Implications

VOL. 02 ISSUE 06 www.informedesign.umn.edu

A Newsletter by InformeDesign. A Web site for design and human behavior research.

IN THIS ISSUE

The Kinesiology of Design

Context Specificity in Performance

Related Research Summaries

The Kinesiology of Design

The title of this article may strike readers of this newsletter as somewhat curious, perhaps obscure. In what sense is kinesiology—the science of movement and human performance—connected with design? The two fields are, in fact, closely connected. A framework for this idea is provided below, followed by some practical implications for consideration.

First, what do we mean by kinesiology? The term is defined in *Webster's Dictionary* as "the science or study of human muscular movements, especially as applied in physical education." In the broadest sense however, kinesiology encompasses the study of the entire realm of physical activity and human performance. Over the past three decades many institutions of higher learning have changed the names of their physical education programs to reference kinesiology, underscoring the broader concerns of the discipline.

Academic programs in kinesiology feature a high degree of interdisciplinary and multi-disciplinary diversity. At the University of Minnesota, for example, the School of Kinesiology has two divisions (Kinesiology, and Recreation and Sports Studies), as well as degree and certificate programs in kinesiology, recreation, coaching, and human factors/ergonomics to name just a few. In addition, the department has scientific research laboratories dealing with the biomechanics of gait and posture, human sensorimotor control and motor learning, health and human performance in extreme environments, physiological hygiene and exercise science, and human factors and ergonomics.

Kinesiology is relevant to design as evident through multiple linkages. Designers may not be consciously aware of these relationships, but do in fact address them extensively during the programming phase and specification tasks of the design process.

Kinesiological Control of Performance -Design Interaction. To better understand the link between kinesiology and design we can refer to the science of human factors and ergonomics. This field is concerned with the interaction of human performance and design factors in the environment, such as tools, machines, equipment, workstations, complex technological systems, jobs, human-created organizations and institutions. Figure 1 illustrates this idea, suggesting that both performance (e.g., accuracy, timing, errors committed, quality, productivity), as well as human

perceptions of their performance and their environment are equally influenced by design of the environment.

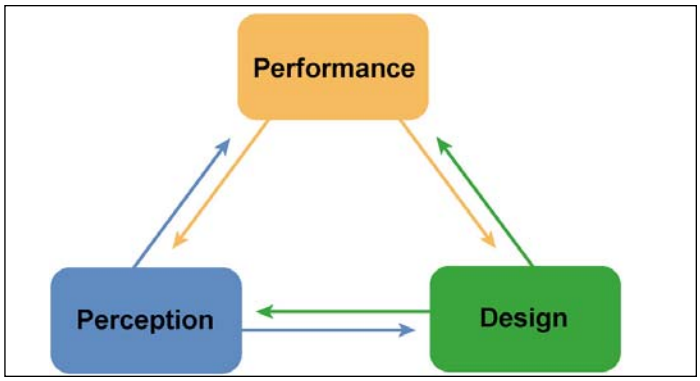

Figure 1. The kinesiology of design is based on performance-design interaction.

In every respect, kinesiology and design are linked through the human movement that is required at some stage to generate the design. Design could not exist without kinesiological performance. This was the case with the manufacture of primitive stone tools by early hominids two million years ago, and it remains true today.

Most people commonly interact with design at work. Every day billions of people engage in work activities to design and thereby control and structure their environments. Work involves interaction with tools, machines, artifacts, and/or systems in a process that is controlled by movement performance, that is kinesiological mechanisms.

Kinesiological Basis of Context Specificity in Performance. Just as kinesiology is essential for design, so too does design influence kinesiological behavior, in a reciprocal manner (Fig. 1). In general, factors that can influence performance are categorized into four groups:

—those related to natural skill and proficiency,
—those related to learning ability,
—those related to social relationships, and
—those related to design of the environment.

Research on how and why behavior varies from person to person points to the key role of the last of groups. That is, variation in human performance is *context specific*, or can be attributed to specific design features of the performance environment.

Derived from a variety of observations and research (see Supporting Evidence), evidence indicates that variation in performance owes as much or more to the design of the physical and social environment as to natural skill and learning ability. In particular, task- or context-specific design factors typically contribute 50 to 90 percent of variation in workplace performance.

How can we explain these findings? Again, the answer is found in kinesiology. In a literal sense, the organization of our central nervous system undergoes continuous modification resulting from the interactions between the brain, body, and environment. This results in a person's individualized, specialized adaptation—both physical and neural—to particular environmental design conditions that is refined continually throughout life. As an example, look around the next time you are in a classroom or auditorium—no two individuals have exactly the same seated posture, despite the similarity of seat design.

Practical Implications

Performance-design interaction has a number of important practical implications for understanding the human condition and for designing environments.

Human-Centered Design—Usable Design—Is Movement-Centered Design. To define a design as "human-centered" implies that the human is able to

Implications

use behavior (motor behavioral mechanisms) to control sensory feedback from the design. The degree to which a design can be controlled effectively via behavior determines its degree of human-centeredness. This principle links kinesiology to usability in design.

Control of Design Feedback is Essential for Learning. It can be argued that a design doesn't do us much good if we cannot learn how to use it. Indeed, one of the attributes commonly associated with usable designs is that such designs promote learning. Research supports the conclusion that learning to use a particular design (such as the wayfinding in a building, or a specific type of desk chair) depends upon how well a person can control the sensory feedback from the design.

