

CHAPTER III

METHODOLOGY

Subjects

In this study, eight male subjects participated in the experiment. Four of the subjects cut pipes, while the other four machine pipes. These kinds of work were considered repetitive and it was believed they could cause mental fatigue. The average ages of the pipe cutting and pipe machining workers were 25 and 32 years respectively. Their weights and heights were 59 kilograms, 167 centimeters for pipe cutting workers and 63 kilograms, 162 centimeters for pipe machining workers. The mean experience of the two groups were 2 and 5 years respectively, and mean years of education was 4 for each group.

The following criteria were applied in choosing subjects:

1. The subject should not suffer from any kind of major disorders.
2. They should have enough sleeping hours, i.e. 6-8 hours per night, the night before the experiment.
3. They should have eaten a meal before starting work.
4. Their vision and audibility should be normal. The orthorater and audiometer were used to test their vision and audibility.

Methods

Both objective and subjective methods of measurement were used

to gauge the quantitative mental fatigue throughout a day shift. The following values were used for objective assessment: 1) critical flicker fusion frequency (FCFF) 2) reaction time, and 3) hand grip strength. In subjective methods, the subjects were interviewed to gauge feeling by using a self-scaling questionnaire. These methods were performed before and after work.

Experimental Design

For the purpose of this study three experimental factors were taken into consideration:

1. Type of Work

The degree of mental fatigue is determined by the kind of work. Highly repetitive work with a cycle time of 30 seconds or less will cause more mental fatigue. The type of work is viewed as an important factor in this experiment. In this study, the two selected forms of repetitive work are pipe cutting and pipe machining.

2. Period of Work

The period of time is considered as another factor in gauging mental fatigue which is accumulated during a day shift. A longer period of continuous work may result in more mental fatigue. In this study, the subjects were tested three times within a day.

3. Size of Products

The size of products is thought to influence the degree of mental fatigue. Therefore, two different sizes of each work will be compared in this study. The smallest and biggest products are used in

this experiment; that is, the pipes with a 1/2 and 2-inch diameter for pipe cutting, and those with a 2 and 6-inch diameter for pipe machining.

Thus, the type of work, period of work and size of products are regarded as influential factors for the experiment on mental fatigue. The experiment with two replications is conducted. Also, the following table is designed for the study:

Table 3.1 Experimental design in this study

Period	Value	Type of task			
		Task I	Task II	Task III	Task IV
I	FCFF				
	RT				
	HGS				
	SSQ				
II	FCFF				
	RT				
	HGS				
	SSQ				
III	FCFF				
	RT				
	HGS				
	SSQ				

- Note:
- I - Before work (morning)
 - II - After 4-hours work (morning)
 - III - After 8-hours work with a one-hour lunch break (afternoon)
 - FCFF - Fuzzy critical flicker fusion frequency
 - RT - Reaction time
 - HGS - Hand grip strength
 - SSQ - Self-scaling questionnaire
 - Task I - Pipe cutting work on 1/2-inch diameter
 - Task II - Pipe cutting work on 2-inch diameter
 - Task III - Pipe machining work on 2-inch diameter
 - Task IV - Pipe machining work on 6-inch diameter

Procedures

Before the tests began, the subjects were interviewed for some personal information. If they had health problems or they did not have the normal amount of sleep the night before, they were asked not to participate in the test. Objective and subjective methods of measurement would be used on the subjects three times a day: 1) before work (morning), 2) after 4-hours work (morning), 3) after 8-hours work with a one-hour lunch break (afternoon).

1. Critical Flicker Fusion Frequency Measurement

1.1 Flicker (Figure A.1)

This has been increasingly employed to measure the degree of fatigue. The equipment is operated in two phases: flickering and constant. If the light is rapidly and successively flickering, it

will turn to appear as a constant light. A red luminescent diode serves as the source of stimuli. The diode is displayed on a white background. It is characterized by the luminescence level of 500 Lux. Its frequency range is from 20 to 60 Hz.

1.2 Training for Critical Flicker Fusion Frequency

Training for critical flicker fusion frequency took place three times a day for four days. The subjects would be asked to press the button when a flickering light (up) was on. When the flickering light appeared to fuse into a constantly shining light, the subjects were supposed to release the button instantly. Thus, the threshold values would be obtained. The test of this stimulus would be applied to the subjects ten times. A five seconds' break was given between each repetition of the experiment. During the test, the subjects remained in a sitting position. A constantly shining light (down) was tested on the subjects in a similar way.

