

The aesthetic and the ethic dimensions of human factors and design

YILI LIU*

Department of Industrial and Operations Engineering, University of Michigan,
1205 Beal Ave, Ann Arbor, MI, 48109-2117, USA

Keywords: Engineering aesthetics; Ergo-aesthetic design; Ethics; Human factors and ergonomics; System and product design.

This article discusses the relationship between aesthetics, ethics, and the traditional research issues in human factors, and argues that it is important and beneficial both to the human society and to the human factors profession that we incorporate the aesthetic and the ethic dimensions explicitly and consciously in human factors research and practice. These two dimensions can help us put the current human factors research in a larger context. We can see more clearly the limitations of current research and the needs and challenges for research in new areas. The two dimensions also offer some new perspectives from which we can examine the current work systems and products, explain the demise of old work systems and products, and predict the possible emergence of new work systems and products.

1. Introduction

‘Will this design be appealing and attractive to the potential buyers or users?’ ‘Is the new product good for the users and acceptable to other people and society?’ System and product designers think about these and other similar questions constantly in making design decisions. The aesthetic appearance of a product has a large bearing on its potential market share, and the ethic implications or consequences of a product can have significant societal implications and make or break the moral reputation of the designer and manufacturer. Although designers and decision-makers deal with aesthetic and ethical issues constantly in their practice, they often make aesthetic and ethic decisions on the basis of their gut-feelings and intuitive judgments.

As a scientific discipline that devotes itself to the study of human-machine-environment systems, human factors and ergonomics has long established its goals of enhancing the safety, comfort, productivity, and ease-of-use of products and systems and has made great strides toward these goals (Wickens *et al.* 1998). While aesthetics has always played a role in the success of product and work design, aesthetics is neither on the list of goals of human factors nor incorporated in its fields of systematic studies. Similarly, although the goals of human factors are highly ethical and the research results are of great value for making ethical design decisions, the ethics of system and product design is considered as a goal rather than a field of systematic scientific study in human factors.

*e-mail: yililiu@umich.edu

In this article I discuss the relationship between aesthetics, ethics, and the traditional research issues of human factors and argue that it is important and beneficial both to the human society and to the human factors profession that we incorporate aesthetics and ethics explicitly and consciously in human factors research and practice. As discussed later in the article, with the aesthetic and the ethic dimensions we can put the current human factors research in a larger context. We can see more clearly the limitations of current research and the needs and challenges for research in new areas. The two dimensions also offer new perspectives from which we can examine the current work systems and products, explain the demise of old work systems and products, and predict the possible emergence of new work systems and products. To better appreciate the role of aesthetics and ethics in human factors and ergonomics, first I would like to provide a philosophical context to the current discussion.

2. Metaphysics, aesthetics and ethics

Ancient philosophers believe that all human pursuits can be classified into three fundamental categories: pursuit of truth, pursuit of beauty, and pursuit of the good and right. Corresponding to this trinity of fundamental pursuits there appears to be three types of judgments: the cognitive (or scientific), the aesthetic, and the moral, which are the topics of study in three main branches of philosophy: metaphysics, aesthetics, and ethics. Metaphysics addresses the issue of truth—the true and fundamental nature of the universe and existence (what truly exist). Aesthetics addresses the issue of beauty and related notions (e.g., tragedy, sublimity). Ethics addresses the issue of what is a good (or bad) thing and what is a right (or wrong) action. As some philosophers put it, ‘Truth, beauty, and the good may be the traditional staples of philosophy’ (Honderich 1995: 14).

As the oldest form of rational, critical, and systematic intellectual inquiry in human intellectual history, in many respects, philosophy is the intellectual cradle of all modern natural and social sciences. While modern philosophers continue their debates on metaphysical, aesthetic, and ethic questions at the most fundamental level, many of these fundamental questions are now studied in more specific forms and contexts in various modern sciences using scientific methods. The questions investigated in the natural sciences such as physics and chemistry have strong roots in metaphysics, while the questions asked in the social sciences such as economics and sociology can be traced to the fundamental questions of ethics. There is a wide gap between the sciences and the arts, which are the topic of study in aesthetics (figure 1).

With the exception of some emerging branches of ergonomics such as macroergonomics and forensic ergonomics, human factors and ergonomics, in its current form and scope of thinking, is largely an applied natural science. Its philosophical root is predominantly that of metaphysics. Not only it adopts the knowledge base and research methods of perceptual and cognitive psychology, computer science, biomechanics, and work physiology, its topics of systematic research is that of pursuit of truth—what is the true process of motion perception, what is the true nature of text understanding, and what is the true biomechanical or physiological explanation for whole-body fatigue or low back pain, to name a few. As I described above, the pursuit of beauty and the pursuit of the good are not themselves treated as topics of systematic research in human factors.

