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Transfer of Self-Contained Self-Rescuer Donning Skills Under Similar Conditions of Practice: The Draeger OXY-SR60B and the CSE SR-100

By M. J. Brnich, C. Vaught, and W. J. Wiehagen

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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TRANSFER OF SELF-CONTAINED SELF-RESCUER DONNING SKILLS UNDER SIMILAR CONDITIONS OF PRACTICE: THE DRAEGER OXY-SR60B AND THE CSE SR-100

By M. J. Brnich,[1] C. Vaught,[2] and W. J. Wiehagen[3]

ABSTRACT

The purpose of this U.S. Bureau of Mines study was to assess the ability of trainees to don an unfamiliar self-contained self-rescuer (SCSR) after having become familiar with how to put on a different type of apparatus. Prepractice instruction was the same for all individuals learning to put on a device: a step-by-step, hands-on talk-through using the "3+3" method. Subjects were assigned to groups that had their initial donning instruction delivered on either the Draeger OXY-SR60B or the CSE SR-100. Trainees' performances were then evaluated using the other model. Donning trials were analyzed using a number of measures. It was found that SCSR design had a moderate influence upon how well the donning task transferred.

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INTRODUCTION

Because of interest shown by the Mine Safety and Health Administration and much of the coal industry, the U.S. Bureau of Mines, in 1986, awarded a research contract to CSE Corp. to develop a prototype Person-Wearable Self-Contained Self-Rescuer (PWSCSR). This apparatus, unlike the larger SCSR's that have been deployed since 1981, is intended to be worn on the miner's belt while he or she performs normal duties. Since the device complies with 30 CFR 11 approval and certification standards, and has been designated a 60-minute-duration SCSR, it can be deployed without any modification of existing regulations.

The PWSCSR is most likely to be phased in gradually, replacing first-generation apparatus as they are taken out of service, or substituting for the filter self-rescuer (FSR) on the worker's belt while SCSR's remain cached under the mine's storage plan. The new device will perhaps be issued initially to occupational categories such as mine examiners, roving mechanics, and others who must travel about the mine, but it will eventually be deployed at the face. Under almost any scenario, there will soon be a mix of SCSR's at many mine sites, and they will probably not be strictly segregated. The problem then becomes one of how to achieve and maintain donning proficiency when the worker may have access to either of two different types of apparatus.

Prior research has established that the Bureau's "3+3" method is as effective for the PWSCSR as it has been for other types of apparatus.[4] This finding is not surprising considering the following two facts: First, the procedure offers a logical ordering of subtasks that places priority on assuming a workable position and getting one's lungs isolated. Second, the 3+3 method is generic and has already been validated on very different SCSR's. The present hypothesis, however, is that individuals who have used the 3+3 to master one device might still experience trouble when confronted with another type of device. This hypothesis was based on existing research that indicates "...the amount of transfer seems to be quite small and positive unless the tasks are practically identical..." in which case, and under the right conditions, "...negative transfer can be produced...."[5]

There is evidence, then, that once a person has learned to do a task, he or she will be able to transfer a small degree of this learning to similar tasks. Under certain circumstances, however, subtle differences in procedure can create cognitive confusion.[6] There are some interesting implications in both of these observations as they apply to SCSR training. First, to achieve proficiency in SCSR donning, there must be a substantial front-end investment of both time and effort on the part of trainers and trainees alike. When the necessity of training people on two apparatus is factored in, this time cost increases significantly, especially if there is little or no task transfer. Second, if there is actually negative transfer, with practice on one device tending to create confusion when the individual is confronted with another type of apparatus, ways must be found to ensure proficiency on both SCSR's. In a mine fire or explosion, a trainer undoubtedly wants no confused workers, and many people who are competent in donning and using the device.

This work was conducted in support of a Bureau research project for teaching and measuring self-rescue and escape skills.

RESEARCH PROBLEM

Based on findings from a task analysis of the PWSCSR, an instructor's manual and evaluation form were prepared for field testing. This package presents a generic procedure for the PWSCSR that is exactly like the 3+3 method developed for the four types of SCSR in common use (manufactured by CSE Corp.; Draegerwerk AG (Draeger); Mine Safety Appliances Co., Inc. (MSA); and Ocenco, Inc.).[7] The procedure offers the following: (1) a donning position (kneeling) that is easy and efficient, (2) a donning sequence that moves critical steps (those tasks necessary to isolate one's lungs) ahead of the others, and (3) a set of "chunked" procedural rules that facilitate easy retention. The present study focuses upon the extent to which the 3+3 task, once learned, will transfer between one first-generation apparatus (the Draeger OXY-SR60B) and the CSE SR-100 PWSCSR.

