Some aspects of the role of the operator in the Supermarket and Retail Store Systems are presented, specifically with respect to the input of data to the system. Major differences between the data input requirements of a system for a supermarket and a system for a retail store include the volume of data and the rate of entry. These are discussed in terms of the system requirements and the alternative methods of implementation. Studies of wand entry for the Retail Store System and fixed optical scanning for the Supermarket System are also discussed.

The role of the operator in the Supermarket and Retail Store Systems

by D. C. Antonelli

Both the Supermarket System and the Retail Store System perform merchandise-processing functions in addition to point-of-sale functions. To perform the merchandise-processing functions, more data is entered into the system by the operator (retail salesclerk or supermarket checker) than if only price were entered, as in the cash register environment. Unlike the cash register, the point-of-sale terminal is a component of a store system, influencing it and being influenced by it. A large measure of this influence is under the operator's control; consequently, the identification and quantification of the operator's influence on total system behavior is a part of the understanding of the performance of the systems.

This paper discusses the operator's data input role and features of the terminals provided to accommodate it. After an introductory discussion of the operator's more general role in the system, the first section of this paper addresses some types of operator data entry parameters and some of their effects upon the data entry task. The second section discusses some of the laboratory tests that have been conducted to explore the data entry process in the Retail Store and Supermarket Systems.

The operator's role in the systems

A performance objective of the Retail Store and Supermarket Systems is that the operator's pace not be controlled by any system component.[1,2] He should be able to enter data into the system at his chosen rate, and the system should accommodate him.

The principal system-related task of the operator in both systems is the input of data. A shopper brings items to the point of sale, where the operator enters data from those items into the terminal. This data can be in a variety of formats; it may be price or code or both.[3] If the system user wants to take advantage of the inventory control and price description look-up attributes of the system,[4] some type of code input is required. The amount of input per item can vary from one to 15 characters depending on the amount of code and price information; the number of characters entered increases with the amount of merchandise-processing information recorded.

The time spent in data entry increases with the amount of data to be entered at the point of sale, requiring a reduction in the level of customer service, an increase in the number of sales devices, or an increase in the rate at which the data can be entered. The store systems provide data-scanning devices permitting the third choice, avoiding the shopper dissatisfaction or labor and equipment costs associated with the other two.

Other tasks are performed by the operator. He has a maintenance function, which includes some error recovery as well as replacing expendable supplies. He is also responsible for the interpretation and communication of sales information, and as such, he is the principal representative of the store to the shopper. These functions will not be discussed in this paper, however, and we will deal primarily with the data entry function of the operator in the Retail Store System and the data entry and item-processing tasks of the operator in the Supermarket System.

The data entry task

The amount of data entry differs between the Supermarket System and the Retail Store System. A typical retail clerk spends a very small proportion of his working time at the checkout device. The supermarket operator, however, spends most of his time at the point of sale and, of that, between one and two thirds is spent actually entering data into the system.

Historically, in both retail stores and supermarkets, only price information has been entered, thus using the sales device as an adding machine. This entry served several purposes: (1) verifying to the consumer the price of the item, (2) assuring that an accurate total was rendered, and (3) allowing management control of receipts. With the advent of sundry tax requirements, the device was used to provide records in the generation of information on taxability. As the cost and diversity of inventory increased, it became necessary to maintain more accurate and timely records, requiring the entry of some type of stock number for an item. The trend is therefore to require more and more data to be entered on each transaction.

The rate of entry required of the operator in a supermarket is different from that of a retail operator. The retail salesperson spends more of his time selling rather than checking the items out. The checkout process is usually more leisurely in the traditional retail environment as well. Several operators may use the same point of sale with little contention for the sales device. In a typical U.S. retail environment, the operator processes between 30 and 40 customers per day. A typical supermarket operator may process that many in an hour.

In the supermarket environment, an operator spends most of his time at the point of sale. Since supermarkets are typically self-service, the operator's main responsibility is to check out the items brought to him by the shopper. Since a typical store has up to 10,000 different items, any code that can accommodate each individual item and have some self-checking capability must average more than three characters of code per item. To code items for the entire industry, as the Universal Product Code (UPC) has recently done, would require at least 12 digits of code with the self-checking capability. In contrast, price information currently requires an average of slightly more than two characters per item. Furthermore, price information is partially redundant in that there are general classes of items with the same price, e.g., baby food. For these types of items, the operator need merely depress the keys once and let the machine cycle the proper number of times. With coded items, this procedure is not possible since each different type of the item will have, of necessity, a different code.

Thus, in both retail store and supermarket applications, store systems require significantly more data to be entered at the point of sale than when only the price was recorded. One of the problems presented by data entry, in terms of the design of both the Retail Store and Supermarket Systems, was to find a technique for data entry enabling the operator to enter a code containing more characters than a price, yet allowing him to enter it at least as rapidly as the entry of price using a cash register. A productivity improvement was desirable in order to trade off increased hardware costs against labor savings.