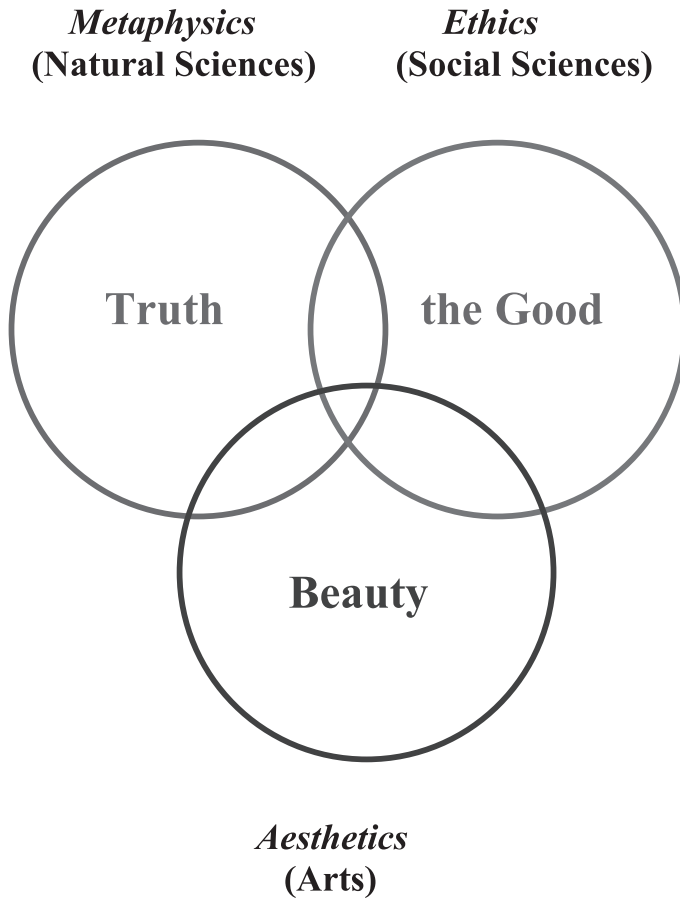


Figure 1. The three fundamental human pursuits are shown in three circles. The three corresponding branches of philosophy are shown in italics, and the three corresponding fields of modern disciplines are shown in parenthesis. The foundation for traditional human factors is mainly the upper-left circle, while aesthetic ergonomics should be based on a comprehensive view of all the three circles (from Liu 2000a,b).

To incorporate aesthetics and ethics in human factors research and practice and go beyond philosophical debates and intuitive judgments, there is a need for developing theoretical and methodological foundations for systematic and scientific investigations of the aesthetic and ethic issues in product and work design. There is a need for developing comprehensive, quantitative, and rigorous understanding of the concepts involved, a need for developing measurement and evaluation methods, a need for identifying the qualitative and quantitative relations between an individual's aesthetic or ethic judgments and design parameters, and a need for developing theoretical frameworks for integrating and interpreting research findings.

Elsewhere I described the need for establishing a scientific and engineering discipline that I call 'engineering aesthetics' (Liu 2000a; 2001; 2003), which addresses two major questions: First, how can we use engineering/scientific/mathematical methods to address aesthetics questions in general and aesthetics questions in the

context of work, product design, and human-machine-environment systems in particular? Second, how can we use engineering/scientific/mathematical methods to help make human/machine/environment systems and products more aesthetic and more ergo-aesthetic? We can use the term 'ergo-aesthetic' to refer to something that is both ergonomic (safe, comfortable, usable) and aesthetic. I have also proposed a theoretical and methodological foundation for addressing these engineering aesthetics questions.

In this article, I illustrate one of the benefits of considering the aesthetic and the ethic dimensions explicitly in ergonomics research. Ergonomics is originally defined as the study of work. One of the important steps of studying something is to categorize them so that we can understand the object of study in a more organized and systematic manner. I show in this article that the aesthetic and the ethic dimensions provide us a broader framework with which we can categorize and understand past, current, and future work systems and products.

3. Five dimensions of human factors and ergonomics

To avoid a proliferation of dimensions, I have found that the following five dimensions are essential and can be used effectively to distinguish five major aspects of system and product design: the aesthetic/affective dimension, the ethic dimension, the arousing quality dimension, the dimension of information processing demands, and the dimension of psychosomatic soundness.

The aesthetic/affective dimension refers to a person's aesthetic/affective appraisal of a stimulus, product in use, or task situation, and it ranges from the negative end (e.g., displeasing, unattractive) through a neutral point (e.g., plain-looking) to the positive end (e.g., pleasing, attractive). The ethic dimension refers to the moral desirability or ethical acceptability of the objects or actions in question, and it ranges from the negative end (e.g., bad/wrong) through a neutral point to the positive end (e.g., good/right).

The arousing quality dimension refers to the degree to which a stimulus or task situation arouses a person or does the opposite, and it ranges from the low end of 'sleep-producing or soporific' through a neutral point to the high end of 'highly arousing'. The dimension of information processing demands refers to the level of difficulty a task situation or product usage imposes on a person's information processing system (perception, cognition, and response selection and execution), and it ranges from extremely low to extremely high levels of difficulty with intermediate levels in between. The dimension of psychosomatic soundness refers to the degree to which a task situation or product usage contributes positively or negatively to the overall soundness, wholesomeness, and well-being of a person's mind and body, ranging from the negative end of 'harmful' to the positive end of 'healthful'.

