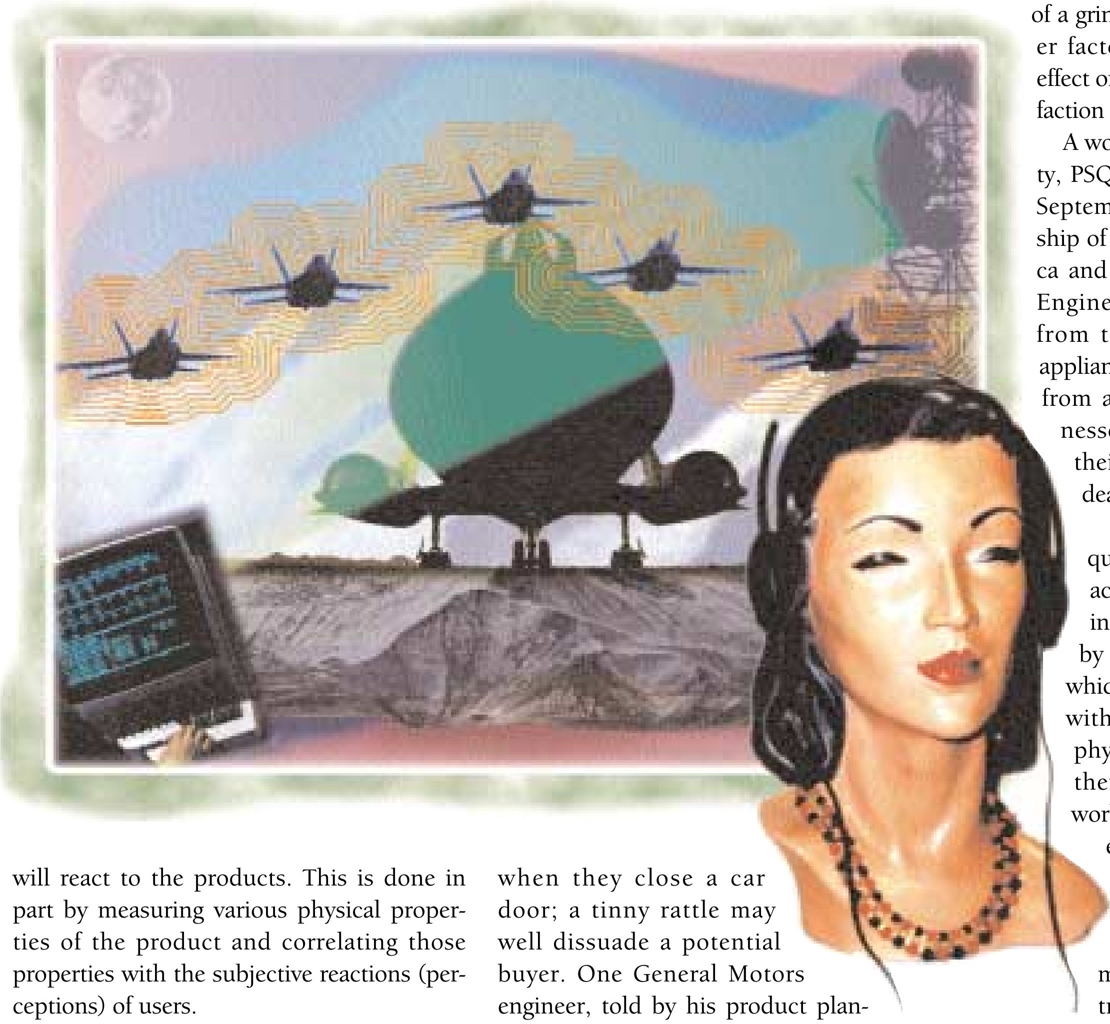
A Sound Guide to Product Acceptance

Acceptance of all products, but especially consumer and certain industrial products, depends on the perception of their utility, quality, and value. In order to design new products to meet user expectations, producers must anticipate how customers will react to the products. This is done in part by measuring various physical properties of the product and correlating those properties with the subjective reactions (perceptions) of users.



If user perceptions are to be considered in a design, one must map out the relationship between perception and design. In most cases, this relationship comes from the designer's experience and engineering tools or from information provided by an original equipment manufacturer to suppliers. But for one particular perceptual attribute—the sound of the product—experience, tools, and information are sadly lacking. Recent developments in this area, however, give promise for short-term solutions and longer-term directions for predicting sound quality.