[4]Vaught, C., and M. J. Brnich, Jr. Memory Aid Enhances Person-Wearable SCSR Donning Proficiency. BuMines Technol. News 374, 1991, 2 pp.

[5]Schmidt, R. Motor Control and Learning. Human Kinetics Publ., 1988, p. 407.

[6]Work cited in footnote 5.

[7]The instructional package for first-generation SCSR's is available through the National Mine Health and Safety Academy.

METHOD

Three random samples, totaling 41 workers, were involved in this study. All these individuals had, since 1986, been trained annually on the Draeger. Their last retraining had been conducted approximately 1 year before the present experiment. Fifteen workers were chosen to constitute a control group. The others were either retrained to don the Draeger or taught to don the PWSCSR.

The actual training scheme involved having each subject put on the device as if he or she were trying to escape a fire or explosion. There are several discrete steps in this activity, and as might be inferred, it comprises a number of possible procedural sequences with an extensive motor component. Although there are necessary conditions for beginning certain steps, each step in any possible sequence is relatively simple from the standpoint that it does not have to mesh with other steps in order to be completed. The task itself is potentially confusing, however, because there are several sequences in which the complete procedure could be done. Nevertheless, as was stated earlier, there is a sequence that is most logical. For the present research the task was made exacting by the fact it had to be performed without prompting, in the sequence that prior analysis had determined to be most efficient, and within a reasonable timeframe.

The 3+3 donning method taught to the trainees contains a chunked sequence of actions that imposes a uniform structure upon the variable discrete steps that, when combined, make up a particular action (depending upon the SCSR model being donned). For example, to fully "activate oxygen" on the Draeger, one is required to (1) lift the opening lever, (2) remove the metal closing clamp, (3) grasp the lid and pull until the split pin is out of the chlorate starter, (4) insert the mouthpiece, and (5) exhale into the breathing bag to activate the bed of potassium superoxide. To fully "activate oxygen" on the PWSCSR, a person would (1) flip up the latching mechanism, (2) release the latching bands, (3) open the case by removing the top and bottom lids, (4) activate the oxygen cylinder by pulling a lanyard down and out to the front away from his or her body, and (5) breath normally into the breathing bag in order to start the bed of potassium superoxide. The structure that the generic method imposes upon the donning task not only presents the chunked actions in a logical sequence, but also constrains the discrete tasks to be performed in a consistent order.

The core of information delivered to trainees learning the 3+3 method provides a two-stage approach to the donning task. First, it presents an efficient position and orientation of the apparatus designed to make the chunked sequence possible. Directions for the first stage are as follows: (1) *Kneel.* Place the SCSR on the floor in front of you; lay your miner's cap on the floor and shine the lamp on the SCSR; work with both hands. (2) *Loop.* Quickly loop the neckstrap over your head in order to position it and the case; leave the strap loose so you will have room to work; now you are ready to begin the 3+3 donning procedure. Directions for the second stage divide the chunked sequence into the three critical actions necessary to isolate one's lungs, and the three secondary actions needed to prepare an individual to escape: (1) activate the oxygen, (2) insert the mouthpiece, (3) put on the noseclips, then (4) put on the goggles, (5) adjust straps, and (6) replace miner's cap. The mode for transmitting this message, as well as the content, remained constant throughout the course of this study.

Hands-on prepractice is a treatment that allows the trainee to have hands-on involvement during the initial instructions. Typically, subjects are brought one at a time into the area where the instruction is to be given. After placing a training apparatus on the floor in front of the subject, a Bureau trainer guides the individual step by step through the entire donning procedure. Unlike treatments that require little active participation on the part of the trainee, this mode of prepractice instruction requires the miner to perform each step of the procedure slowly, methodically, and correctly. In addition, feedback is given at the conclusion of the instruction, and the correct steps are reiterated.

Immediately following prepractice instruction, the subjects were required to practice until they had reached the criterion goal of being able to perform a perfect sequence. They were then given a donning trial, using not the apparatus they had just been trained on, but the other type of device. There are, therefore, two treatments included in this assessment. Treatment 1 consisted of training a sample of subjects on the PWSCSR and, once they had demonstrated competence on this device, having them don the Draeger. Treatment 2 had individuals trained to criterion with the Draeger undergo an evaluation on the PWSCSR. For purposes of the present study, these performances would permit researchers to assess certain aspects of both positive and negative task transfer as individuals changed from one apparatus to another.