As discussed below, the traditional ergonomic research topics such as safety and ease-of-use can be defined by the terms and concepts of the last three dimensions, while the addition of the first two dimensions listed above can significantly expand the scope of thinking of ergonomic research and practice.

It should be emphasized here that each of the five dimensions is neither unidimensional nor completely independent from other dimensions. For example, many factors influence the perceptual and cognitive demands of a task, and many factors jointly determine whether a task situation is safe or harmful. Research in engineering aesthetics and ethics will undoubtedly demonstrate that the aesthetic and the ethic dimensions are themselves multi-dimensional. Aesthetic and ethic

judgments may not be completely independent of each other either. However, each of the five dimension listed above seems to represent a major and unique aspect of a system or task situation. It is neither possible nor fruitful to draw a 5-dimensional representation of the five dimensions on a 2-dimensional sheet of paper. In the following sections, I focus on some selected pairs of dimensions.

3.1. *The aesthetic/affective dimension and the arousal quality dimension*

Figure 2 shows the two-dimensional space formed by the aesthetic/affective dimension and the arousal quality dimension. The aesthetic/affective dimension, shown as the horizontal axis, ranges from the unattractive and displeasing end on the left to the attractive and pleasing end on the right, with varying degrees of attractiveness in between. It should be noted that the aesthetic dimension is defined with reference to the senses of the experiencing person who is the subject of discussion, not to the senses or the judgments of other people or the general public. The arousal quality dimension, shown as the vertical axis, ranges from the low end of 'soporific' to the high end of 'arousing'. Each point in this two-dimensional space represents a pair of attractiveness and arousal values, and thus characterizes a unique experience with its own attractiveness and arousal levels. The four quadrants in the two-dimensional space represent four major types of situations, each

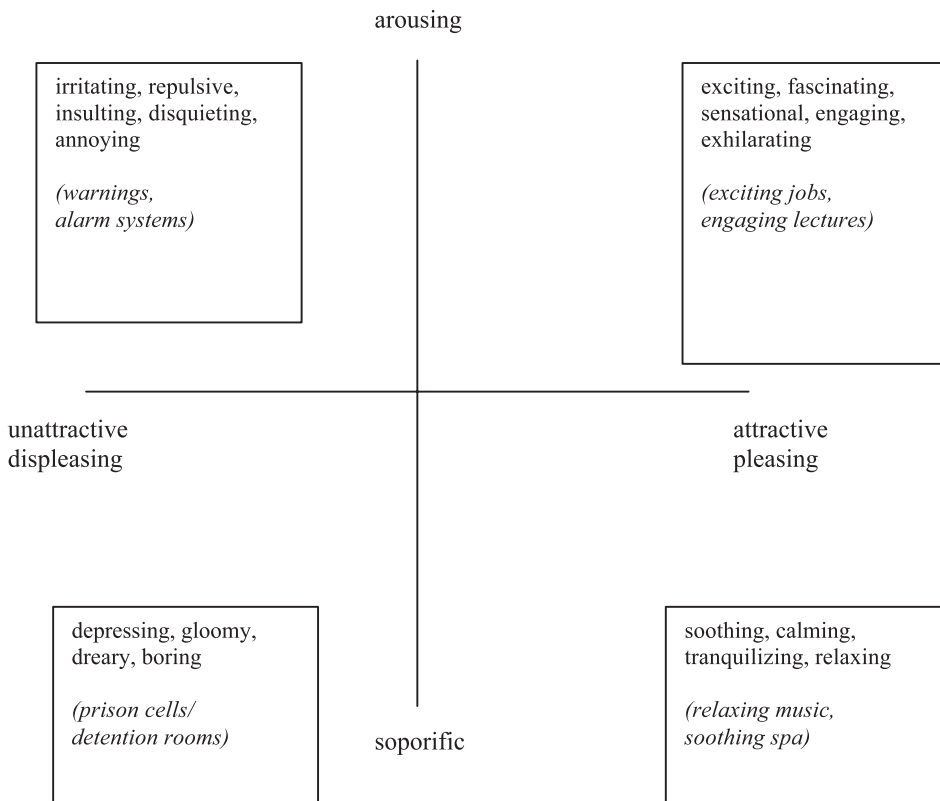


Figure 2. The two-dimensional space defined by the aesthetic dimension and the arousal quality dimension.

representing a qualitatively different type of experience. Although different points in the same quadrant are not associated with identical experiences, the experiences they represent are qualitatively more similar to each other than to those represented by points in other quadrants. For illustration purposes, I will only compare experiences represented by different quadrants rather than those within the same quadrant.

