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Slot versus Insertion Magnetic Stripe Readers: User Performance and Preference

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Four magnetic stripe readers were evaluated for percentage of good reads, throughput, and user preference using a simulated time-and-attendance task. Two were slot readers, one with a vertical slot and one with a horizontal slot. Two were insertion readers, one with the insertion parallel to the horizontal plane and one with the insertion 20 deg below the horizontal plane. Twelve participants were divided into four groups of three members each. Each group approached each reader from both directions. The percentage of good reads was high on all readers and was not significantly different. The differences in throughput and preference were significant and favored the slot readers. It did not seem to matter whether the slot was vertical or horizontal. The angle of entry for the insertion readers produced no significant differences.

INTRODUCTION

There are two basic styles of magnetic stripe readers in current use: slot and insertion. A slot reader is designed to allow the user to pass a coded magnetic stripe (affixed to a card or badge) in front of a magnetic sensing head while guided by a slot. With an insertion reader, the badge is inserted into and then withdrawn from an opening a little larger than the cross-sectional dimensions of the badge.

Because the insertion reader controls more degrees of freedom of the movement of the badge, it is possible that insertion readers have a higher percentage of good reads, where a good read is defined as the correct sensing of the information on the magnetic stripe. On the other hand, this additional constraint on movement may have adverse consequences for throughput, or the rate of good reads per minute.

Another issue is that of horizontal versus vertical orientation of the slot in a reader. It was hypothesized that for a queue of users (like that in a time-and-attendance task) the throughput for a horizontal reader would be superior to that for a vertical reader, since using the horizontal slot seems to be more compatible with the motion of a user walking past the reader while clocking into work.

The angle of entry into an insertion reader is usually parallel to the horizontal plane. Because lowering the angle of entry into the reader (i.e., tilting the point of entry below the horizontal plane) may help to prevent contaminants from falling into the opening, the angle of insertion of the badge into the insertion reader was studied. The advantage of reducing contamination could be offset by a disadvantage in user performance.

For some applications (e.g., banking tasks) it may be more important to emphasize accu-

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racy, and for other applications (e.g., time-and-attendance tasks) it may be more important to emphasize throughput. The purpose of this study was to investigate the trade-offs in user performance and consistencies in user preference regarding the two slot and the two insertion magnetic stripe readers for a simulated time-and-attendance task.

METHOD

Subjects

Ten employees of a temporary-help agency (six men and four women) and two IBM employees (both men) participated. The participants represented a range of age, handedness, education, employment experience, and badge-reader experience.

Materials and Apparatus

Four magnetic stripe readers were constructed for use in this study (see Figure 1): (1) a horizontal slot reader; (2) a vertical slot reader; (3) an insertion reader with the insertion level with the horizontal plane; and (4) an insertion reader with the insertion angled 20 deg below the horizontal plane.

An LED display was attached to the readers to monitor the number of good and bad reads. Performance data were collected at the reader and transferred to diskette storage on an IBM Portable Personal Computer.

The Mag Tek Model 2105-002 magnetic stripe reader was used in the slot readers, and the American Magnetic Model 100 magnetic stripe reader was used in the insertion readers. All of the readers were presented under the same conditions, with the magnetic heads at a height of 107 cm.

Procedure

Instructions were read to the participants, who were then randomly divided into four groups, with three members per group. Each

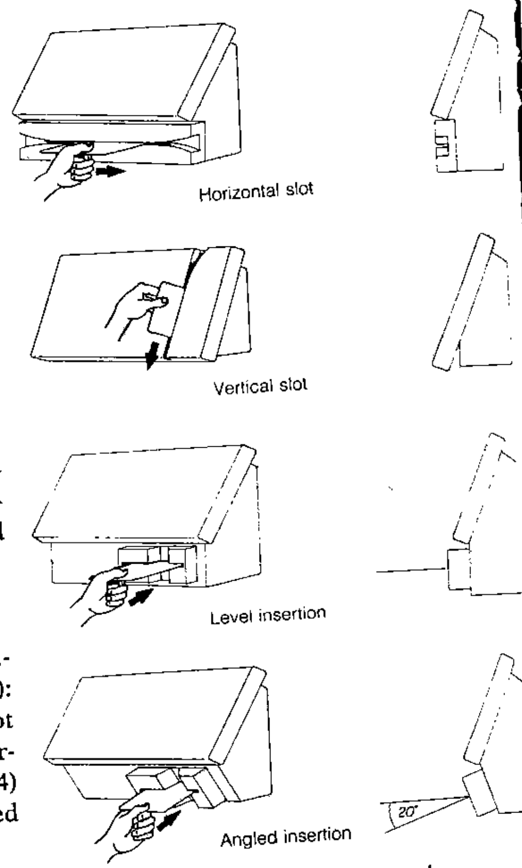

Figure 1. *The four badge readers.*

participant was given a badge with his or her participant number coded on the stripe so that performance could be individually tracked. The groups were assigned to readers using a Latin square designed to control for first-order transfer effects (Bradley, 1958). In other words, each participant used each reader, and each group of participants used the readers in a different order so that each condition and its immediately preceding condition were counterbalanced.