The trend of increasing amounts of data per transaction has been accompanied by a trend, particularly in retail stores, of increasing complexity of the transactions. Some stores have more than 600 possible combinations of sales transactions. Since, frequently, a large proportion of the total year's sales are made in only two months, large numbers of temporary help must be trained to handle the temporary surge in sales. The cost of training retail salesclerks is therefore significant, especially since much of this investment is lost after the peak sales season. It is easier to learn a simple task than a complex one; a data entry device that permits simplified entry of complex data would be desirable.

The data entry tasks differ between the supermarket and the retail store. Their respective data entry devices also differ.

Choices of data entry

The selection of a method of data entry was determined by the requirements of the system and the availability and state of the art of various technologies. The methods selected for further study were key entry, wands, and fixed, optical bar scanners.

key entry

Some type of key-entry device was required for both the Retail Store and the Supermarket Systems. The key-entry device could be used for data entry in reduced-function system configurations, as an exception entry device in full-function systems, and for store support and other noncheckout-related functions. The conventional mechanical cash register, with its columnar keyboard, offered little in terms of capacity for improvement. The keyboard on these devices is typically quite large, and the force required for the depression of a key is usually high. In order to improve the productivity of a key-driven system, a keyboard that is compact, to minimize the keying motion, and that is light to the touch was required. In a comprehensive review of the literature[5] it was concluded that a numeric pad configured in a three by three matrix with the 1-2-3 keys at the top was the optimum in terms of speed of entry and ease of use. This configuration offered advantages in terms of ease of training and the number of errors made during the learning process.

wands

When wanding, the operator must use both hands on each item, one to move and orient the item, the other to move the wand across the symbol. When the number of digits to be entered is small (less than four), then key entry on a three by three pad is superior to wand entry. When the number is larger than four characters, wand entry can yield a substantial productivity gain depending on the total number of characters.[6] The use of the wand in the supermarket did not appear to offer the potential for a significant productivity gain over the key entry of price. However, the retail application seemed a plausible candidate for a wand entry device. Wand entry offers a technique of formatting that can simplifiy entry of complex data fields; the training of inexperienced operators can therefore be simplified. Furthermore, a wand is more convenient than a fixed scanner for the reading of labels on the wide variety of item shapes and sizes found in the typical retail store.

fixed scanners

As mentioned above, a necessary condition for the supermarket application was a productivity increase large enough to justify the product cost. In order to obtain a productivity gain, a method of material handling was required to improve the flow of materials through the checkstand. The method chosen enables the operator to dedicate both hands to item handling; a fixed scanner permits the operator to scan items as he passes them over the read area, synchronizing both hands for the same operation.

Performance specification and testing

Laboratory tests were conducted to support the Retail Store and Supermarket Systems in three areas, including (1) specification of parameters, i.e., how must the system/component perform in order to be acceptable as a system/component, (2) measurement of component performance, and (3) measurement of system performance. After some introductory discussion relating to application testing in the laboratory, these three areas will be addressed briefly and some general examples will be described.

One of the major problems concerning research in these application areas is that laboratory research is sometimes unreliable. Results obtained in laboratory studies are sometimes unreplicable in field tests. For practical purposes, it was necessary that most research be conducted in the laboratory environment. It thus proved necessary that the validity of laboratory testing be demonstrated.

To test the validity of laboratory data, a supermarket configuration was selected for a comparative study. A particular checkstand/register/operator configuration that had been extensively field tested was set up in the laboratory. The cash register was attached, using various electromechanical switches, to an IBM 1130 computer. A computer program captured all essential timing elements to be studied. These included ring time, tax computation and entry time, bagging time, and average order processing time. A total of six operators participated in the study. The principal dependent variable was processing time for the ringing and bagging of each item.

The results indicated that the laboratory data were within two percent of field-derived data. It was postulated that this small difference could be reduced by even more careful control in terms of item selection. For example, the produce items in the laboratory study were, of necessity, plastic copies of the original foodstuffs. The plastic weighed considerably less than the real item, and, consequently, the processing time for the plastic items was faster than with the real ones.

Since the variables to be determined on the proposed system were similar to those of the study, it was expected that tests of a similar nature, when conducted on the proposed system, would yield data predictive of actual field performance.

The selection of variables for study in the laboratory is important in that some are more conducive to laboratory implementation than others. For example, in the study mentioned above, only those variables that are primarily controlled by the operator/checkstand/register interaction were evaluated. Other elements such as those that are highly shopper-controlled are not readily amenable to laboratory study. Because of the difficulty of estimating their frequency of occurrence, it is usually much easier to obtain this type of information from field data. Their effect on the behavior of the system must be understood, however.