'Exciting' experiences such as enjoying a beautiful piece of music, watching the launch of a space-shuttle, or listening to an engaging lecturer, belong to quadrant 1 (the upper-right quadrant) of figure 2 and can be described with adjectives such as 'fascinating', 'sensational', or 'engaging'. In quadrant 2 (the upper-left quadrant), we find the type of situations that is highly arousing, but in displeasing ways. Bad odour, loud noise, and glaring light tend to fall into this category, and they are usually described as 'irritating', 'annoying', or 'repulsive'. Situations or products that are both displeasing and soporific can be found in the third quadrant (the lower-left quadrant), and they can be best described as 'depressing', 'gloomy', or 'boring'. A dark workplace that requires workers to perform monotone job procedures is an example of this type of situation. In quadrant 4 (the lower-right quadrant), we find soporific situations or stimuli that are pleasing to the senses. 'Relaxing' in a comfortable sofa and listening to a piece of 'soothing' music are examples of this type of 'soothing' experience.

It should be emphasized here that 'ergo-aesthetic' design does not imply that workplace or product designers should only use designs that are pleasing or attractive. On the contrary, ergo-aesthetic design advocates the careful and proper selection of aesthetic levels of design to fit the needs and characteristics of the intended use. In fact, properly selected and adopted, all the four categories in figure 2 can be usefully employed in system and product design. The use of quadrants 1 and 4 in design are quite intuitive and has been illustrated in the paragraph above. What is not so obvious is the value of proper use of quadrants 2 and 3. One example of effective use of quadrant 2 type of situation is the use of bad odours or loud noises as alarm signals to capture a person's attention or as warning signs to 'repel' people away from dangerous materials. The picture of a skull on the packaging of poisonous chemicals may help protect people from accidental uses. Packaging designs for adult's products (e.g., razors) that are pleasing to adults but neutral or displeasing to young children may help discourage children from accessing those products. Apparently, prisons and detention centres that are designed to be 'displeasing' and 'non-arousing' can be characterized by descriptors of quadrant 3.

3.2. *The aesthetic/affective dimension and the dimension of information processing demands*

Figure 3 shows the two-dimensional space defined by the aesthetic/affective dimension and the dimension of information processing demands. The aesthetic/affective dimension is shown as the horizontal axis, as in figure 2, and the dimension of information processing demands is shown as the vertical axis, ranging from extremely low information processing demands to extremely high, with intermediate levels of information processing demands shown in between. The four quadrants represent four categories of task situations or design.

In quadrant 1 we see the type of task situation or product design that imposes high information processing demands on the individual in pleasing and attractive ways, and we often call this type of task 'stimulating, challenging, or thrilling'. Examples of this type of task include playing video games, solving interesting puzzles, or

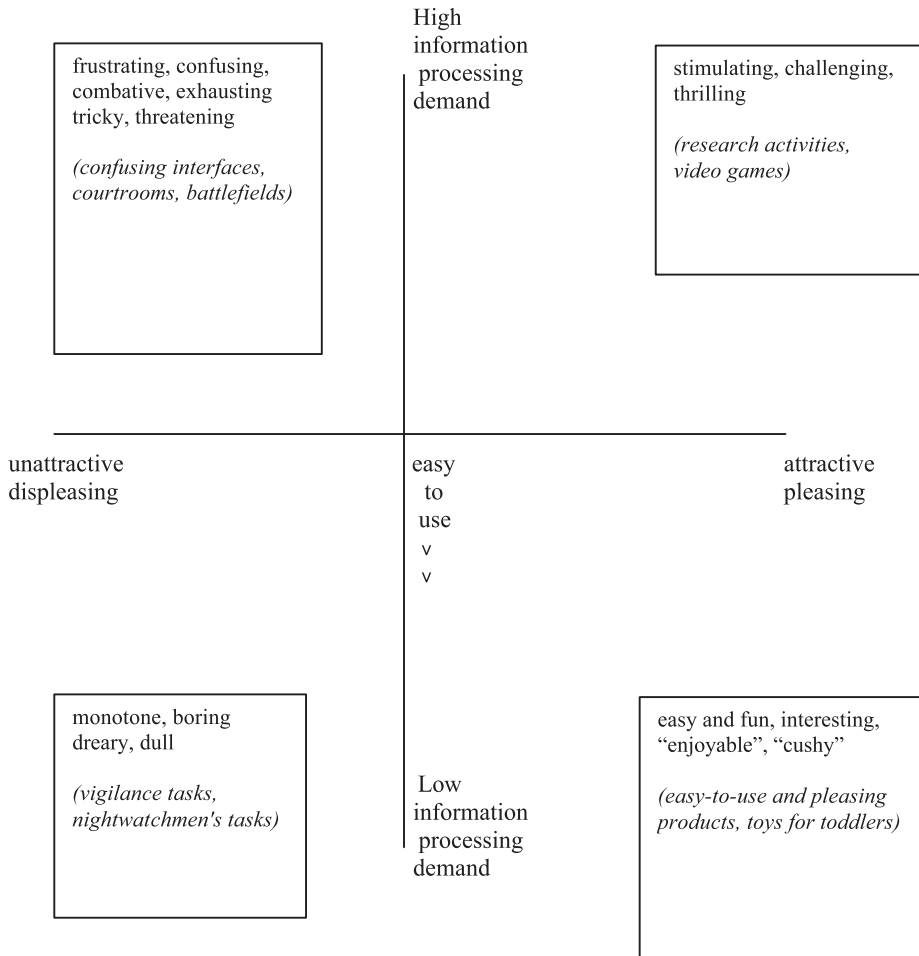


Figure 3. The two-dimensional space defined by the aesthetic dimension and the dimension of information processing demand.

