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The Effectiveness of Feedback Procedures on Machine Set-Up Time in a Manufacturing Setting

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THE EFFECTIVENESS OF FEEDBACK PROCEDURES ON MACHINE
SET-UP TIME IN A MANUFACTURING SETTING

by

Connie J. Wittkopp

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THE EFFECTIVENESS OF FEEDBACK PROCEDURES ON MACHINE SET-UP TIME IN A MANUFACTURING SETTING

Connie J. Wittkopp, Ph.D.
Western Michigan University, 1988

The purpose of the present study was to evaluate the effectiveness of a treatment package designed to improve and maintain set-up time in the extrusion department of a rubber manufacturing company. Subjects were exposed to various behavioral techniques including training and a feedback system in the form of both written and verbal supervisory comments with an emphasis placed on improving performance through use of videotaping. An attempt was made to maintain treatment gains by teaching supervisors how to give information concerning set-up performance to their employees. Results indicate that average weekly set-up times for each machine were significantly below baseline levels during the initial intervention and remained there throughout a 30 week period.
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The effectiveness of feedback procedures on machine set-up time in a manufacturing setting

Wittkopp, Connie Jean, Ph.D.
Western Michigan University, 1988
DEDICATION

To my parents who have seen me at my very worst and at my very best yet stayed with me through it all - your strength has always kept me going.
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I thank Dr. Alan Poling, my friend, advisor and committee chair, for his guidance throughout my career; his untiring patience and support have made me a better person. My committee members have also helped shape my life. Dr. Dale Brethower's "High Rate, Inc." helped me fine-tune critical thinking skills. Dr. Bill Redmon gave assistance and advice. Special thanks are in order to Dr. John Rowan, committee member and plant manager, for believing in me and supporting this project.

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Connie J. Wittkopp

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CHAPTER I

INTRODUCTION

In applications of behavioral science, the goal is to design programs to improve performance. The organizational behavior analyst employs a multitude of techniques based on operant conditioning principles to modify behavior in organizational settings. Analysts utilize established techniques based on functional relationships, that is, relationships among antecedents, consequences, and behavior, to motivate employees and improve performance.

"Feedback" is one technique commonly used in organizational behavior management. The concept of feedback has generated abundant experimental literature and has received considerable attention in the area of organizational behavior management (e.g., Andrasik, 1979; Emmert, 1978; Latham & Baldes, 1975; McSween & Lorber, 1981). A feedback system as originally conceived involves a basic control system which is homeostatic in nature and has been defined as "a control system which operates to achieve prescribed relationships between selected system variables by comparing functions of these variables and using the difference to effect control
(Find & Beatly, 1978, p. 21). This definition describes a feedback system in which an error-detecting device (servomechanism) signals the system when a controlled variable is different from the desired reference input; the device then corrects the input. A thermostat controlling a furnace to maintain relatively constant temperature is a common example of such a system.

Feedback, in the context of human performance, involves guiding performance by giving information about performance (Brethower, 1972). Feedback procedures take a very wide range of specific forms. Ford (1980) has proposed that feedback procedures can be meaningfully divided into five categories. His classification system "defines a number of dimensions along which feedback procedures may be functionally analyzed. The system identifies the extremes of each dimension and briefly describes intermediate points along the dimension" (p. 184). The five categories are:

1. Individual feedback-Group feedback procedures. According to Ford (1980), "The parameters of this dimension are established by the number of individuals contributing to the performance under scrutiny" (p. 184). At one end of the continuum, feedback about performance is delivered to a single person; at the other, it is delivered to a very large group.
2. Private feedback—Public feedback procedures. The limits of this dimension "are determined by the degree of availability of performance information to others" (p. 184). At one end of the continuum, information about performance is available to only one person; at the other, it is available to a large group of people.

3. Personal feedback—Mechanical feedback procedures. The boundaries of this dimension "are determined by the degree to which feedback is mediated by mechanical instruments and devices" (p. 185). At one end of the continuum, feedback is delivered directly by someone either in a verbal or written form; at the other, feedback is delivered by the use of a mechanical device.

4. Immediate feedback—Delayed feedback procedures. "The contiguity of feedback delivery with performance defines the limits of this dimension" (p. 185). At one end of the continuum, feedback is immediately delivered; at the other, it is delivered after a predetermined time interval.

5. Schedule of feedback procedures. "Feedback may be delivered on a schedule varying from one minute or shorter, to one year or longer" (p. 185).

