TECHNICAL SESSION II

EDUCATION AND TRAINING

"Organizational Climate and Injury Rate in the Underground Coal Mining Industry: A Cross-Lagged Panel Design"

by

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ABSTRACT

This study was designed to explore the contribution of organizational climate and management practices to the injury experience in underground coal mines. A cross-lagged panel design was used in which miners from 22 mines completed questionnaires assessing 27 organizational climate, structure, and function dimensions on 2 occasions. The results strongly support the hypothesis that climate and management practices have causal effects on incidence of disabling injuries. Specifically it appears that disabling injuries decrease when decisions are decentralized, when management is flexible and innovative in trying new procedures and programs, and when morale is high.

INTRODUCTION

Kerr in 1957 advanced the Goals-Freedom-Altertness (GFA) theory of accident causation which centered around management style, practices, and organizational climate as key variables in the accident chain. The chain evolved from management allowing workers to participate in the setting of

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goals and the methods of attaining them, thus creating a climate of support, trust, and loyalty, and fostering high morale among the workforce. This, Kerr postulated, made for habits of alertness and problem solving which in turn promoted safe behavior and fewer accidents.

Although Kerr felt that the theory accounted for 30 to 40 percent of the variance in accident data, there have been few studies addressing the theory. Early studies (Kerr, 1950; Keenan, Kerr, and Sherman, 1951; Sherman, Kerr, and Kosinar, 1957) were methodologically weak. Departments were assessed by supervisors, rather than by the workers themselves, on a series of miscellaneous factors, correlating each with accident frequency and severity. No attempt was made to equate job hazards or working conditions across departments. The questionnaires were crude, employing single items to assess factors. Static correlations were used, thus precluding causal inferences.

A methodologically more sound study addressing the GFA theory was carried out by Hitchcock and Sanders (1974) among munition workers and support personnel. A comprehensive questionnaire was used to assess the workers' perceptions of management style, practices, and organizational climate. The results supported GFA theory for the ordnance workers, but not for the more autonomous, skilled, and satisfied support personnel. For the ordnance workers, low injury rates were found in groups that had high achievement motivation, identified with the organization, and felt that the organization was willing to support them. The major problem with this study was that again static correlations were used, making it impossible to infer causation.

The current study sought to remedy this shortcoming by employing a cross-lagged correlational methodology (Blalock, 1962; Campbell and Stanley, 1963; Lawler, 1969; Kenny, 1975). Using a panel design would allow for making tentative causal inferences regarding accidents and climate and management practices. Before the present study, one never knew, for example, if injuries caused a reduction in morale, or if high morale contributed to lower incidence of injury or if some third variable caused both. A resolution to this dilemma would be appreciated by those trying to show management that variables of interest to industrial-organizational psychologists can directly benefit an organization in a tangible way.

METHOD

Twenty-two (22) underground coal mines in 5 states were visited twice at a median interval of 7 months. Each time, disabling injury and man-hour data from the prior 3 months were collected and from 10 to 27 miners filled out a 127-item questionnaire. They were paid $10.00 for completing the questionnaire. The questionnaire items were taken and modified from Patchen (1965), Pritchard and Campbell (1969), and Taylor and Bowers (1971). The items were rationally combined into 21 scales of management practices and organizational climate and 7 safety-related scales. Table 1 lists and briefly defines each scale. Nine items that showed negative within-scale intercorrelations, based on the first visit data, were discarded. Ten items were repeated in the questionnaire to check for consistency of response. Approximately 30 percent of the 788 questionnaires were discarded for inconsistencies. The responses for each item on the questionnaire were averaged across miners within each mine. The item means were then combined to yield scale scores for each mine on each visit.

With more scales than mines, a meaningful factor analysis was precluded. Correlations between scales are acknowledged. The purpose of the study, however, was not to isolate specific orthogonal factors that might account for injuries, but rather to discover whether management practices and organizational climate in general were more likely either causes of, or caused by, injuries. The scale that shows causal relationships with injuries should paint a picture of a management and organization which fosters lower injury rates.

RESULTS AND DISCUSSION

Table 2, Columns 1 to 5, presents the necessary data to perform cross-lagged analyses for each scale with disabling injury rate (per million man-hours). C is climate, I is injury, and 1 and 2 are the two visits. The notation C1I2, for example, signifies the correlation between a climate scale measured on the first visit with injury rate measured on the second visit.

To use cross-lagged techniques, an assumption of stationarity (Kenney, 1975) must be made. Based on analysis of the data, quasi-stationarity was tentatively accepted. This assumes that the causal coefficients of each variable change by a constant from visit 1 to visit 2 and each variable has its own unique constant.