conducting research on a topic one is deeply interested in. If task situations impose high information processing demands in displeasing or unattractive ways, shown in quadrant 2, then we tend to call them 'frustrating or tricky'. We even call them 'threatening' if task failures may lead to dangerous consequences or 'combative' if the task situation involves antagonistic or opposing parties. Examples of 'frustrating' or 'confusing' product designs include poorly designed software or hardware devices or poorly prepared instructional materials. Examples of 'threatening' task situations include emergency situations in which the warning and display systems are confusing rather than helpful, as exemplified by the Three Miles Island Nuclear Power Plant accident in 1979. Examples of 'combative' situations include courtroom legal arguments and battlefield operations, where the opposing parties plan and adopt strategies to outsmart, outmanoeuvre, and attack the other party in the battle.

In quadrant 3 we find task situations that are not attractive or pleasing to the users, although they impose low information processing demands. We tend to call

this type of task 'monotone', 'boring', or 'dull', examples of which include control room monitoring in most everyday situations, night watchmen's job, and listening to a teacher talking about an easy topic in an uninteresting way. If a job is both pleasing and easy to perform, we tend to say that the job is 'fun and easy', and sometimes we call this type of job 'quite enjoyable', 'cushy', or 'interesting'. This type of job is shown in quadrant 4 of figure 3.

Cognitive ergonomics has been focusing its research attention on the ease-of-use or usability of systems and products. It is clear that ease-of-use only covers the lower half of the two-dimensional space in figure 3, and designers should be reminded that ease-of-use is only part of the consideration. An easy-to-use system or product can be pleasing or displeasing, whereas a difficult situation can be highly attractive and challenging. A situation can be difficult and displeasing by nature (like a courtroom battle), and thus it is futile to make it pleasing and it is undesirable to make it easy for the opposing party. Designers should consider ease-of-use and aesthetic needs at the same time to seek the most appropriate combination of the two for the specific situation.

3.3. *The aesthetic/affective dimension and the dimension of psychosomatic effects*

In figure 4 the aesthetic/affective dimension is shown with the dimension of psychosomatic effects or 'psychosomatic soundness', which ranges from the negative end of harmfulness to the positive end of healthfulness. If a task situation or experience contributes positively to the healthfulness of the person in pleasing and attractive ways, we tend to call that experience 'rejuvenating', 'refreshing', or 'invigorating', shown in quadrant 1. A trip to the spa, completion of an exercise programme, and enjoying a delicious and healthy meal are examples of this type of situation.

Not all healthful situations are pleasing or attractive to the experiencing person, however. For example, drug rehabilitation programmes and physical rehabilitation programmes can be extremely painful to the patient during the treatment process. This type of situation is shown in quadrant 2 of figure 4. Because the long-term health benefits far outweigh the short-term pain of the patient, designers of treatment programmes and products must always first focus on the health benefits, while at the same time try to minimize the pain of the patient. This is a clear example that aesthetic/affective considerations should not be of the first priority in some design situations.

Designs and task situations shown in quadrant 3 are not only displeasing but also harmful, and they are characterized by descriptors such as 'stressful', 'hazardous', or 'life threatening'. Examples of this type of situation include workplaces that violate ergonomic and safety principles and guidelines, 'sweatshops', and certain jobs that are dangerous in nature, such as military operations, law enforcement, and firefighting.

In quadrant 4 we find activities and task situations that are harmful or potentially harmful, but are highly attractive and appealing to the participants. Many sports or adventurous activities involve high levels of physical injury risk, but avid participants of these activities do not refrain from participating even if they are fully aware of the risks. In fact, the risks may become part of the thrill they seek in participating in these sports or activities. Many people continue to participate in their favourite sports, even after they have been injured and their health conditions urge them to withdraw from these activities. Certain addictive behaviours such as narcotics use are harmful to both the body and the mind of the users, but millions of