As indicated by the wide range of applications that meet Ford's (1980) classification of feedback procedures,
the term is commonly a loose and nontechnical description. Numerous forms of feedback have been used to motivate both employees and employers and to improve their behavior in various work settings (e.g., Catano, 1976; Erez, 1977; Komaki, Barwick, & Scott, 1978; Kraut, 1976; Runnion, Johnson, & McWharter, 1978). As Peterson (1982) noted, "Feedback, or information about past performance, can potentially serve any of a number of behavioral functions" (p. 101). According to Peterson, information about past performance is a physical stimulus and as such "given the proper history of conditioning, it could be a conditioned reinforcer, a conditioned punisher, a discriminative stimulus, a conditioned stimulus in a respondent paradigm, or an establishing stimulus" (p. 101). Detailed reviews of research in the area of feedback have been provided by Balcazar, Hopkins, and Suarez (1986), Illgen, Fisher, and Taylor (1979), Kopelman (1982), Nadler (1979), and Prue and Fairbank (1981). Several representative samples of research in this area are discussed below.

Komaki et al. (1978) conducted a study using verbal praise and a feedback procedure to improve safety performance in a food manufacturing plant. In this study the experimenters identified safety practices which could be measured in behavioral terms. Intervention consisted
of a training session on safety as well as information concerning safety performance. Following the training session, the safety rules were posted in the employees' work areas. Observers collected data in the form of percentage of tasks performed safely by the group as a whole. This percentage was then placed on a graph in each of the work areas. In addition to the observed percentage, a desired percentage of 90% was placed on the graph. This enabled the employees to readily determine whether the departmental goal had been achieved. The experimenters instructed supervisors to provide performance information in the form of verbal recognition to those employees who were performing the tasks safely. Results indicated that the workers' safe performance increased substantially from 70% to well over 90% during the intervention phase.

Komaki et al. (1978) stated that once safety practices were behaviorally defined and positively reinforced, desirable behavior was improved therefore substantiating the hypothesis that a behavioral approach to improving performance is an effective technique. There is, however, some question as to whether the improvement in performance can be attributed to a reinforcing effect of praise, because the supervisor did not administer praise as planned.
Ford (1984) conducted a study to determine the effects of two types of feedback procedures used in combination and separately on teaching skills of paraprofessionals. Using the classification system proposed by Ford (1980), the feedback procedures employed consisted of the personal-mechanical dimension. Prior to the onset of the study, a performance rating form was developed and the resultant rating employed as the primary dependent variable. During intervention, the supervisor videotaped each participant once a week while conducting a training program. Participants were provided with one of three types of feedback:

1. Supervisor feedback procedure. The supervisor filled out the rating form immediately following the videotape session and then discussed each item with the participant.

2. Video tape-recorded (VTR) feedback procedure. This procedure consisted of having the participant view the videotaped training session with the option of filling out the performance rating form without the supervisor present.

3. Combined (VTR plus Supervisor) feedback procedure. During this procedure, the supervisor and participant viewed the videotaped session together. The supervisor filled out the performance rating form and
reviewed it with the participant using the videotape for clarification when needed.

Each of the feedback procedures resulted in improvements in performance across all participants. The combined procedure produced the greatest and most rapid improvement in work performance, whereas the videotape procedure produced the least and most gradual improvement.

Many studies in organizational behavior management intentionally or unintentionally combine one or more feedback procedures with another procedure, such as goal setting (e.g., Latham et al., 1975; Locke, 1980). For example, Latham et al. (1975) investigated the validity of Locke's 1968 theory of goal setting by measuring the net weight of 36 trucks in a logging operation. The investigators defined a performance goal in terms of the maximum legal net weight. In addition to setting the goal, the supervisors were instructed to give verbal praise when drivers met or exceeded the goal. The findings indicate there was immediate change in the performance of the truck drivers; 60% loaded appropriately prior to goal setting, whereas over 90% did so after the intervention. The authors argued on this basis that setting a specific goal increased performance. There is however, some question as to whether or not goal
setting was the only contributing factor to the improved performance. The researchers later discovered that the truck drivers were keeping a daily log of their truck weight. A feedback procedure of this sort has been defined by Ford (1980) as private feedback; information about performance is tracked by the individual and affects his or her behavior.

