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Roger C. Jensen

Montana Tech of the University of Montana

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ALERTNESS-SUPPORT ACTIVITIES FOR CONTROL ROOM OPERATORS IN AUTOMATED INDUSTRIAL PLANTS

Roger C. Jensen

Occupational Safety, Health, and Industrial Hygiene Department
Montana Tech
Butte, Montana

A survey of control room operators in a nuclear power plant identified practical activities for maintaining alertness during the early morning hours. Nine on-duty operators rated 16 activities they were allowed to do on shift. Activities most effective for alertness were splashing cool water on the face, drinking coffee, and doing things that used muscles. The least effective activities were passive monitoring and studying for exams. The large range of ratings indicates that activity has a major role in operator alertness during the early morning hours.

INTRODUCTION

There is a considerable body of literature on factors that affect alertness of people who work night shifts on either a rotating shift schedule or a fixed schedule (e.g., Baker, 1995; Dekker, Tepas, and Colligan; 1996; Moore-Ede, 1993; Tepas, Paley, and Popkin, 1997).

A significant source of research on maintaining alertness has been the National Aeronautics and Space Administration (NASA). The NASA Fatigue Countermeasures Program focused on aircraft crew performance and alertness during long flights (Rosekind, et al. 1993). More than a decade of research led to the conclusion that the most effective methods for maintaining performance and alertness during long flights include the use of caffeine, crew scheduling practices, physical activity, and controlled rest on the flight deck (Rosekind, et al. 1993).

Another summary of literature regarding activities that help turn up alertness was provided by Moore-Ede (1993). He categorized alertness-enhancing activities and practices into muscular activity, temperature, aroma, ingested nutrients, and sense of danger, interest, or opportunity.

The survey reported here concerned the effectiveness of different activities and practices for maintaining alertness during the early-morning hours, between 0300 h and 0640 h. Findings are compared with those reported by Moore-Ede (1993).

METHODS

Nine operators provided their opinions about the effects of various activities on their alertness. They were specifically asked to focus on the time period 0300 to 0640 h. Three separate crews were involved. At the time of data collection two crews were working evening shifts and one was working the night shift.

The instrument used to obtain ratings of effectiveness consisted of a list of activities. To the right of each activity was a line for indicating the effectiveness of the activity for maintaining alertness. The operators were asked to draw a short vertical line through the effectiveness rating line for each activity on the list. Following the rating scales there was an open-ended question asking for other ways to maintain alertness while at work.

The marks on the rating scale lines were read independently by two individuals in order to make certain that the values were accurate. With nine operators and 16 activities rated, there was a potential for 144 marks to read. One participant did not rate two items and another did not rate one item, so the actual total was 141.

Readings from the effectiveness rating lines used in the rating instrument were converted from the measured distances into an equivalent 100 point scale. Thus, a zero value indicates that the activity was not considered effective, and a 100 value indicates that an activity was rated as very effective. Average rating values were determined for each activity. The 16

activities were ranked by their respective average rating values.

RESULTS

The activities are listed in Table 1 in order of their average effectiveness ratings. These ratings indicate that the most effective activity for maintaining

alertness between 0300 and 0640 h was "Splashing cool water on face" followed closely by "Drinking a cup of coffee" with average ratings of 54 and 52, respectively. The least effective was "Reviewing materials for Licensing exam" with an average rating of 10.

Table 1 Effectiveness of activities for maintaining alertness

Activity	Rank	Average Rating
Splashing cool water on face	1	54
Drinking a cup of coffee	2	52
Stretching while at your work station	3	47
Taking short walk within the control room	4	46
Discussing the weather	5	40
Eating mid-shift meal	6	40
Cleaning up the work station	7	38
Consuming snacks with strong tastes	8	37
Consuming snacks with strong smell like peppermint	9	36
Making a tag for a lockout/tagout procedure	10	35
Chewing gum	11	34
Discussing technical matters about plant operations	12	32
Drinking soda with no caffeine	13	28
Recording activities in a log book	14	26
Passively monitoring a stable system	15	22
Reviewing materials for Licensing exam	16	10

DISCUSSION

The survey results provide information about activities that have a broad range of effectiveness for helping control room operators maintain alertness through the early morning hours. For the most part, the findings are consistent with activities Moore-Ede (1993) identified as "switches" that help turn up alertness; and which he classified into groups that include muscular activity, temperature, aroma, ingested nutrients, and sense of danger/interest/opportunity. However, a categorization system somewhat different from

Moore-Ede's was chosen in order to provide more-practical information to people who work night shifts.