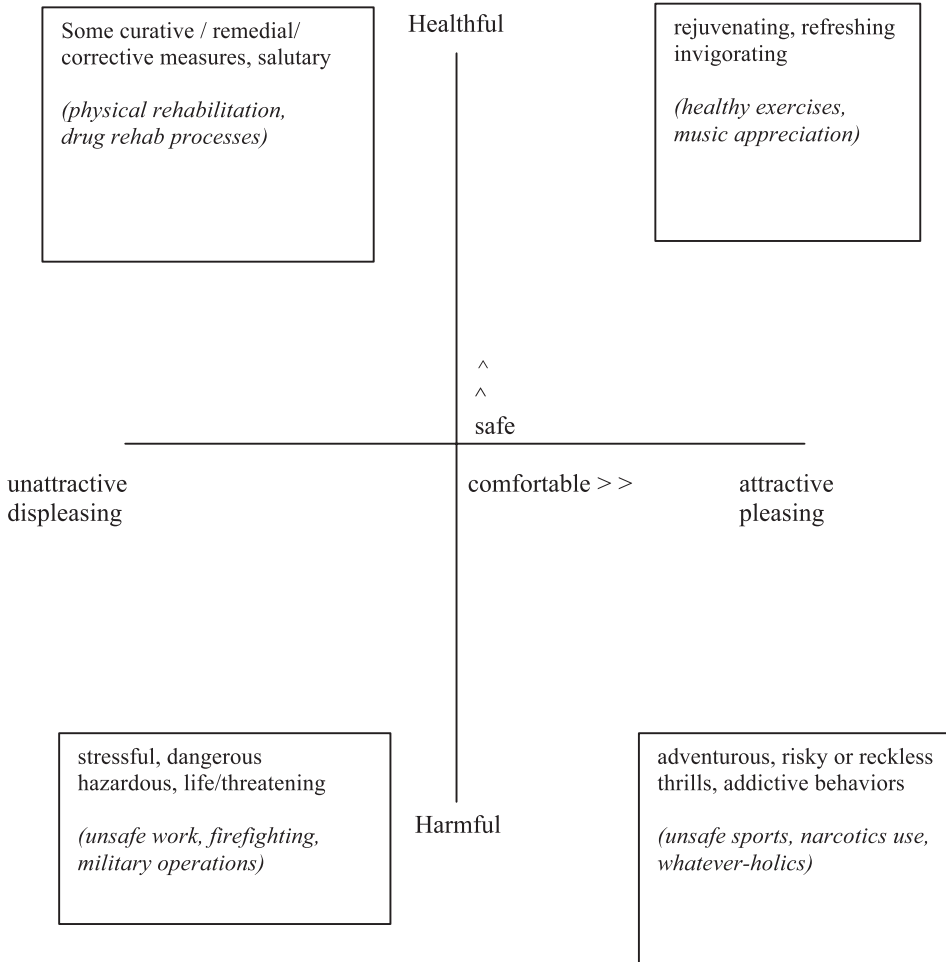


Figure 4. The two-dimensional space defined by the aesthetic dimension and the dimension of psychosomatic effects.

users across the globe seem to ignore the health warnings, even in the presence of strict laws banning these activities.

The focus of attention of physical ergonomics research has been on the safety and comfort aspects of human-machine system design. When we examine figure 4 closely, it is clear that safety and comfort cover only part of the two-dimensional space in figure 4. A safe condition can be found anywhere on or above the horizontal axis, because safety implies only the absence of harmful factors, but not necessarily the presence of nourishing factors that strengthen or enhance the health condition of a person. Similarly, a comfortable situation can be found anywhere on or to the right of the vertical axis, because it only implies that the situation is acceptable or pleasing to the body or the senses of the experiencing person. A comfortable situation can be either harmful or healthful.

When we examine the evolution of work systems and products, we can see the gradual disappearance of unsafe and uncomfortable workplaces and products and

the promotion of safe and comfortable ones. The vector of change is pointing from the lower-left quadrant to the upper-right quadrant. This suggests that future generations of work systems and products should not only be safe and comfortable, but rejuvenating and refreshing to the workers and users. Design of rejuvenating work systems and products is a challenge to human factors.

3.4. *The aesthetic/affective dimension and the ethic dimension*

In the discussion above, we have ignored the ethical issue of whether certain things are good or certain actions are right. In figure 5, the aesthetic/affective dimension and the ethic dimension are shown together to illustrate the importance and value of incorporating the ethic dimension explicitly and systematically in human factors