Latham et al. (1975), described above, considered a feedback system and goal setting as two separate operations. It can, however, be argued that in this case a combination of goal setting and feedback procedures resulted in the improvements noted (Locke, 1980).

Erez (1977) conducted a study to determine whether a feedback system was a necessary component when employing goal setting to improve performance. He found that the participants' goals were significantly higher in the feedback group than in the no feedback group. In addition, the results indicated that the relationship between goals and performance was significantly higher in the feedback condition.

In behavioral terms, goal setting can be defined as providing an antecedent verbal stimulus intended to improve performance (e.g., giving a verbal instruction) and then providing information about that behavior; this relation constitutes a form of operant conditioning.
Communication about the level of desired performance (i.e., written or verbal instructions, standards, policies, etc.) prior to the actual performance also constitutes an antecedent event in behavioral programs. These events are often introduced in the form of training.

Training can be defined as "a process whereby learned outcomes can be specified in terms of particular behavioral responses" (Kopelman, 1986, p. 105). Employee training has become a major concern in organizations. Kopelman (1986) reported that more than 90% of all private institutions have formal training programs. Many organizations rely on antecedent control to improve performance. That is, training is given to employees under the assumption that knowledge of a particular task alone is sufficient to change their behavior. Although training in this sense can be important, it may be inadequate to achieve and maintain a desired level of performance.

Such an outcome is evident in a study by Komaki, Heinzman and Lawson (1980). They implemented a treatment package consisting of a training component and a feedback component designed to increase safe practice in a vehicle maintenance division of the department of public works. There were five phases: (1) baseline, (2) training only...
(desired practices were discussed and posted), (3) training and a feedback procedure (supervisors graphed daily performance), (4) training only, and (5) training and a feedback procedure. Results indicated that employees showed only slight improvement during the training only phase (9% increase) but substantial improvement during the training and feedback phase (26% increase). The researchers concluded that training, in the form of discussing desired practices, is not sufficient to improve and maintain performance.

To clarify the role that both antecedents and consequences have in improving behavior, Komaki, Collins and Penn (1982) conducted a study to assess the effects of antecedents and consequences in improving safety performance. The study consisted of two conditions:

1. Antecedent control condition. Under this condition the authors held a meeting with subjects to explain safety rules using slides to illustrate both safe and unsafe practices. Following the meeting, the researchers displayed safety rules in each department highlighting a different rule every three days. In addition to posting the rules, the supervisor held a safety meeting once a week to discuss the rules.

2. Consequent control condition. Under this condition of the experiment, in place of the rules, the
authors displayed a graph of the percentage of safe items for each department. In addition, a weekly meeting was held in which the supervisor reviewed safety scores with the participants.

Results indicated that under the antecedent condition, improvements occurred in only two of the four departments. Under the consequent condition, performance significantly improved over baseline and antecedent conditions in all departments.

The studies described above constitute only a small sample of the research concerning various techniques designed to motivate employees and improve performance. On whole, research in this area suggests that a combination of antecedents (e.g., goal setting and training) and performance consequences such as feedback appear to be an effective treatment package in organizational work settings (Illgen et al., 1979; Kopelman, 1982; Nadler, 1979).

Organizations spend a great deal of time and money on training for managerial effectiveness. Kelly (1982) reported that on an annual basis, more than 100 billion dollars is spent on training and development. A pressing problem, however, is maintaining a particular system once it has produced desired results. Transfer of learning from the training room to the actual job, as well as
maintaining learned skills, has become a critical issue in organizations. Maintenance requires considerable time on the part of supervisors directly involved, as well as those managers directly in charge of the system (Warren, 1982). There is little empirical work evaluating the long-term effects of various treatment packages, which is a major concern for organizations implementing such programs.

Within the area of organizational behavior management there has been a growing concern for the development of a technology for behavioral generalization and maintenance (Kohler & Greenwood, 1986; Komaki et al., 1982). A number of studies have addressed the importance of generalization and maintenance (Baer & Wolf, 1970; Stokes & Baer, 1977) however, effective procedures for producing such effects have yet to be fully developed. Kohler and Greenwood (1986) stated that "when fully developed, these procedures will ensure that deliberate behavior changes occur within a number of diverse settings, will generalize to other forms of behavior, and will be maintained after the initial change agent and procedures have been removed" (p. 19).