Cool Temperature on the Skin

Moore-Ede (1993) stated "It is common experience that cool, fresh air, especially on the face, rouses one from a sleepy state." In our survey the highest rated activity was splashing cool water on the face. There was also one hand written comment about stepping outside of the plant into cool air. Although this survey listed cool water and Moore-Ede (1993) mentioned cool air, the distinction may not have practical significance to operators.

Muscular Activity

Moore-Ede (1993) includes muscular activity on the list of alertness switches, and indicates that more vigorous activity has a stronger effect on alertness than does moderate or less vigorous activity. From the list of activities included in this survey, not counting activities with minor physical movement like drinking a soda, are the following:

- stretching while at your work station (47)
- taking short walk within the control room (46)
- cleaning up work station (38)
- chewing gum (34)

The conclusion is that muscular activity is effective for helping operators maintain alertness during the early morning hours. Additionally, these findings do not conflict with Moore-Ede's (1993) observation that vigorous muscular activity is more helpful than moderate muscular activity. Several hand written comments about taking a walk through the plant, combined with effectiveness ratings are supportive of the proposition that more vigorous activity (e.g., using the large leg muscles) is more effective than less vigorous activity (e.g., chewing gum).

Ingesting Caffeine

Drinking a cup of coffee was rated as being the second most effective activity on the list for maintaining alertness. Of course, coffee has been a popular source of caffeine for night shift workers for many years. One value of including this activity on the list is that the rating level for drinking coffee (52) can serve as a reference value for an activity that is familiar to most readers.

Moore-Ede (1993) used a single category—called “ingesting nutrients”—for intake of both food and pharmacological substances such as caffeine. The categorization system used in this paper keeps the ingestion of caffeine separate from the consumption of food and snacks because of their different physiological effects.

Consuming Meals and Snacks

The survey included several activities that involve the consumption of food, snacks, and drinks without caffeine. These activities are listed below, with their average effectiveness rating in parentheses:

- eating mid-shift meal (40)
- consuming snacks with strong tastes (37)
- consuming snacks with strong smells (36)
- drinking soda with no caffeine (28)

Compared to other activities on the list, these ratings (from 28 to 40) indicate a moderate level of effectiveness. There are different possible explanations for the reasons why food and snacks are regarded as moderately effective for maintaining alertness. The explanation offered by Moore-Ede (1993) is that food provides nutritional value. Another is that the process provides stimulation for the senses of taste and smell. A third is that the process of consumption provides a mild amount of physical activity. It may be that all three reasons are valid to some extent.

The effects of the mid-shift meal deserve some comment. One may expect that a meal would result in a decrease in alertness as blood distribution emphasizes digestion and de-emphasizes supply to the brain. But the survey indicated that the meal helps alertness. An explanation that appears most likely is that the process of eating exposes the individual to aromas and tastes that have a temporary alerting effect. This temporary increase in alertness may be what the operators remembered when they responded to the survey. It is quite possible, perhaps probable, that soon after returning to their workstation the effects of the changed blood distribution kick in and cause a reduction in alertness. However, this survey was not designed to examine that possibility.

Aroma is listed as one of Moore-Ede's (1993) alertness switches. The operators in the present survey rated the consumption of snacks with strong smells as having essentially the same effectiveness as consuming snacks with strong tastes. Additionally, most food, snacks, and sodas offer a combination of aromas and flavors. Therefore, as a practical matter, aroma is listed as a separate category. Thus, a single category is used for food, snacks, and non-caffeine drinks.

Cognitive Stimulation

Primarily mental activities received a wide range of effectiveness ratings. The highest rating was 40, for discussing the weather. The lowest rating was reviewing materials for Licensing exam. Some thoughts are offered on the possible reasons for the wide range of effectiveness ratings, with the acknowledgement that this survey did not ask the operators to give reasons for their ratings.

Moore-Ede (1993) included in his list of alertness switches the category called “sense of danger, interest, or opportunity.” The present survey did not inquire about possible sense of danger, but did include two items on the activity list that involved discussions of specified subjects. Discussing the weather was rated 40, while discussing technical matters was rated 32. These

are average ratings. A closer examination of the ratings indicated that the operators fell into two distinct groups in regard to rating these discussions. Five of the operators rated discussion of the weather relatively high and discussion of technical matters relatively low. Four operators provided ratings that were in the opposite direction.

Apparently, the weather was a subject of sufficient interest to five of the participants that discussing it helps them maintain alertness. Moore-Ede's (1993) commented to the effect that alertness is helped by discussions of interesting topics and the performance of interesting tasks. A fair conclusion is that the subject matter of discussions within the control room makes a difference for supporting alertness between 0300 and 0640 h. Topics that operators find interesting are more effective than topics of less interest. Furthermore, the subject matter that is effective for some individuals may not be effective for others. Additional support for this conclusion was found in the answers to the open-ended question about other activities that are effective.