Two important rules of user acceptance are that (1) sound is information, and (2) noise is as much psychology as physics. Motorists, for example, want a solid "thud" when they close a car door; a tinny rattle may well dissuade a potential buyer. One General Motors engineer, told by his product planners to improve the sound of door closure without adding too much cost, turned that challenge into a Ph.D. thesis. He employed signal analysis, jury testing, mechanism analysis, and value-tradeoff studies to successfully design a quieter door. In this instance, the mapping from perception to design worked well.

Although sound quality is normally associated with consumer products, it also plays an important role in industrial products. Because of Occupational Safety and Health Administration regulations and workers' compensation guidelines, companies require a maximum allowable overall sound level for tools and equipment. Sound level is one dimension of sound quality. The annoyance caused by a sound—for instance, the sound of a grinder or stepper motor—is another factor that can have a significant effect on purchasing decisions and satisfaction with the product.

A workshop on product sound quality, PSQ '97, was held on Cape Cod in September 1997, under the sponsorship of the Acoustical Society of America and the Institute of Noise Control Engineering. About 30 participants from the automotive, aircraft, and appliance industries, along with others from academia and consulting businesses, spent two days describing their experiences and methods of dealing with product sounds.

Much of the work on sound quality and its influence on user acceptance has relied on jury testing, a method originally developed by the food and flavor industries, which have been concerned for years with the relationship between the physical and perceptual arenas of their products. Participants who worked with those industries related experiences in which the measurements of chemical constituents—even by such advanced methods as nuclear magnetic resonance, mass spectroscopy, and gas chromatography—failed to correlate with important perceptual attributes of foods and fragrances. The characteristic of "musky," for example, does not neatly match up with any one set of constituent perfume chemicals. Therefore, those industries have had to employ psychophysical testing methods using panels of consumers to determine what ranges of ingredients people will find acceptable or desirable.

With sound, however, we appear to have a better situation. Our ears respond to pressures. Not only can we physically sense sound pressures, but we can also record them, either with a single microphone or a binaural artificial head (an artificial mannequin head with microphones in the ear canals) to recover an amazingly accurate representation of the original sound. These sound signals can be further conditioned and digitally processed by computer with various algorithms to recover the information desired. The whole process is the "measurement" of sound. But how much can such measurements assess the interplay of sound and the mind, whose study is known as psychoacoustics, and help us to anticipate human reaction to various sounds?

Some physical features of sound correlate extremely well with perception. The outstanding example is loudness, for which the human perception of the "strength" of the sound (called loudness) and the computational signal-processing scheme (the algorithm, also named "loudness") are so strongly correlated that few people bother to make the distinction between the two. Speech-interference level (the degree to which background noise reduces one's ability to hear spoken words) and the detectability of sounds in the presence of background noise also have well-established algorithms that accurately correlate physical conditions with human perceptions.

It is when sounds have some cognitive value that the situation changes. Product sounds please, annoy, and convey information, and these play on one another. Equal levels of sound from my neighbor's lawn mower (which is keeping our neighborhood attractive) and the skinhead motorcyclist racing along my suburban street provoke quite different emotional responses.

There is a tendency in psychoacoustic studies to choose stimuli that do not have cognitive value because the element of cognitive value makes a study much harder to interpret. The fundamental goal of psychoacoustics is to understand how the brain works, not necessarily how to improve product sounds. There have been many attempts, however, to use the results from that science to predict product acceptance, with mixed results. But the methods of jury testing and experimental design used in psychoacoustic studies are highly relevant to achieving better product sound quality. The successful use of jury testing to make favorable design choices for washing machines and vacuum cleaners was discussed in presentations at PSQ '97.

Some algorithms or "metrics" for sound have been introduced in an attempt to provide a better correlation of physical measurements of sound with the perception of product sounds, although the mapping between those metrics and design choices remains a major issue. Some examples are "fluctuation strength," "sharpness," and "roughness." Since the term roughness, for example, can describe both a subjective reaction to sound—"that engine sounds rough"—and an algorithm widely present in sound-signal analysis systems, we can ask how well they correlate. For example, do these algorithms provide as good a correlation with human perceptions as do the "loudness" algorithm mentioned above and jury perceptions of loudness? According to the participants in PSQ '97, the answer is no.

So for now, and undoubtedly for years to come, we must rely heavily on jury testing to help decide how to achieve better quality product sounds. Nonetheless, the desirability of an accurate sound quality predictor is great and of considerable usefulness as the perception of sound becomes an increasingly important and competitive component of consumer satisfaction. We must continue to find methods that supplement or complement jury testing and to improve the mapping between sound and perception and its incorporation into products.

BIOGRAPHY

Physicist Richard H. Lyon, professor emeritus of mechanical engineering at the Massachusetts Institute of Technology, is president of RH Lyon Corp., a product development company in Cambridge, Massachusetts (rhlyon@lyoncorp.com).