Generalization is said to occur when a desired behavior is emitted under nontraining conditions that are similar to the training condition (Baer, Wolf, & Risley,
1968; Johnston, 1979). Stokes and Baer (1977) reported several methods for addressing generalization, although none of the procedures has been developed to the point of having reliable and consistent effects. The most common method appears to be the "train and hope" method. This method involves a passive look at whether generalization occurred following a particular intervention.

Another approach discussed in the literature involves identifying natural contingencies of social reinforcement (Ayllon & Azrin, 1968; Baer and Wolf, 1970). Kohler and Greenwood (1986) consider naturally occurring reinforcers as those "that fall outside the set of experimental variables used to produce the initial behavior change and that are under the control of the peer group" (p. 20). A major problem in industry is that such reinforcers may not automatically follow appropriate behavior. Therefore, relying on naturally occurring reinforcers may not be adequate to ensure maintenance of treatment effects.

To maintain a desired behavior once the training conditions have been removed, Marlatt and Gordon (1980) developed a model termed the relapse prevention model. In this model, individuals are taught self-control techniques; they learn to identify and deal with circumstances that may lead to relapse. "That is, long-
term behavior change is predicted to be enhanced by anticipating and monitoring past and present failures" (Marx, 1982, p. 433). Although this model was specifically developed for addictive behaviors, Marx (1982) suggested that the same techniques could be used to maintain long term effects of managerial training. That is, transfer of training can be achieved and maintained by teaching managers how to use information from past failures to prevent future failures.

Positive transfer is a term that has been coined to identify "the extent to which individuals use what they learned in a training situation on the job" (Wexley & Baldwin, 1986, p. 503). Several authors have discussed the difficulty of achieving positive transfer (Fleishman, Harris, & Burtt, 1955; McGehee, & Thayer, 1961). However, Goldstein (1980) indicated that there has been a lack of empirical evidence concerning any posttraining strategies designed to enhance the maintenance of a desired behavior.

Wexley and Baldwin (1986) conducted a study involving the positive transfer of three posttraining strategies derived from the literature on positive transfer. The purpose of the study was to determine to what extent each of the strategies resulted in the retention and application of trained time management
skills. In the study, 256 college students participated in a three-hour workshop designed to improve time-management skills. Following the workshop, subjects were randomly assigned to one of four conditions:

1. Assigned goal setting. Under this condition, subjects attended a transfer session where the experimenters provided a list of 17 behavioral objectives taken from the time-management workshop. In addition, the subjects were asked to fill out, three times a week, a checklist consisting of items pertaining to the behavioral objectives. The checklist was to serve as a reminder of the goals that were to be met. At the end of four weeks the participants received written feedback at a group session concerning their performance relative to achieving the behavioral objectives.

2. Participative goal setting. Under this condition, the experimenters worked with the subjects to design a list of behavioral goals from the workshop. The subjects were then asked to develop a daily planner and design a to-do list each evening to be used the next day. In addition, the experimenters asked the subjects to rate their own performance using a five point scale. At the end of four weeks participants received written feedback at a group session concerning their own self ratings relative to behavioral goals, as well as an overall
statement summarizing the ratings compared to the learning points from the workshop.

3. Relapse-prevention model. In addition to the time management workshop, the experimenters taught subjects self-control strategies intended to enhance and maintain the skills learned in the workshop. Specifically, subjects were taught how to identify and deal with the problem of relapse by developing lists of responses that could be used to cope with relapse.

4. Control condition. Under this condition, the experimenters simply asked the subjects to return in eight weeks for a final data collection session.

Results indicated that the first two conditions, assigned and participative goal setting, were significant in maintaining the desired behavior over a two month period. In addition, maintenance under both of these conditions was superior to that under the relapse-prevention condition and that of the control group.

Although there has been a great deal of concern with the development of feedback procedures to establish and maintain appropriate behavior in the workplace, further attempts to develop simple and effective procedures appear justified. The present study evaluated a treatment package consisting of various behavioral techniques including training and a feedback system.
designed to improve set-up time in the extrusion department of a rubber manufacturing company. Improvement of set-up time in a manufacturing setting is critical to developing a competitive industrial position (Shingo, 1985). Manufacturers are now being asked to ship smaller quantities with quicker lead times. Reduction in set-up time makes it possible to respond quickly to fluctuations in demand and creates the necessary condition for lead time reactions.