1.3 Procedure for Critical Flicker Fusion Frequency

The different threshold values were obtained at the training period. The subjects examined would then observe the stimuli of these values, displayed in a fixed duration of five seconds' exposure of each stimulus and three seconds' break in between. Each stimulus would be randomly presented ten times. The subjects were to distinguish between flickering and constantly shining lights.

Techniques for the measurement by this procedure:

1. The subject should be measured both before and after work, so that the different values obtained are later used to indicate mental fatigue.

2. The measurement should be done immediately after work, since a break after the end of a working period may cause the recovery of the body from fatigue.

3. According to the hypothesis of this study, the subjects will see the flickering light when the value of the frequency of the light is low. If the value of the frequency is high, the subjects will see the constant light. But if the result of the experiment is not in accordance with the hypothesis, the experiment should be repeated with the previous experiment. This is to screen boredom from mental fatigue. However, when the repeated experiment does not provide a favourable result, its results should not be taken into consideration for the conclusion of the study.

4. The subjects should be tested by the flicker two or three times before each actual experiment.

5. The subjects' attention for the experiment and malady influence the result of the experiment.

2. Reaction Time Measurement

2.1 Reaction Timer (Figure A.2)

The reaction timer works to find out perceptions, interpretations and motor reactions. In this experiment, the reaction timer used was a simple one in which light and sound serve as two stimuli. The obtained values indicated response time (in seconds) which is useful for the study of human performance and fatigue.

2.2 Training for Reaction Time

According to previous research, the responses of the

subjects to stimuli (light and sound) were related to learning. Therefore, in order to eliminate the effect of learning upon data collection, reaction time training was done with the subjects. This training took place during training sessions after the subjects were trained for critical flicker fusion frequency. The method for the training and that in the experiment were the same. It is mentioned in 2.3.

2.3 Procedure for Reaction Time

For the reaction time measurement, light and sound would be two stimuli, each of which was displayed to the subjects twenty times. During the test, the subjects remained in a sitting position with the forefinger of their preferred hand on a button on a response box which was set on a table. They would push the button as soon as possible when the stimuli were shown. The values from the reaction time measurement appeared on the stimulus window.

3. Hand Grip Strength Measurement

3.1 Grip Dynamometer (Figure A.3)

Muscular strength may denote physical efficiency. If muscular fatigue occurs, it will bring about an increase in mental fatigue. Besides, muscular fatigue will lead to weariness and lethargy which are symptoms of mental fatigue. Hence, the differences in strength before and after work will give an explanation for subjects' mental fatigue. The muscular strength is gauged by a piece of equipment called the grip dynamometer.

3.2 Procedure for Hand Grip Strength

The subjects were asked to press the grip dynamometer as strongly as they could with a right hand while they were in a standing position. The average of scores from the test, which had been done twice, would be used as an index of fatigue.

4. Questionnaire on Fatigue

4.1 Self-scaling Questionnaire (Appendix B)

The questionnaire is used to assess feelings at a particular moment under industrial conditions. It consists of two main sections:

Questionnaire 1 deals with personal data and working experience.

Questionnaire 2 is filled out by workers. This self-scaling part is designed to record their feelings. The bipolar questionnaire lists the following contrasting pairs of feelings:

bored	-	interested
disliking work	-	enjoying work
tired	-	refreshed
weak	-	strong
exhausted	-	vigorous
sleepy	-	awake
tense	-	relaxed

The scales have eleven points from -5 to 5. The lowest (-5) and highest (5) values indicate an extreme feeling. Zero represents a normal state.

4.2 Procedure for Self-scaling Questionnaire

The information on the subjects was collected by the use of the questionnaire. The first part of the questionnaire was used to find out personal data. The other part was used to assess their feeling of fatigue. The subjects were asked to choose one of the numbers on designed scales. Verbal descriptions were set at the starting and ending point of each scale. For example, -5, on the bored-interested scale would mean the worker was extremely bored. These scales were used to show how intense subjects' mental fatigue was at a particular moment.



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