Prior to each donning trial the individual was equipped with a miner's belt, cap, and cap lamp. An SCSR was placed on the floor in front of the subject. The trainee was requested to await a signal from the trainer, and at this signal to put the SCSR on as if he or she were in an actual mine emergency. No questions were answered or information given at this stage of the process. During the donning trial, which was performed with no prompts, the trainer evaluated the subject's proficiency by means of a specially designed connect-the-dots evaluation form. This form, which has exhibited inter-rater agreement of more

than 90% in hundreds of trials, is intended to show sequencing errors and actions that are done incorrectly (fig. 1). A helper recorded times for both the critical actions and the secondary actions. At the end of the trial, if an error had been made, the instructor pointed it out and explained how to do that particular step correctly.

There were two means of evaluating the performance trials that are used here. Taken together, they provide a good assessment of the effectiveness of each person's donning attempts. First, it was possible to record both the number and types of errors committed. This includes sequencing errors, omissions, and incorrect execution of particular steps. Second, there were two measures of time: the number of seconds a subject required to isolate his or her lungs, and the amount of time he or she took to complete the entire procedural task. Results are discussed below.

ANALYSIS

In order to begin an exploration of the results, subjects' performances on the trials following instruction were divided into two categories: (1) not proficient—those who did not get their lungs isolated from the ambient atmosphere, or those who succeeded in getting their lungs isolated but did not secure the apparatus well enough to allow them to escape, or those who isolated their lungs but secured the apparatus in such a fashion that it would have allowed escape only under favorable conditions—and (2) proficient—those whose performance, although not perfect, made them escape ready, or those who had a perfect 3+3 sequence on the first trial. Figure 2 contains pie charts that present the observed performances for those evaluated on an apparatus different than the one they had just been trained on (Draeger or PWSCSR). These charts may be compared with that of the control group, who were not recently trained but evaluated with the device they had last attempted to don a year before.

It is instructive to examine the areas in the charts. Essentially, there was a greater proportion of proficient sequences for those trained on the PWSCSR but evaluated on the Draeger than was found among the control group. Conversely, there was a smaller proportion of proficient sequences for those trained on the Draeger but evaluated on the PWSCSR than had been exhibited by the control group. The chi-square (X^2) value is given below the pie charts.

A second measure of performance immediately following treatment is the amount of time it takes individuals to get the apparatus on. The most important, or "critical," steps are those that are necessary to isolate one's lungs from the ambient atmosphere. The lower graphics in figure 3 provide information about how quickly these critical steps were performed by those who were able to do them on the first trial. As can be seen, those trained on the Draeger required approximately 9 seconds (s) longer (on average) to get their lungs isolated with the PWSCSR than did those trained on the PWSCSR and evaluated with the Draeger.

The upper graphics in figure 3 present information about total times (the number of seconds trainees required to finish the donning procedure, regardless of whether they completed all the steps). It is interesting to note that for total times, the mean for those trained on the PWSCSR but evaluated on the Draeger is slightly greater than the mean for those trained on the Draeger but evaluated on the PWSCSR (77 s versus 71 s). Another interesting part of this graphic can be seen when the standard deviations about the two total means (depicted by the shaded rectangular areas) are compared. A likely explanation for these observations is that most of those trained on the PWSCSR were actually able to don the Draeger, although some confused the sequence and consequently wasted time. Individuals trained on the Draeger, however, were simply not able to put on the PWSCSR and subsequently stopped short of completing the task.