Prior to the onset of the study, the experimenter, who was also the Corporate Statistical Process Control Manager, spent approximately one month in the extrusion department observing everyday operations. During this time, the experimenter participated in various activities such as learning the steps involved in making a set-up. In doing this, the experimenter asked the operators a lot of questions concerning why particular tasks were being done and learning the sequencing of events that take place during the set-up. In addition, the experimenter discussed any concerns the employees had pertaining to their particular duties, and helped to expedite maintenance work orders that needed to be completed (e.g., fixing air hoses, water leaks, etc.). By spending time in the department prior to collecting any data, the experimenter established a working knowledge of the
department as well as credibility and a line of communication with all members of the department. Then, the intervention was designed. Using Ford's (1980) classification system, the feedback procedures employed were immediate, private, and included both personal and mechanical elements. Following the initial intervention, an attempt was made to maintain the treatment gains by teaching supervisors how to effectively audit and give feedback concerning the set-up performance of their employees.
CHAPTER II

METHOD

Subjects and Setting

The study was conducted in the extrusion department of a rubber manufacturing plant in a small midwestern town. Extrusion is a fabrication operation consisting of two parts: "a delivery system which pumps the rubber compound (and sometimes imparts a degree of distributive mixing) and a die system which forms the material into the required shape" (Johnson, 1982, p. 1). The extrusion department operates on two eight-hour shifts, five days a week, and was selected on the basis of economic need to improve set-up times.

Subjects consisted of eleven men (nine operators and two supervisors) between the ages of 25 and 55 years with a mean age of 40 years. With the exception of supervisors, all workers belonged to the United Rubber, Cork and Linoleum and Plastic Workers of America Union. Seven of the nine operators had worked in this department for five years or more.

Prior to the onset of the study, the experimenter, met with the Union President and the Plant Manager to discuss the project. It was agreed in writing that
videotaping would be used as an instructional tool only and would not result in any disciplinary action. The operators were then given a full explanation of the purpose of the current research and asked to participate. The operators were told that there would be no disciplinary action taken for participating (or not participating) in the current study. The experimenter obtained informed consent from each of the operators involved. The consent form contained a statement of confidentiality, as well as the right to withdraw from the study at any time.

Apparatus and Materials

The extrusion department contained four extruders: two coldfeeds (3.5" and 6" diameters), and two hotfeeds (4.5" and a 6" diameters). The two coldfeeds each operate with a two-man crew. The 4.5" hotfeeds operate with a two-man crew, and the 6" hotfeed operates with a three-man crew. Each crew is responsible for meeting a daily standard consisting of pounds extruded per man-hour. Weekly, the poundage produced is graphed and posted in the work area by the supervisor.

During the month the experimenter spent in the extrusion department clocks were placed at each machine to time set-up. Operators were responsible for starting
and stopping the clocks at the appropriate time. Set-up time was defined as the time from when the last tube within quality specifications was cut off of the extruder on one order to cut off of the first tube within specification on the next order. Times were recorded by the operator to the nearest minute, and served as the primary dependent variable. Graphs depicting set-up time were posted weekly in a central location within the extrusion department.

Dependent Variable

Prior to the onset of the study, the Corporate Industrial Engineer conducted time studies on set-up at each extruder. The studies consisted of timing the sequence of steps taken to complete a set-up. Several observations of each step in the sequence of behaviors were taken and an average time for each step was determined. The steps were divided into two categories, internal set-up and external set-up. Internal set-up can be defined as any step in the process that can be completed only when the machine is off (e.g., changing a pin and die, setting temperatures). External set-up is any step in the process that can be performed while the machine is running (e.g., paperwork, getting the proper equipment ready). Once the time studies were completed
and the steps identified, a procedure for improving set-
up time was devised (see example below). The procedure
consisted of listing each step in the set-up process in a
sequence to achieve optimal performance. Optimal
performance was determined by the managers and the
operators based on the time studies and the logic of the
process.

Independent Variable

The independent variable involved detailed verbal
instruction, combined with verbal and visual information
concerning performance. At the onset of the study, the
researcher, supervisor, and two volunteer operators from
the study designed detailed verbal descriptions (task
analyses) of each set-up procedure for each machine.
These descriptions detailed in sequence each response the
operator was to perform and its consequences (i.e., the
stimulus changes it produces, if any). For example, the
early steps in one set-up might appear as follows:

1. Operator A uses an appropriate wrench (3/16") to
remove the pin and die (large flat metal plates) from the
extruder head, resulting in a bare head.