Groups were taken into the lab two at a time and were given brief instructions on how to hold the badge for the reader they were to use. No specific instructions were

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TABLE 1

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Reader
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Vertical slot
Average data from s
Level insertion
Angled insertion
Average data from i

Note: For preference, 1

given regarding speed versus accuracy. Each group used a reader for four trials before using another reader. The duration of a trial was five minutes on the first reader and three minutes on the remaining readers. The members of a group walked in a circle in front of the reader to simulate a queue of people waiting to use the reader. On the first and third trials, the participants approached the reader in counterclockwise movement, and on the second and fourth trials they approached the reader in a clockwise movement. The groups were given a rest period between each trial while the data collected during that trial were transferred from the readers to a portable personal computer.

These data were used to compute good-read percentages and throughput rates. The badge readers could detect and count good and bad reads, and an observer was stationed at each reader to keep track of null reads. A read was bad if the reader could detect the magnetic stripe but could not read the information. A null read occurred if the badge reader could not detect the magnetic stripe and therefore could not record the attempt. In practice, the usual consequence of a bad or null read is for the user to try again. In this experiment, the participant did not try again.

After using all four readers, the participants were asked to indicate their preference for the readers by ranking them from 1 to 4, with 1 for the most preferred and 4 for the least preferred.

RESULTS

The averages for the three dependent variables are shown in Table 1. The throughput averages are based on the performance of the four groups, since individuals within a group were not independent of one another. An analysis of variance showed the differences to be statistically significant, $F(3,9) = 26.7, p < 0.0001$. The percentages of good reads are based on all 12 participants; the differences are not statistically significant, $F(3,33) = 2.4, p > 0.05$. The preference data were also based on all 12 participants, and were found to be significantly different using a Friedman test, $S = 510.5, p < 0.001$. A Friedman test was used because the preference data were ranks.

Table 2 shows the results of multiple-comparisons tests conducted on the significant dependent variables of throughput and preference. Throughput was analyzed with Bonferroni *t* tests, and preference was analyzed using a test based on the Friedman statistic (Hollander and Wolfe, 1973).

From these results, one would conclude that there is no evidence for a throughput or preference difference between the two slot readers or between the two insertion readers, but there is strong evidence that both the slot

TABLE 1

Means (and Standard Deviations) for Three Dependent Measures

Reader	*Throughput (Good Reads/Min)*	*Percentage Good Reads*	*Preference*
Horizontal slot	27.50 (6.60)	97.5 (3.6)	1.67 (0.65)
Vertical slot	26.13 (6.95)	98.2 (2.4)	1.46 (0.58)
Average data from slot	26.81 (6.74)	97.8 (2.8)	1.56 (0.16)
Level insertion	18.38 (4.91)	98.0 (2.2)	3.38 (0.57)
Angled insertion	18.56 (5.27)	99.7 (0.7)	3.50 (0.67)
Average data from insertion	18.47 (5.06)	98.8 (1.29)	3.44 (0.16)

Note: For preference, 1 = most preferred and 4 = least preferred.

TABLE 2

Multiple Comparisons for Throughput and Preference

Throughput (Good Reads/Min)	Preference
HS > VS	HS > VS
HS > LI**	HS < LI*
HS > AI**	HS < AI*
VS > LI**	VS < LI*
VS > AI**	VS < AI*
LI < AI	LI < AI

Notes: HS = Horizontal Slot
VS = Vertical Slot
LI = Level Insertion
AI = Angled Insertion
* $p < 0.01$
** $p < 0.001$
A larger throughput is better, but a smaller preference is better.

readers had a higher throughput than, and were preferred over, either insertion reader.

The difference between the throughput averages for the slot and insertion readers is 8.34, whereas the difference (statistically insignificant) between the percentage of good reads is 1.01. Comparing insertion with slot readers, it seems that, with no significant difference in the percentage of good reads, there is a gain of 45% in the throughput rate.

DISCUSSION

For this simulated time-and-attendance task, the slot readers were superior to the insertion readers. The differences in throughput and preference were statistically significant, and favored the slot readers. Although the differences in the percentage of good reads appeared to favor the insertion readers, these differences were not statistically significant. There was a large gain in throughput for a nonsignificant difference in the percentage of good reads when comparing slot with insertion readers.

It did not seem to matter whether the slot of the slot reader was vertical or horizontal. Nor did it seem to matter whether the opening for the insertion reader was level or 20 deg below the horizontal plane.

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Review and Ev
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INTRODUCTION

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