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Developing the IBM Personal System/2 Mouse: An Industrial Design/Human Factors Collaboration

BIOGRAPHICAL SKETCHES

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ABSTRACT

This paper describes a collaboration between industrial design and human factors in the design of the IBM Personal Systems/2 (PS/2) (TM) mouse. The initial industrial design concept is discussed, followed by a description of four human factors studies conducted to determine user preference among three competitive shapes. It was found that two relatively minor modifications to the original design significantly improved its rating by the test participants.

INTRODUCTION

The benefits of combining the efforts of industrial designers and human factors psychologists in the development of consumer goods have been described by Sears (1986). This paper describes a collaboration between industrial design and human factors in the design of the IBM Personal Systems/2 (PS/2) (TM) mouse.

A mouse is a popular type of pointing device used to control objects displayed on a computer screen. The user places one hand on the top of the mouse, moves it on a smooth surface, and the controlled object moves on the computer screen in a way which corresponds to the movements of the mouse. The surface is usually a desk top, although a special surface is required for some types of mice. A mouse usually has from one to three buttons whose function is defined by the software.

INITIAL INDUSTRIAL DESIGN CONCEPT

The initial design requirements for the PS/2 mouse were typical of any hand-held and hand-operated product. The final product had to be easy to grasp and use, cause the operator minimum or no discomfort while in use, be flexible enough to be operated by a wide range of users with either hand, and be compatible with the appearance of the IBM Personal System/2.

To define the best possible shape for the mouse, research was conducted in three areas: the human hand, published articles on pointing devices, and existing mice. The study of the human hand turned out to be the most informative and influential of the three. Primarily, the hand was studied in an at-rest position on a desk-top surface, which was the intended typical surface for operating the mouse. Several conclusions were reached. With the user in a sitting position, the hand forms a half-tear-like shape while at rest on a desk-top surface. The front of the hand (finger area), being higher and wider than the rear, almost forms a straight line where the palm ends. The rear of the palm forms a very irregular, radius-like cavity that is narrower and lower than the front.

In order to maximize comfort while using the mouse, it is reasonable to conclude that the design should fill as closely as possible the cavity formed by a typical hand at rest on a desk-top surface. Three-dimensional preliminary models were built using various wedged shapes that accommodated the cavity. They were refined to a final rectangular shape that was wider and higher at the front than at the rear, formed a straight line at the front, and ended with a full radius at the rear. The side view included a very generous radius at the front, mimicking the arch formed by the fingers. Two buttons (long and narrow, similar to the shape of a finger) ran parallel to the length of the mouse, and followed the generous radius down the front. The long narrow shape allowed users to press the buttons in a range of positions, instead of limiting their activation to one set location as with some existing mice.

Industrial Design was satisfied with the results of the overall shape, but had concerns about some basic inconsistencies with existing mice, which typically were higher in the rear and rectilinear in shape. A preliminary evaluation by Human Factors confirmed that the basic shape, while not following the norm, was well accepted.

The final production design is very similar to the refined concept, which met our original goals and is very complementary to the PS/2 product line. Semantically, the design expresses how it should be held and operated.

FOUR HUMAN FACTORS STUDIES

After industrial design developed the original design for the PS/2 mouse, a series of four studies were conducted to determine users' preference for the shape and button

style of the PS/2 and two competitive shapes. The competitive shapes were the Box and Humped designs. The three mice are shown in Figure 1. A description of the studies and the resulting modifications to the original design of the PS/2 mouse illustrate the collaboration between industrial design and human factors on this product.

The general approach taken in the studies was to let the participants use the mice for a short period of time. After using all three mice, the participants ranked them in order of preference. A different group of 24 employees from a temporary employment agency participated in each of the first three studies, and another group of 12 temporary employees participated in Study 4, for a total of 84 participants. Studies 1-3 were conducted before any IBM PS/2 prototypes were available. Only in Study 4 were the participants able to use the mice to control a program. The results of the four studies are shown in Figure 2, where a high preference is good (rank average close to 1) and a low preference is bad (rank average close to 3). Participant rankings were analyzed using Friedman tests and multiple comparisons based on Friedman ranks (Hollander and Wolfe, 1973).

In Study 1, the Box and Humped mice were finished working models, and the PS/2 mouse was an unfinished working model. The overall Friedman test was significant ($p<.01$). Only one multiple comparison was significant, showing the Humped mouse preferred to the Box mouse ($p<.005$).

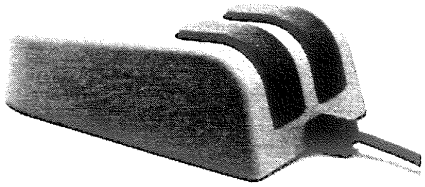
To counter the criticism that the comparison in Study 1 was unfair to the PS/2 mouse (due to its unfinished condition), Study 2 was conducted with wood models for all three mice. As the graph in Figure 2 shows, the pattern of results did not change substantially. The overall Friedman test was still significant ($p<.01$), and the Humped mouse was still preferred to the Box mouse ($p<.01$).

In Studies 1 and 2, the PS/2 mouse was ranked between the Humped and Box mice, but was not shown to be statistically different from either.