Staff using equipment at a shared workstation: personal posture and stature, and tasks contribute to design feedback.

To Change Behavior, Change Design. Behavior is self-controlled. One cannot directly control the behavior of another. However, behavior changes as environmental design conditions change. To effect behavioral change, therefore, the best strategy is to modify design characteristics of the physical or social environment.

The Impact of Changes to a Design Should be Tested Along the Way. Once out in the "real world," a new or modified design may result in different patterns of behavior that typically are not predictable from studies of prior designs. As improvements or modifications are made to a design they should be tested. This method of evaluation—termed usability testing—is the best way to arrive at a better design.

Performance and Design Are Interdependent. Evidence was noted above that design factors influence variations in performance, and vice versa. Since the dawn of our species we have endeavored to tailor and control the design of our environment and our technology to meet our needs, and in so doing have specialized our behavior to exploit these designs.

Human Evolution is Intimately Linked to the Kinesiology of Design. Throughout the course of evolution humans have used movement to interact with their environment. They have used movement to create and interact with designs to aid performance and perform work. One can argue that human evolution is the result of human actions taken to enhance performance by creating and refining designs.

Collectively, the above observations suggest that designers literally hold society's future in their hands. Thus, design—especially at the micro level of detailing—must be evidence-based.

References:

—Hoffman, S., and Harris, J. (Eds.) (2000). *Introduction to kinesiology: Studying physical activity*. Champaign, IL: Human Kinetics.

—Jones, M. (1966). *Individual differences*. In E.A. Bilodeau (Ed.), Acquisition of skill (pp. 109-146). New York: Academic Press.

—Norman, D. (2000). *The design of everyday things*. New York: Basic Books.

—Smith, T. (1993). *The scientific basis of human factors—a behavioral cybernetic perspective*. In Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting (pp. 534-538). Santa Monica, CA: Human Factors and Ergonomics Society.

—Smith, T. (1994). *Core principles of human factors science*. In Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting (pp. 536-540). Santa Monica, CA: Human Factors and Ergonomics Society.

—Smith, T. (1998). *Context specificity in performance—the defining problem for human factors/ergonomics*. In Proceedings of the Human Factors/ Ergonomics Society 42nd Annual Meeting (pp. 692-696). Santa Monica, CA: Human Factors and Ergonomics Society.

—Smith, T. (2001). *Work. Human control of the behavioral environment*. In Karwowski, W. (Ed.), International Encyclopedia of Ergonomics and Human Factors. New York: Taylor & Francis.

—Smith, T., Henning, R., & Smith, K. (1994). *Sources of performance variability*. In G. Salvendy and W. Karwowski (Eds.), Design of Work and Development of Personnel in Advanced Manufacturing (Chap. 11, pp. 273-330). New York: Wiley.

Context Specificity in Performance: Supporting Evidence

Below, a few of the many lines of scientific research that provide evidence for context specificity of performance are discussed. Observations into some of these areas began over 475 years ago.

Performance in the Workplace. In 1525, Agricola published the first scientific treatise on human work, dealing with underground mining in northern Europe. This publication presented how variation in human work performance can be influenced by design factors in the work environment, such as the design of tools and machines; technology; the physical environment; shift and work schedules; safety features; and supervisory approaches.

Exercise Response. Research in exercise response began 70 years ago. Changes in cardiorespiratory function, such as heart and ventilatory rates, blood pressure, cardiac output, and oxygen consumption, vary linearly in relation to the exercise workload level—a design factor.

Causes of Industrial Accidents. Investigations of the causes of industrial accidents began 70 years ago. Although "human error" commonly is touted as a major cause of industrial accidents, available evidence indicates that about half of all industrial accidents are attributable either to poor ergonomic design, or to an interaction of worker behavior with poor design.

About the Author:

Thomas J. Smith, Ph.D., has research and teaching experience in the areas of human factors and ergonomics, work physiology, human performance, kinesiology, and occupational science. He is a Research Associate with the School of Kinesiology, University of Minnesota, and a Senior Consultant with Orfield Laboratories, an environmental and occupancy research consulting firm in Minneapolis. He is a Certified Human Factors Professional with over 90 publications.

Related Research Summaries

InformeDesign has many Research Summaries about kinesiology and related, pertinent topics. This knowledge will be valuable to you as you consider your next design solution and worth sharing with your clients and collaborators.

"Specifying Seating for the Elderly"
—*Journal of Gerontology: Medical Sciences*

"Computer Monitor Viewing Angle"
—*Human Factors*

"Physical Strain of Moving Trash Containers"
—*Applied Ergonomics*

"Scanner and Checkstand Design Can Influence Wrist Injury"—*Human Factors*

"Classroom Furniture School Children Prefer"
—*Ergonomics*

"Effects of Adjustable Patient Beds on Nurses"
—*Ergonomics*

"MS Patient Experiences and Perceptions"
—*International Journal of Consumer Studies*

"Posture Affects Computer Workers' Comfort and Health"—*Applied Ergonomics*

Photos Courtesy of:

Kate Bukoski, University of Minnesota (p. 1 & 3)
Debbie Boyles, University of Minnesota (p. 4)

InformeDesign℠
Where Research Informs Design

The Mission

The Mission of InformeDesign is to facilitate interior designers' use of current, research-based information as a decision-making tool in the design process, thereby integrating research and practice.

Created by:
University of Minnesota

Sponsored by:
ASID | American Society of Interior Designers