Parameter specification

The specification of parameter tests was designed to quantify some of the variables relating to the way the operator uses the system. For example, the design of a fixed scanner for the supermarket application requires an understanding of the velocity distribution for items passing over the scan area. To have an adequate number of scans for a given scan pattern, the velocity of the label being scanned is an important design parameter. The label velocity influences the designs of both the scan pattern and the velocity of the scan beam. No previous data relating to this type of velocity distribution was available, so a brief study was conducted in the laboratory.

Table 1 shows the proportional frequency for item velocity at the scan window. The data is based on tests conducted using nine operators, both male and female, with a full range of item sizes.

Similarly, the design of a code and wand requires information relating to the movement characteristics of the wanding motion. Table 2 shows the mean and range of velocity for a smooth-tipped, "L-shaped" wand reading a magnetic code on one-fourth inch stripes. These stripes were placed on a variety of materials ranging from one-inch gummed labels to three-inch hanging tickets. Operators were male and female and experience levels ranged from novice to highly practiced.

Table 1 Observed cumulative proportional frequency for item velocity

Velocity (inches per second) x	*Cumulative Distribution* $Pr(V \leq x)$
5	0.031
15	0.145
25	0.377
35	0.685
45	0.880
55	0.964
65	0.978
75	0.994
80	0.999

Measurement of component performance

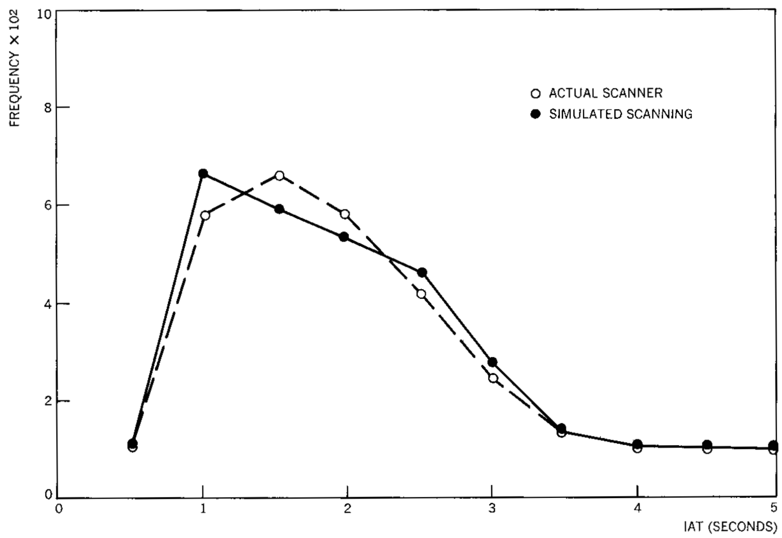
The way that the operator uses each device of the system needs to be evaluated and, where appropriate, quantified. These evaluations can often be pencil and paper in nature, e.g., when the device is not unique, such as a commonly used display, and there are preestablished criteria for its successful use. However, when the device is unique and/or when there are no preestablished criteria for the successful incorporation of the device into a system that is highly dependent on operator interaction, operator testing is required. For example, in the supermarket application, it was expected that scanning would be an efficient technique for entering the type of grocery item into the system. Previous testing and field data had established a rate for price entry on conventional cash registers. The concept of scanning needed to be evaluated to ensure its effectiveness as a data entry technique. Initially, a feasibility test of scanning concepts was performed on a simulated scanner. This test was followed by a similar test on actual hardware.

Table 2 Observed wand velocity range

Velocity (inches per second)		
Min	*Avg*	*Max*
0.60	6.50	41.67

The purpose of the feasibility test was to demonstrate the upper bound of scanner throughput and to provide data on the distribution of item interarrival times for input into simulation models.[1] The checkstand used in the study was an over-the-end checkstand. This checkstand design is one in which the operator simultaneously bags each item as he rings it up on his register device. (In the conventional checkstand this is not possible: the operator typically bags after he has finished ringing the order, or he may have the services of a separate bagger who bags while the checker rings up the order.) The simulated scanner was inserted in the over-the-end checkstand. It consisted of a treadle-type device which had a total travel of about one eighth of an inch. The operator passed each item over the treadle to simulate the scanning of some label on the button of each item passed over

Figure 1 Observed frequency distribution of item interval time (IAT) for simulated scanner and actual scanner



the scanner. When the treadle was depressed, unless an error was simulated, a solenoid clicked, indicating that the operator should continue processing that particular item. When no click followed an item passage, a "reason" was required. Errors were simulated via a program on the 1130 computer. The error rate simulated was five percent. Six supermarket checkout operators, each with at least a year of checkout experience, took part in the study. Twenty-five orders with an average order size of 17 items were used. The range of items was from one to fifty. The content of these various orders was distributed approximately as it is found in the supermarket application.