2. While operator A is performing step 1 (above),
Operator B removes the #16 pin and die from the storage
area to the left of the extruder and carries it to an
area just in front of the extruder head. This task should be completed by the time task 1 (above) is finished.

3. Operator B places the #16 pin and die in the extruder head; Operator A centers the pin and tightens the four bolts that hold it in place.

At the onset of the intervention phase, the researcher and the supervisor conducted a meeting with each crew. The meeting consisted of a complete explanation of the written procedures, including the purpose of each step listed. A copy of the written procedure was given to each member of the crew and a copy was posted on the extruder. The researcher also discussed the purpose for videotaping and described the process that would be involved. Immediately following the meeting, the researcher, supervisor and crew members proceeded through an actual set-up at the machine. During this session, the researcher gave direct instruction to each member of the crew following the steps listed on the written procedure. After the session, the experimenter videotaped a complete set-up.

After each videotaped session, the operators were brought into the supervisor's office and shown the tape. Information about set-up performance was given by the experimenter and/or the supervisor. The feedback
procedure used was in the form of specifying what was done correctly, as well as any discrepancies between the actual performance and the performance specified by the written procedures. In providing this feedback procedure, the experimenter and/or supervisor described any departures from the required sequencing of tasks in appropriate response topographies. Appropriate performance was verbally praised, as well as reported. Videotaping continued on an average of one set-up per day for two weeks and then a minimum of once of week for the next four months. Frequency was largely determined by the production schedule.

For each videotaped set-up, the operators' recorded a set-up time. A set-up time was also determined from the videotape by the experimenter. In 105 of 106 instances (99%), the time recorded by the experimenter was within one minute of that recorded by the operator. To evaluate the accuracy of the experimenter's rating, set-up time was determined from 48 of the videotapes by the General Foreman. In each case, his rating was within one minute of the experimenter's.

Following the videotaping on all machines the researcher, supervisor, and general foreman designed an audit form consisting of various checkpoints from the written task analysis. The audit form was designed as a
checklist or tool for the supervisor to help maintain the effects of the intervention (i.e., videotaping and verbal feedback).

In order to expedite the usage of the audit form, the experimenter conducted a four-hour training session with supervisors which consisted of an introduction to the purpose, the logic of the audit form, and an explanation on how to give constructive feedback. Examples of videotaped set-ups were shown to the supervisors and they were asked to fill out the audit forms.

Each supervisor was asked to give information about the set-up performance based on their observations. Then the experimenter responded to the supervisor by addressing the following questions. (a) Did the supervisor confront the issues (i.e., Did he cover all of the items on the audit form)? (b) Was the supervisor positive in his approach to the situation (i.e., Did he emphasize positive performance)? (c) Did the supervisor present the issues in a constructive manner (i.e., provide examples or alternatives without being confrontational)? (d) Did the supervisor listen to the operator's explanation and offer constructive comments? (e) Did the supervisor complete the meeting by telling the operators' what to do differently and why? (f) Was
there agreement between the supervisor and operators before the meeting ended?

Experimental Design

The experimenter employed a multiple baseline design across machines. The design combined the logic of the across subjects and across settings variations of the multiple baseline since each machine was staffed by two or three individuals, and the machines were spatially isolated from each other. Initially, the experimenter collected data for workers at all machines in the absence of the experimental intervention. Baseline data were collected for three months at the end of which the intervention was introduced for the individuals who operate one of the two coldfeeds; baseline observations continued for the other individuals.

Following two weeks of intervention for the individuals operating the coldfeed, operators of one of the two hotfeeds were exposed to the intervention; treatment continued for the individuals previously exposed to the intervention and baseline observations continued for the other operators. Eventually, treatment was arranged for the operators of the other machines. Treatment introduction across these extruders occurred in a temporally-staggered sequence as described above.
The experimenter introduced the audit form (training session described above) to the supervisor once the intervention described above had been implemented for all machines and the data (average weekly set-up times) appeared stable on visual inspection. The researcher asked the supervisor to conduct a complete set-up audit on each of the four machines at least once a week for three months. The experimenter observed the supervisor a minimum of once a week and gave feedback to the supervisor as discussed above. In addition, the experimenter collected the audit forms weekly and gave feedback covering completeness of the audits. All of the set-up times recorded on the audit sheet by the supervisor were checked against the operators recorded set-up times.