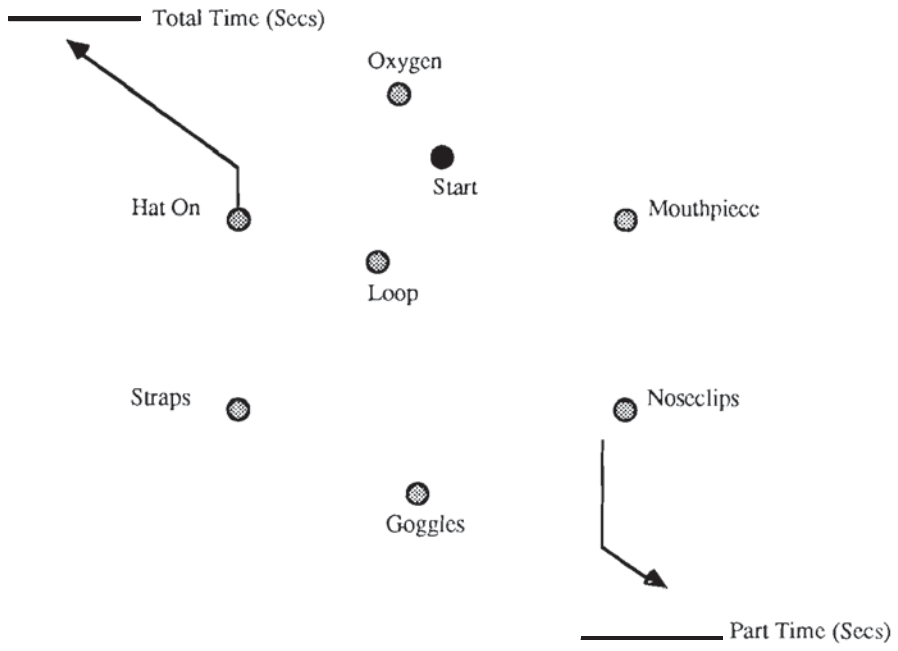
A third measure of performance is errors. Figure 4 provides an accounting of errors made on each task by apparatus used. An examination of the figure shows that the areas where people seemed to have the most trouble were in activating the oxygen, inserting the mouthpiece, donning the goggles, and adjusting the straps. These omissions are relatively serious, and would impair a person's ability to escape. In each category, there were more errors committed by people who had been trained on the Draeger but who were donning the PWSCSR than by other groups. As a matter of fact, at least some of those trained on the Draeger who then attempted to don the PWSCSR had problems with each step in the donning task, except remembering to replace their hard hats. Achieving adequate strap adjustment was problematic for both groups, but especially for those trained on the Draeger and evaluated on the PWSCSR. Actually, this subtask did not tend to transfer well in either direction.

Evaluation for _____ Date _____

Serial Number _____ Mine _____ Trial # _____

Tape (Y or N) _____ Type of Unit _____

1. Connect the dots in the diagram below to show the steps the trainee took in donning the SCSR. If a step was started but not finished, dip the line toward the step. Do not touch the dot if the step was not completed or was done incorrectly.



2. After the task is completed, please list any errors that need to be corrected and then review these errors with the trainee.

_____

_____

_____

_____

_____

_____

Figure 1.—Evaluation form used in teaching and assessing 3+3 donning method.

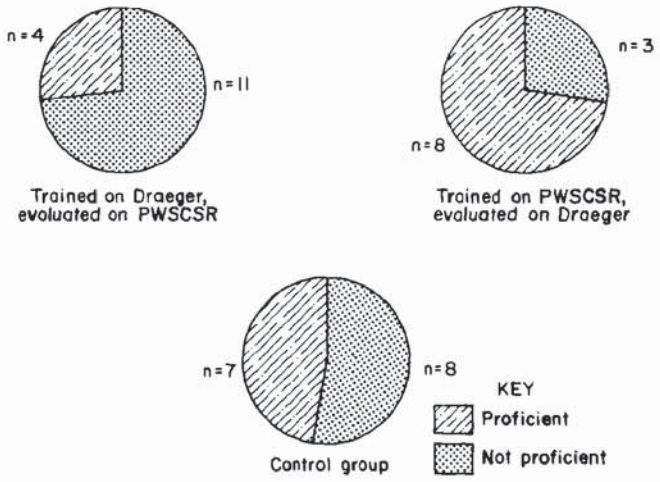


Figure 2.—Donning proficiency for individuals trained and evaluated on different units. Pearson chi-square = 5.42; p = 0.067.