The study was replicated using different operators on actual hardware. The interarrival distributions from both studies are shown in Figure 1, indicating that, for the conditions tested, the simulated hardware closely represented the actual hardware.

System performance

The objective of system performance testing is to evaluate and understand the behavior of the total system in a realistic environment with all significant supporting hardware and function. This type of testing is often done in the laboratory to establish controls in the testing situation which are not possible in a field test. Data generated from these types of tests can be used to provide specific input to the total system models.[1] Whereas system components are designed and their parameters can be directly included in system models, system performance depends also

Table 3 Observed timing of wand entry operations

Cash transactions	*Time**	*Charge transactions*	*Time**
Operator no. (7 keystrokes)	1.63	Operator no.	1.63
Type of sale (2 keystrokes)	0.51	Type of sale	0.51
2.13 items @ 3.09 (orientation)	6.58	Account no. (14 keystrokes)	9.53
Average for 1st item = 3.34		2.4 items @ 3.09	7.42
Average for following items = 2.89		Average for 1st item = 3.34	
2.13 strokes @ 0.85	1.81	Average for following items = 2.89	
Total key	1.09	2.4 items @ 0.85	2.04
		Total key	1.09
	11.89		22.22
	0.27	Misc. activities	2.38
	12.35		24.60

*All times in seconds

on the interaction between the operators and the devices. System performance testing incorporates the effects of this interaction. For example, the total Retail Store System consists of more than just the point-of-sale terminals, it includes ticket printers, display stations, etc. The total system load is a function of the level of activity at the point-of-sale terminals and at these devices. In order to balance the system load, the rate of operator input on all the devices must be understood. The example given below will illustrate the nature and type of operator-relevant data for the retail point-of-sale terminal.

A study was designed to measure the amount of time required of the operator to input the necessary sales and item-related data to process a representative traditional retail order. Twenty orders were assembled for the study. The composition of these orders was such that a total of 10 different departments was included, but each order was composed of merchandise from only one department. The nature of the items ranged from hardware to hanging goods. Twenty-five percent were charge orders, and 75 percent were cash orders. The average order size was 2.2 items. Charge orders were slightly larger than cash orders. For each item, the wand read an average of 3.1 characters of code, 1.5 characters of department information, and 2.8 characters of price. Table 3 details the timing of wand entry sequences for the cash and charge sales described above.

Table 4 presents the total time observed in the study for a wand entry transaction, including overhead variables. These overhead variables were obtained through field studies of typical retail environments. An average of 2.2 items per transaction was assumed. The observed times shown in Table 4 indicate the total

Table 4 Observed timing of wand entry sales transactions

Cash	*Time**	*Charge*	*Time**
Operate retail terminal	12.35	Obtain credit card	5.40
Receive cash	5.40	Insert form	8.00
Make change	13.20	Operate retail terminal	24.60
Give change	5.40	Totals printing	4.70
Bag and give	10.20	Obtain signature	11.40
	46.55	Bag and give	10.20
			64.30

*All times in seconds

time taken by the clerk to process the customer once he is at the terminal. It does not include the "selling" time or any component for walking to the point of sale.

Another way of looking at the data is to isolate the terminal occupation time, defined as the time when the terminal is unavailable for any other operator's use. For cash transactions, the terminal is occupied when the operator number is keyed in and is again made available after the customer's change has been given. For charge transactions, the terminal is occupied when the operator starts to insert the charge form and is again made available prior to obtaining the customer's signature. Thus, there is time available for processing certain aspects of the transaction without using the terminal. During peak periods, this time becomes critical in that the processing of these sales details can be arranged in such a manner as to reduce the contention for a terminal that is shared by several operators. Table 5 shows the occupation time observed in the study for wand entry transaction types.

Summary

The operator's general role in the total Retail Store and Supermarket Systems was discussed briefly and his specific role in the input of data was discussed in some detail. Some of the major differences between the data input requirements of a system for a supermarket and for a retail store included the volume of data and the rate of entry required. These items were discussed in terms of the system requirements and alternative methods of implementation. The alternatives selected were wand entry for the Retail Store System and fixed optical scanning for the Supermarket System. These techniques required the investigation of some basic human performance parameters. Examples of some of these studies were presented and discussed to illustrate a portion of the testing activities that were performed to define and measure the operator's role and interaction with some system components.

Table 5 Observed occupation time for an average wand entry transaction

Cash	*Time**	*Charge*	*Time**
Operate terminal	12.35	Insert form	8.00
Receive cash	5.40	Operate terminal	24.60
Make change	13.20	Totals printing	4.60
Give change	5.40		37.30
	36.35		

*All times in seconds

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