Although supervisors were supposed to audit each machine at least once each week, they failed to do so. In all, 35 audits were conducted. For 33 of the audits (94%), the time recorded by the supervisor was within one minute of that recorded by the operator.
CHAPTER III

RESULTS

The purpose of the present study was to create a simple and effective behavioral package designed to improve and maintain set-up time in the extrusion department. Figure 1 shows the average weekly set-up times for each machine for each week of the study. For each of the machines, mean set-up time declined to below the baseline level when the intervention was introduced. Furthermore, mean set-up time remained below baseline level for the duration of the study.

However, the magnitude of the reductions in mean set-up times varied considerably across machines. For example, when mean set-up times for baseline and the first eight weeks of intervention are compared, the reduction for machine 1 is 7.5 minutes (38.2 baseline - 30.9 intervention). For machine 2, it is 12.4 minutes (39.2 baseline - 26.8 intervention); for machine 3, 5.7 minutes (28.0 baseline - 22.3 intervention); and for machine 4, 13.4 minutes (36.2 baseline - 22.8 intervention).

Figure 2 provides a summary of results which display mean set-up times for the four machines during all baseline sessions, the first eight weeks of intervention
for each machine, and the final eight weeks of intervention for each machine. The data in Figure 2 were statistically analyzed by repeated measures analysis of variance followed by planned comparisons using the Tukey method (Hopkins & Glass, 1978). There was a significant overall effect ($F = 54.97$, df = 2, 93, $p < .01$). Planned comparisons revealed that mean set-up times were significantly ($p < .01$) below baseline levels during the first eight and final eight weeks of intervention. Moreover, mean set-up times did not differ significantly ($p > .01$) from the first eight to the last eight weeks of treatment.
Figure 1. Average Weekly Set-up Time for Each Machine During Each Week of the Study.
Figure 2. Mean Setup Time Combined (for all four machines) for all Baseline Sessions, First Eight Weeks of Intervention, and the Final Eight Weeks of Intervention.
CHAPTER IV

DISCUSSION

Results of the present study reveal that a relatively simple training and maintenance program was effective in improving machine set-up time in a rubber manufacturing plant. For each of four machines, mean set-up time declined to below the baseline level when the intervention was introduced. Furthermore, mean set-up time remained at below the baseline level for the duration of the study. This suggests the intervention, and not some extraneous variable, was responsible for the change in performance. However, because a treatment package was used, the specific variable(s) responsible for the change in performance are not readily apparent.

Feedback was a major component of the intervention, and it is widely accepted in organizational behavior management that feedback procedures can change behavior (Kopelman, 1982; Prue & Fairbank, 1981). Despite this, attributing behavior change to feedback does not explain the mechanisms through which behavior is affected. As noted by Peterson (1982) and discussed in the introduction, stimulus events considered as feedback may serve a variety of behavioral functions. Depending on
past and present circumstances, they may serve as conditioned stimuli, establishing operations, reinforcers, punishers, or discriminative stimuli.

Changes in behavior following a feedback intervention are often attributed to the effects of reinforcement (Morasky, 1982; Fairbank & Prue, 1982; Skinner, 1953), but Prue and Fairbank (1981) have suggested that feedback may produce changes in behavior through other processes. These processes have been largely ignored in the analysis of feedback. For example, feedback may be given in the form of instructions. These instructions provide the employee with a performance standard specifying what is important to the organization. Often this type of feedback is repeated over many sessions and therefore the supervisor informs the workers as to what the expected performance level actually is. This is in agreement with Locke, Cartledge and Koeppel (1968) who have persuasively argued that feedback, either intentionally or unintentionally, always involves some type of performance standard.

Interactions involved in the process of giving feedback may also account for some of the effects on behavior (Fairbank & Prue, 1981). When information about performance is given, supervisors might interact more frequently with the workers; in addition, supervisors are
is providing objective feedback which may produce a more positive environment in which to work.

Regardless of how it influences behavior, feedback appears to be an effective technique for improving the performance of individuals in many organizational work settings. Several characteristics of feedback make it attractive to the organizational behavior manager (Fairbank & Prue, 1982; Kopelman, 1986). Fairbank and Prue (1982) found that implementation of a feedback procedure sometimes results in a decrease in the use of punishment as a means to control behavior.

In addition, Kopelman (1986) discusses several advantages of employing feedback as a technique for improving performance: (a) Feedback can be based on data that already exist within the organization, (b) implementation of a feedback system requires very little time or money, (c) feedback usually does not require any major changes in day-to-day activities, (d) the results of feedback are often immediate, (e) feedback can be implemented in settings where other interventions are not feasible, and (f) feedback used in conjunction with other techniques such as training enhances the effects of performance improvement.