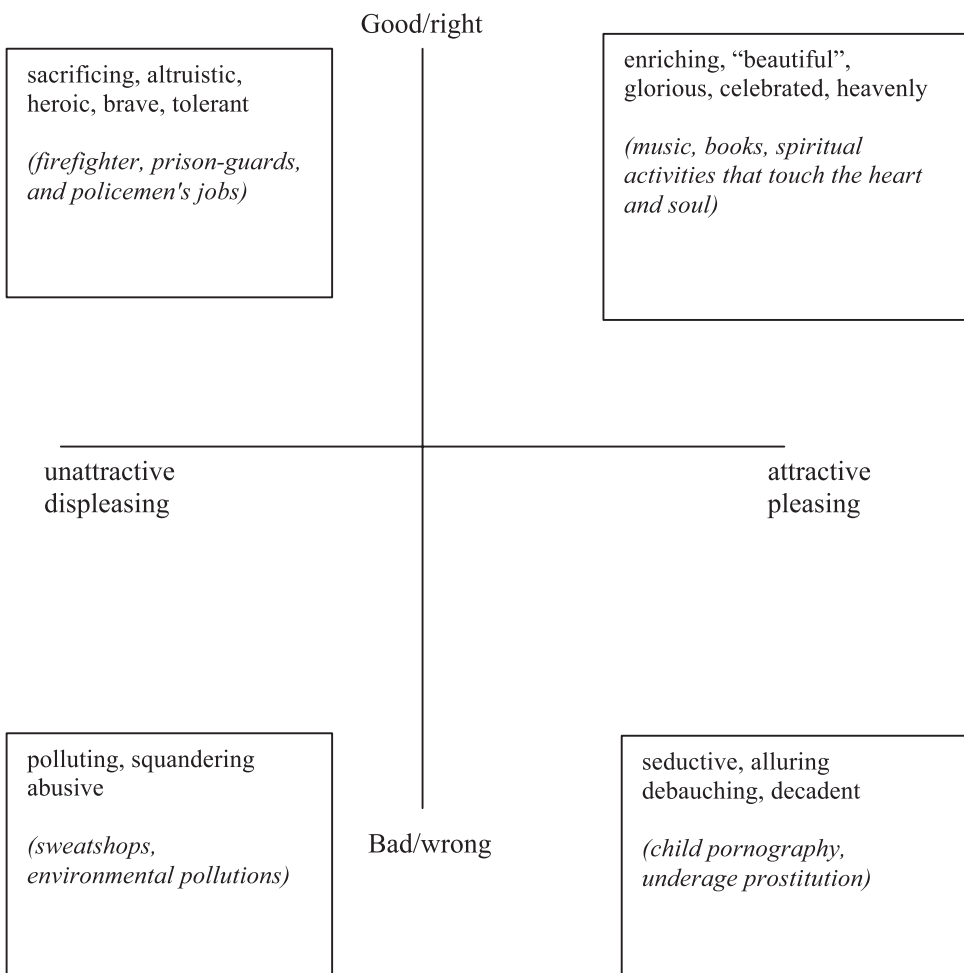


Figure 5. The two-dimensional space defined by the aesthetic dimension and the ethic dimension. As defined in the text and used throughout this article, the aesthetic 'pleasing/attractive' dimension is defined with reference to the senses of the experiencing person who is the subject of discussion, not to the senses or judgments of other people or the general public.

research and practice. In figure 5, the ethic dimension is shown as the vertical axis, ranging from the negative end of 'bad or wrong' to the positive end of 'good or right', with varying degrees of goodness or badness shown in between. As in figures 2 to 4, the aesthetic/affective dimension is shown on the horizontal axis. The four quadrants defined by the two dimensions clearly represent four types of situations or systems. Again, as noted earlier, the aesthetic 'pleasing/displeasing' dimension is defined with reference to the senses of the person experiencing this who is the subject of discussion, not to the senses or judgments of other people or the general public.

An experience that is both extremely pleasing to the senses and extremely positive along the ethic dimension are often celebrated as a 'glorious', 'beautiful', or 'heavenly' experience that enriches the heart and soul of the individuals experiencing this. These descriptors are shown in quadrant 1 of figure 5. However, not all ethical actions would please the senses of the person performing these actions, and in fact, many ethical actions require a great deal of sacrifice and endurance from the performing person. Risking one's life or health to save another person's life or to enforce social order in dangerous or life-threatening situations is 'heroic' and 'brave'. These descriptors, shown in quadrant 2 of figure 5 characterize the daily work activities of firefighters, prison-guards, and law enforcement officers.

Quadrant 3 shows the type of situations or actions that are not only displeasing but also unethical. Systems or products that pollute the environment, exploitative production practices such as 'child labour', and wasteful action that squander natural resources displease the senses in their appearance and are deplorable in their ethics. Quadrant 4 shows 'enticing' and 'seductive' products or situations that attempt to corrupt one's morals and ethics by pleasing and alluring one's senses. Child pornography and underage prostitution are undebatable examples of this type of situation.

As a scientific discipline that devotes itself to the study of work and product design, human factors and ergonomics has largely ignored many of the issues raised above. Little attention has been paid to the work of firefighters, prison guards, or law enforcement officers. Little effort has been devoted to pollution control and environmental protection. No systematic work has been done to examine the ethical implications of product design from the human factors point of view.

Although it is still an issue of debate in philosophy about whether aesthetic response is independent of utilitarian value judgements and ethic judgements, more and more philosophers have started to examine the moral functions of art and the moral responsibilities of the artist. As mentioned by Mary Devereaux (1997), 'A central concern of aesthetics today is the relation of aesthetics and moral value. Moral philosophers, in turn, are looking to art. . . . We might say, with slight exaggeration, that we are experiencing an ethical turn in aesthetics and an aesthetic turn in ethics' (Devereaux 1997). Clearly, human factors researchers should examine the moral functions of design and the moral responsibilities of the designers.