The model that a third variable is causing the relationship between a scale and injury rate can be tested (Kenney, 1973) by computing the ratio (C1I2 * I1C2)/(C1I1 * C2I2). If the ratio is greater than 1.0, the third variable model can be rejected; Kenney (1973) indicates that this is a very conservative test, erring in the direction of accepting the model when it may, in fact, not hold. Kenney, in fact, points out that it is difficult to reject the model using this stringent criteria and, for this reason, suggests not using it. Applying the test to the data, however, yielded 17 variables with ratios greater than 1.0, as shown in Table 2, Column 6.

TABLE 1. — Definition of Scales

Climate Scales:

1. Decision Decentralization - (3 items, .37 median r): Degree to which workers share in the decisionmaking process on important matters.

2. Shared Authority - (3 items, .53 Md r): Degree to which workers are given authority to handle day-to-day problems and emergency situations.

3. Worker Autonomy - (2 items, .06 r): Degree to which supervisors watch over workers to make sure they do things correctly.

4. Management Receptiveness - (3 items, .69 Md r): Degree to which management is interested in the ideas and suggestions of the workers and gives them serious consideration.

5. Innovative Flexibility - (2 items, .44 r): Degree to which management is willing to find and try new ways of doing things.

6. Structure - (3 items, .60 Md r): Degree to which the mine codifies things, writes things down, and has established standard operating procedures.

7. Production Pressure - (3 items, .72 Md r): Degree to which workers feel rushed and under pressure to get the work out.

8. Feedback - (3 items, .73 Md r): Degree to which supervisors give the workers feedback concerning the workers' performance.

9. Performance Reward Dependency - (2 items, .78 r): Degree to which rewards are dependent on performance.

10. New Worker Development - (4 items, .53 Md r): Degree to which management takes time to orient and introduce the new worker to the mine and its operation.

11. Continued Employee Development - (3 items, .78 Md r): Degree to which supervisors help develop the talents and abilities of their men by coaching and counseling.

12. Management Planning - (2 items, .73 r): Degree to which management does a good job of planning and little time is lost due to poor planning.

Table 1. —Climate Scales (cont.):

13. Decision Timeliness - (3 items, .59 Md r): Degree to which management makes decisions promptly and with a minimum of delay.

14. Consistency of Orders - (3 items, .59 Md r): Degree to which there are no conflicting orders given by different people in the mine.

15. Management Supportiveness - (2 items, .91 r): Degree to which management is interested and sympathetic with workers' welfare and personal problems.

16. Management Concern for Working Conditions - (3 items, .81 Md r): Degree to which management is concerned with improving working conditions.

17. Identification with the Company - (6 items, .61 Md r): Degree to which the miners are proud of the mine and their loyalty extends off the job as well.

18. Achievement Motivation - (3 items, .40 Md r): Degree to which the workforce is motivated to improve its performance.

19. Morale - (4 items, .66 Md r): Degree to which there is a high level of morale and low levels of grievances and turnover.

20. Cooperation Between Workers - (2 items, .69 r): Degree to which work groups cooperate to get the work accomplished.

21. Social Relations Among Workers - (2 items, .54 r): Degree to which the miners are friendly toward each other.

Safety-Related Scales:

1. Quality of Safety Committee - (10 items, .69 Md r): Degree to which miners held positive attitudes toward their safety committee.

2. Management Safety Attitudes - (4 items, .79 Md r): Degree to which management is concerned about safety in the mine.

3. Worker Safety Attitudes - (6 items, .49 Md r): Degree to which the workforce is actively promoting safety in the mine.

4. Attitude Toward Safety Inspections - (3 items, .40 Md r): Degree to which miners feel that Federal safety inspections are valuable.

Table 1. —Safety-Related Scales (concluded):

5. Accident Cause - (1 item): Degree to which miners feel responsible for accidents and have control over their behavior (internal vs. external control).

6. Perception of Safety Record - (1 item): Degree to which miners believe the safety record of the mine is above average.