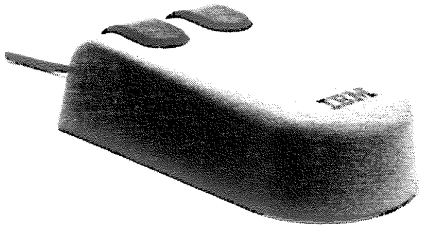
The most persistent comments from participants in Studies 1 and 2 regarding the PS/2 mouse concerned the button height and the radius of curvature where the mouse contacted the palm of the hand. The original design of the PS/2 mouse had buttons 1 mm high and a 3 mm radius of curvature. Based on the participants' comments, the PS/2 mouse design was changed to buttons 2 mm high and a 7 mm radius of curvature.

Study 3 used the wood models from Study 2 for the Humped and Box mice, and an appropriately modified wood model for the PS/2 mouse. The dramatic change in preference for the PS/2 mouse as a result of these modifications is shown in Figure 2. The overall Friedman test was significant ($p<.005$). The PS/2 mouse was equally ranked with the Humped mouse, and both were significantly preferred to the Box design ($p<.005$).

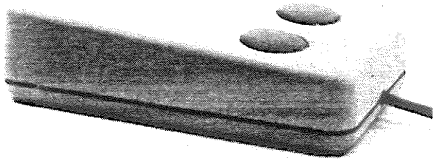
In Study 4, the mice were all finished working models attached to a prototype PS/2 system. In Studies 1-3, the participants had only moved the mice on a table top. In Study 4 they used the mice to control a program. This study directly compared the original and modified versions of the PS/2 mouse as well as the Humped mouse. Under these more realistic conditions, the only significant multiple comparison was that the modified version of the PS/2 mouse was preferred to the original design ($p<.04$).



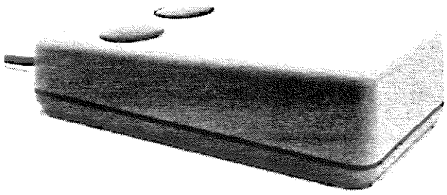
The PS/2 Mouse: Front View



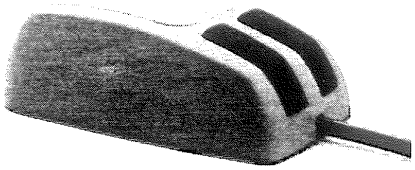
The PS/2 Mouse: Rear View



The Box Shape: Front View



The Box Shape: Rear View



The Humped Shape: Front View

The Humped Shape: Rear View

Figure 1. Front and rear views of the three mice

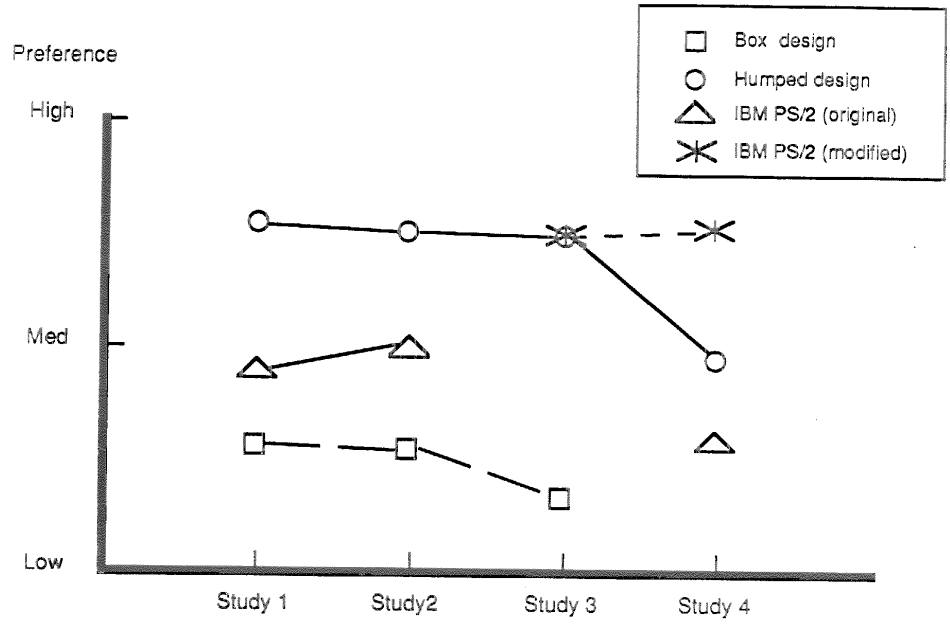


Figure 2. Results of the four human factors studies

CONCLUSIONS

The final design of the IBM PS/2 mouse represents a successful collaboration between industrial design and human factors. The design began with an industrial design concept, tempered by anthropometric (size and shape of the human hand) and engineering (volume of internal electronic and mechanical components) constraints. Two studies conducted with non-IBM participants suggested that the initial design could be improved by altering two relatively minor (in the industrial design sense) characteristics: button height and palm edge radius.

After industrial design and human factors studied the comments and redesigned the PS/2 mouse, two follow-up studies demonstrated the effectiveness of the change in improving user preference.

Sears (1986, p. 7) reported that "designers often feel that testing design concepts is a sure way to ruin an innovative design, whereas the human factors psychologist will maintain it is a critical step in removing risk and guaranteeing a successful product". In this case, the changes to design improved user preference without affecting the innovativeness of the design.

REFERENCES

Hollander, M and Wolfe, D.A. (1973). Nonparametric statistical methods. New York, NY: J.Wiley.

Sears, R. J. (1986). Market value innovation: designing the experience. Innovation, 5, 2-8.