Three work-related cognitive activities that rated as being lower on the effectiveness scale were: recording activities in a log book, passively monitoring a stable system, and reviewing materials for Licensing exam. None of these activities provide stimulation of the larger muscle groups or serve to increase circulation. It appears that these activities provide a low level of stimulation for the mind as well. The implication from this finding is that if tasks are to be assigned to operators for performance during the early morning hours, it would be helpful if the tasks are the type operators consider interesting.

Concluding Theory

A generalized concept derived from these findings is this. During the early morning hours a typical process operator experiences a tendency to become less alert. This is driven by the natural circadian cycle (Dekker, et al. 1996; Rosekind, et al. 1993). Most operators can counter the tendency by performing activities that stimulate their body and mind. Figure 1 portrays the process as being analogous to a container with water. The level of water represents the level of alertness. A drain at the bottom opens during the early morning hours and allows some of the alertness to slowly drip out. At the top of the graphic is a watering can representing the addition of stimulation that contributes to the operator's alertness.

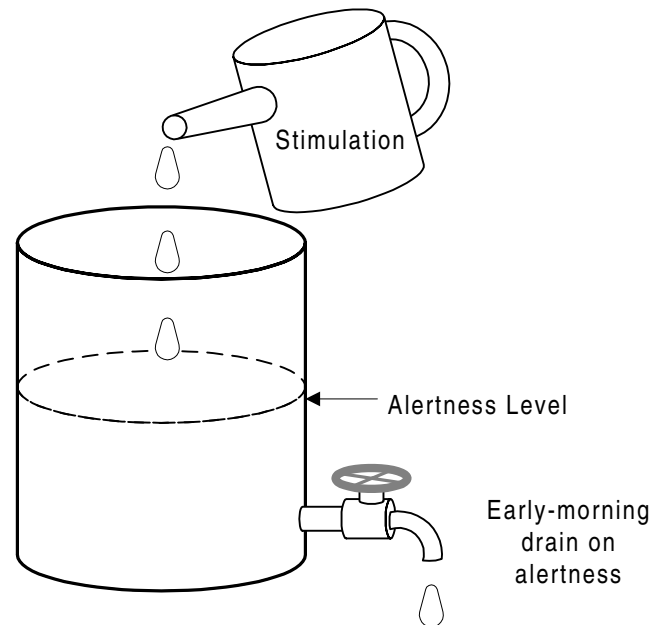


Figure 1. Graphic model of operator alertness during the early morning hours

The drain on alertness occurs at different rates for different individuals. For example, the rate at which alertness drains will be less for a well-rested individual than for one who starts the shift with a sleep debt. Similarly, an operator who has had time to adjust to night shift work will generally have a slower alertness drain than someone on their first or second night shift on duty.

The concept represented in Figure 1 indicates that as alertness drains there is a need for stimulation to maintain the alertness level. Routine process monitoring provides little stimulation. More helpful stimulation comes from physical and cognitive activities. As the present survey found, the physical stimulation can come from ingestion of caffeine, consumption of food or snacks, applying cool water or air on the face, and exercising the larger muscles. The cognitive stimulation may come from discussing subjects of interest to the individual or from performing work-related tasks that are interesting.

Conclusions about Alertness Factors

These findings suggest that support for operator alertness between 0300 and 0640 h can most effectively be achieved by providing opportunities for the personnel

to do something more than sitting at a work station monitoring or studying. Management could provide support by any of the following:

- Assign work that involves some muscular activity.
- Assign work that stimulates the mind.
- Provide opportunities for control room personnel to get some exercise other than work-related.
- Grouping individuals into crews based in part on their sharing of interests.
- Encourage operators to make changes in routine during periods of passive monitoring.

ACKNOWLEDGMENTS

The study was sponsored by the U.S. Nuclear Regulatory Commission, Contract No. NRC-04-94-086. The author greatly appreciates the support of the Commission's technical representatives, Ms. Dolores Morisseau and Dr. Jay Persensky. Funds came from the Small Business Innovative Research program of the Nuclear Regulatory Commission. The contracting business was UES, Inc., Dayton, Ohio. The author received invaluable support from colleagues at UES, Inc. — Dr. William Askren, Mr. John Howard, and the late Dr. Julien Christensen. Important contributions were also provided by long-time members of the Human Factors and Ergonomics Society — Dr. Lewis Hanes and the late Mr. Harold "Smoke" Price.

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