Results of the present study are in accordance with those of many other investigations showing the utility of
feedback procedures. Moreover, the present results illustrate that a simple and cost-effective feedback system may be adequate for the long-term maintenance of performance gains. Set-up time remained at below baseline levels for the course of the investigation (about one year) with only a minimal maintenance program. Such an outcome is of obvious practical significance.

Table 1 provides an estimate of the potential increase in productivity brought about through the present intervention. Data presented in this table are based on all machines operating at full capacity, that is, on sufficient orders to keep all machines running. As shown in Table 1, the projected productivity improvement, in terms of pounds per year, is an increase of 15%.

A possible weakness of the present investigation involves the use of self-report data: the primary dependent variable was operator-reported set-up time. It is of course possible that this measure did not accurately reflect actual set-up time. Perhaps by virtue of being aware of the goal of the project (reducing set-up times) they simply reported erroneously low times when the intervention was in effect. Two kinds of evidence suggest this was not the case. The first concerns the measures of interobserver agreement calculated from videotapes and audits. These data demonstrated that the
Table 1
A Comparison of Productivity Prior to and Following (Projected) Intervention

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<tr>
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<tbody>
<tr>
<td>1</td>
<td>789</td>
<td>732</td>
<td>1.078 Hrs.</td>
<td>.715</td>
<td>1.166</td>
<td>920,117</td>
<td>1.593</td>
<td>1.255</td>
<td>990,195</td>
</tr>
<tr>
<td>2</td>
<td>521</td>
<td>658</td>
<td>.792 Hrs.</td>
<td>1.445</td>
<td>1.184</td>
<td>721,107</td>
<td>1.172</td>
<td>1.706</td>
<td>889,078</td>
</tr>
<tr>
<td>3</td>
<td>84</td>
<td>114</td>
<td>.627 Hrs.</td>
<td>1.094</td>
<td>1.828</td>
<td>151,565</td>
<td>.999</td>
<td>2,002</td>
<td>168,168</td>
</tr>
<tr>
<td>4</td>
<td>207</td>
<td>296</td>
<td>.699 Hrs.</td>
<td>1.302</td>
<td>1.516</td>
<td>317,352</td>
<td>1.079</td>
<td>1,853</td>
<td>383,571</td>
</tr>
<tr>
<td>TOTALS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,914</td>
<td>2,112,741</td>
<td></td>
<td>6,916</td>
<td>2,431,012</td>
</tr>
</tbody>
</table>

*Based on fiscal 1985-86 productivity reports.

**Definitions:**
1. **Average time per order** is average pounds per order divided by average machine rate of output in pounds.
2. **Orders per year** is average machine cycle divided into 2000 machine hours per year available per machine. This represents 50 work weeks per year times 40 hours per week.

**Results:**
The projected productivity after intervention, if the gains in the reduction of setup times are maintained, show an increase in yearly pounds produced of 15.06%.
set-up times reported by operators were consistently close to those recorded by independent observers.

A critic might contend, however, that operators recorded set-up times accurately when they were observed, but not at other times. Some data are available that bear on this issue. Each month for each machine, an efficiency ratio was calculated. This ratio equals \((\text{running hours earned}) / (\text{running hours reported})\). Running hours earned was determined by dividing the units produced in a day by the expected production per hour. Running hours reported for each shift equaled (eight hours) - (reported set-up time). If operators were systematically under-reporting set-up times the efficiency ratio should have decreased when the intervention was instituted, because the actual running time would be less than reported. This did not occur. During the period when baseline was in effect for all machines, the efficiency ratio was .909. At the sixth month of the study, it was .938, and during the last month, it was .898. The last two values represent treatment conditions for all machines. The absence of a difference in efficiency ratio suggests that operators were not systematically under-reporting set-up times.

The present study demonstrated the usefulness of a behavioral treatment package designed to improve set-up
time in a manufacturing setting. Efficiency has become a growing concern within organizations. The first step in performance engineering is to improve day to day activities (Brethower & Wittkopp, 1987) which allows organizations to start planning for the future. This is a necessary component to remain competitive in the marketplace. Organizational behavior management provides a powerful technique, that if used correctly allows organizations to be better prepared for the future.
BIBLIOGRAPHY


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