4. Conclusion

This article discusses the relationship between aesthetics, ethics, and the traditional research issues in human factors. It has shown that traditional human factors research topics such as safety and usability can be organized into three dimensions: the arousing quality dimension, the dimension of information processing demands, and the dimension of psychosomatic soundness. Incorporating the aesthetic and the ethic dimensions explicitly in human factors research as two new dimensions can help us put

the current human factors research in a larger context. We can see more clearly the limitations of current research and the needs and challenges for research in new areas.

As shown in this article, the aesthetics dimension helps us realize that human factors must go beyond safety and usability. Further, the aesthetics and the ethics dimensions together help us realize that aesthetic human factors is not just about design for pleasure; it is about displeasing situations as well. It is not just about tangible products made to sell or consume; it is also about intangible systems, jobs, and environments. Clearly, the arguments that affective design is pleasurable or hedonic design or it is about 'from performance and pain to pleasure' (Helander *et al.* 2001, Jordan 2001, Nagamachi 2001) only reflect part of the goals and missions of aesthetic ergonomics. Similarly, the argument that 'good ergonomics is good economics' (Hendrick 1995) may be too narrow. Human factors and ergonomics must go beyond economic concerns. Broad aesthetic and ethic considerations of a design situation may suggest that good ergonomics sometimes is not necessarily good economics.

It should be pointed out here that the five dimensions of human factors and ergonomics presented in this paper only represents a starting point or overall framework for further interdisciplinary research. Theories, methods, and research findings in a diverse range of disciplines such as the psychology of emotions (Lewis and Haviland-Jones 2000), consumer behaviour (Sewall 1978, Holbrook and Huber 1979), industrial design (Noblet 1993), ergonomics (Wickens *et al.* 1998), as well as aesthetics (Korsmeyer 1998) and ethics (Sterba 1998) will contribute to this interdisciplinary research.

References

- DEVEREAUX, M. 1997, *The philosophical status of aesthetics*, Speech at the 1997 Annual Meeting of the American Society of Aesthetics, Santa Fe, New Mexico.
- HELANDER, M. G., KHALID, H. M. and THAM, M. P. (eds) 2001, *Proceedings of the International Conference on Affective Human Factors Design* (London: ASEAN Academic Press).
- HENDRICK, H. 1995, *Good Ergonomics is Good Economics* (Santa Monica, CA: Human Factors and Ergonomics Society).
- HOLBROOK, M. and HUBER, J. 1979, Separating perceptual dimensions from affective overtones: An application to consumer aesthetics, *Journal of Marketing Research*, **5**, 272–283.
- HONDERICH, T. (ed.) 1995, *The Oxford Companion to Philosophy* (Oxford: Oxford University Press).
- JORDAN, P. W. 2001, New century supertrends: Designing a pleasurable future, in M. G. Helander, H. M. Khalid and M. P. Tham (eds), *Proceedings of the International Conference on Affective Human Factors Design* (London: ASEAN Academic Press), 3–8.
- KORSMEYER, C. (ed.) 1998, *Aesthetics: The Big Questions* (Oxford: Blackwell Publishers).
- LEWIS, M. and HAVILAND-JONES, J. M. (eds) 2000, *Handbook of Emotions*, 2nd edn. (New York: Guilford Press).
- LIU, Y. 2000a, Engineering aesthetics and ergo-aesthetics: theoretical and methodological foundations, in *Proceedings of the 5th Annual International Conference on Industrial Engineering-Theory, Applications and Practice* (CD-ROM). Taiwan, 2000.
- LIU, Y. 2000b, The aesthetic and the ethic dimensions of human factors and design, *Proceedings of the 5th Industrial Engineering Conference on Industrial Engineering-Theory, Applications, and Practice* (CD-ROM). Taiwan, 2000.
- LIU, Y. 2001, Engineering aesthetics and aesthetic ergonomics: A dual-process methodology and its applications, in M. G. Helander, H. M. Khalid and M. P. Tham (eds), *Proceedings of the International Conference on Affective Human Factors Design* (London: ASEAN Academic Press), 248–255.

- LIU, Y. 2003, Engineering aesthetics and aesthetic ergonomics: Theoretical foundations and a dual-process research methodology, *Ergonomics*, **13/14**, 1273–1292.
- NAGAMACHI, M. 2001, Kansei Engineering: A powerful ergonomic technology for product development, in M. G. Helander, H. M. Khalid and M. P. Tham (eds), *Proceedings of the International Conference on Affective Human Factors Design* (London: ASEAN Academic Press), 9–14.
- NOBLET, J. 1993, *Industrial Design: Reflections of a Century* (Paris: Abbeville Press, Inc).
- SEWALL, M. 1978, Market segmentation based on consumer ratings of proposed product designs, *Journal of Marketing Research*, **15**, 557–564.
- STERBA, J. P. (ed.) 1998, *Ethics: The Big Questions* (Oxford: Blackwell Publishers).
- WICKENS, C. D., GORDON, S. and LIU, Y. 1998, *Introduction to Human Factors Engineering* (New York: Addison-Wesley-Longman).