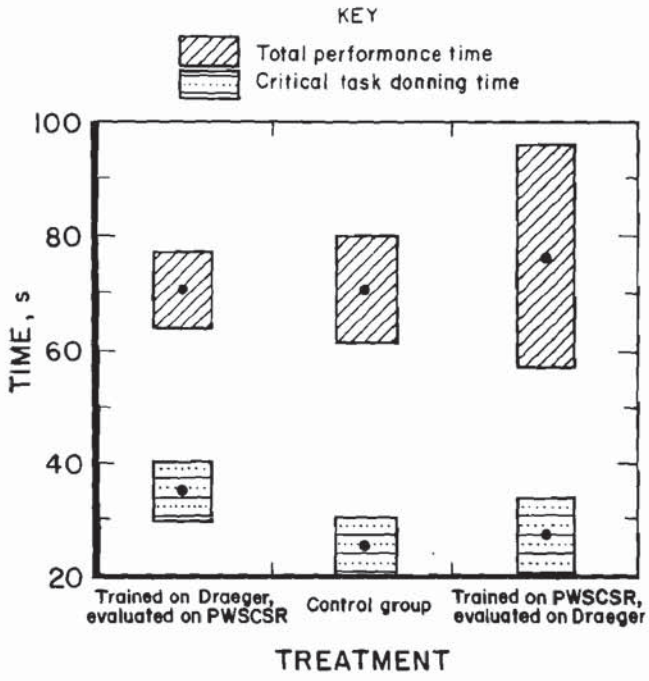
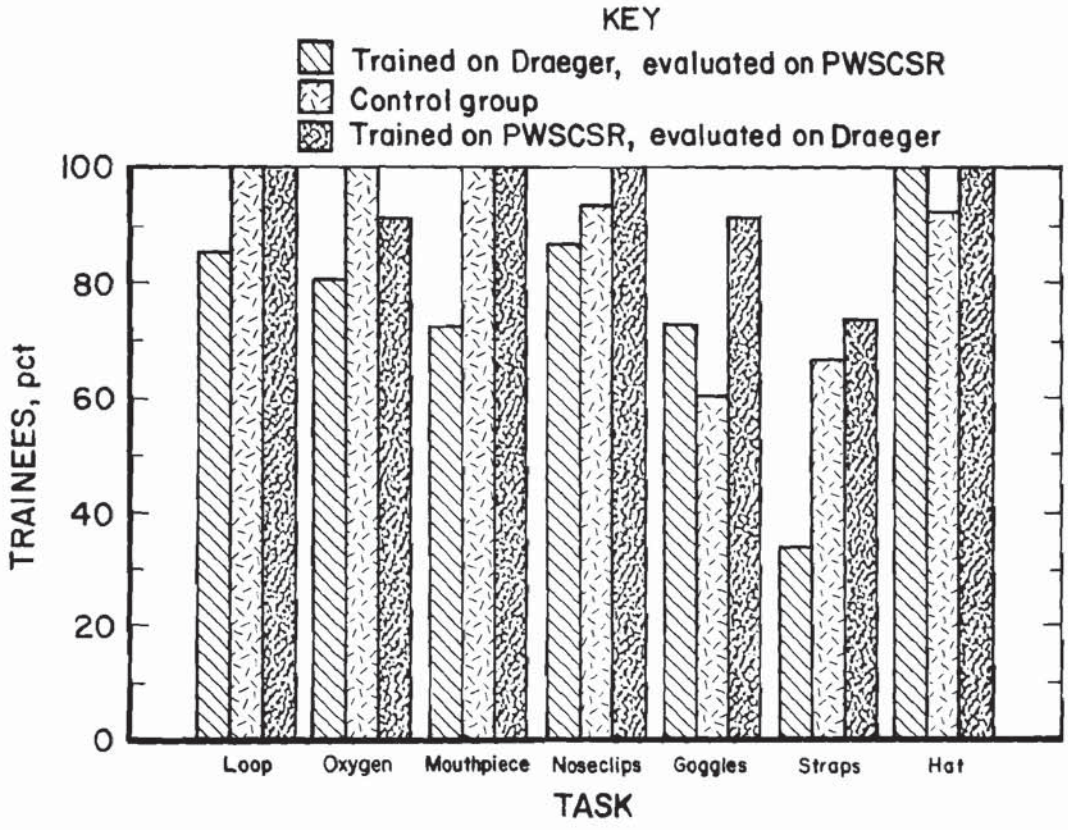


Figure 3.—Data for critical donning task times and total performance times for subjects trained and evaluated on different units.



ıure 4.—Percent of trainees performing donning steps correctly.

DISCUSSION

This report has addressed an important problem related to the anticipated deployment of new PWSCSR's—even when the training method is the same for all apparatus. This issue involves task transfer, or what happens when individuals taught to don one device attempt to put on another type of apparatus. If, as common sense would indicate, there are differences in the degree of difficulty each SCSR confronts the individual with, then it might be expected that the task of putting on an apparatus would transfer better in one direction than in the other. Particular attention should be paid to achieving and maintaining proficiency on the device people have the most trouble learning. While this does not obviate the need to give thorough hands-on training with each type of SCSR, it presents a cautionary note to instructors who are in the process of introducing new apparatus. This introduction must not be done casually.

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