7. Safety Knowledge - (15 items): Multiple choice test to assess the miners' knowledge of good safety practices.

TABLE 2.—Correlations between climate scales and disabling injury rate measured at two points in time

*p < .05 **p < .10

Column:	1	2	3	4	5	6	7	8	9	10	11	12	13
	Auto	Synchronous		Cross Lagged		Test of Model[1]	Rel. Estimate	Corrected Syn.		C1I1 vs C2I2	Corrected Cross-Lagged		C1I2 vs I1C2
	C1C2	C1I1	C2I2	C1I2	I1C2			C1I1	C2I2	Z	C1I2	I1C2	Z
Decision Decentralization	.69*	.00	.00	-.33	.21	00	.493	.00	.00	.00	-.12	.57	2.31*
Shared Authority	.55*	.27	-.45*	-.26	.06	<1							
Worker Autonomy	.35	.30	-.32	.11	.14	<1							
Man Receptiveness	.69*	.20	-.28	-.27	.23	1.11	1.133	.47	-.11	1.94**			
Innovative Flexibility	.61*	.04	-.42*	-.37*	.21	4.6	4.950	.14	-.12	.80	-.24	.32	1.78**
Structure	.41*	.05	-.40*	-.34	.12	2.0	2.092	.14	-.14	.88	-.18	.23	1.30
Production Pressure	.63*	-.18	.13	.27	.42*	4.8	.088	-.22	.10	1.00	.06	-1.761	4.15*
Feedback	.76*	.12	-.43*	-.30	.20	1.1	1.871	.32	.16	1.49	-.15	.39	1.70**
Perform Reward Depend.	.70*	.18	-.41*	-.24	.05	<1							
New Worker Development	.60*	.01	-.36*	-.27	-.07	5.3	19.609	.05	-.07	.35	-.25	-.07	.54
Continued Employee Dev.	.71*	.23	-.23	-.21	.30	1.2	.019	.19	-.27	1.36	-.03	1.1851	3.67*
Man. Planning	.58*	.01	-.25	-.26	.06	6.2	8.831	.04	-.06	.30	-.19	.08	.84
Decision Timeliness	.59*	.25	-.55*	-.10	.20	<1							
Consistency of Orders	.66*	.14	-.33	-.27	.23	1.3	.743	.30	-1.5	1.42	.11	.57	2.33*
Man. Supportiveness	.75*	.22	-.27	-.24	.15	<1							
Man. Concern Working Cond.	.77*	.19	-.43*	-.34	.12	<1							
Identify with Company	.87*	.18	-.37*	-.34	.08	<1							
Achievement Motivation	.72*	.23	-.22	-.16	-.05	<1							
Morale	.76*	.02	-.16	-.34	.28	29.0	39.938	.11	-.03	.42	-.37	.25	1.95**
Cooperation between Workers	.34	.38*	-.04	-.23	.28	4.3	.111	.51	-.03	2.14**			
Social Rel. Among Workers	.39*	.14	.32	.20	.55*	2.4	48.72	.85	.05	3.44**			
Quality of Safety Committee	.92*	.16	.20	.18	.22	1.2	18.46			2.65**			
Man Safety Attitude	.64*	.24	-.48*	-.24	.15	<1		.76	.04				
Worker Safety Attitude	.52*	.20	-.30	-.37*	.07	<1							
Attitude Toward Safety Ins.	.55*	.22	-.31	-.20	-.04	<1							
Accident Cause	.44*	.50*	.09	.15	.43*	1.4	.190	.76	.06	3.19**			
Perception of Safety Record	.86*	.00	-.30	-.25	.08	-	721.133	.00	-.02	.06	-.56	-.03	1.68**
Safety Knowledge	.53*	.26	-.01	-.15	-.12	6.9	.072	-.31	-.01	.95	-.03	-.53	1.72**

[1] Estimate of reliability used to correct coefficient underestimated the actual reliability. Cross-lags compared using a cross-lag value of .99.

Each of these variables was then analyzed to determine if it were more likely that changes in the variable were causing changes in injury rate or vice versa. To do this, under the assumption of quasi-stationarity, the cross lagged correlations must be corrected for changes in causal coefficients, i.e. reliability, from visit 1 to visit 2. A method for determining estimated reliability suggested by Kenny (1973, 1975) was used, and the results are shown in Table 2 Column 7. If the assumption of quasi-stationarity is valid, the synchronous correlations, corrected for changes in reliability, should not be significantly different. Each pair of synchronous correlations was corrected (Table 2, Columns 8 and 9) and compared using a conservative 0.10 alpha level. Of the original 17 variables that passed the first test, 5 showed significant differences between the synchronous correlations (Table 2, Column 10). Quasi-stationarity, therefore, may not hold for these five variables; hence, they should not be analyzed further for causal inference. The other 12 variables apparently meet the assumption of quasi-stationarity and can be investigated further. To do this, the cross-lagged correlations are corrected for changes in reliability (Table 2, Columns 11 and 12). If the cross lags are not statistically different, it might still be that a third variable is causing both variables, or that the causal effect was nonexistent or too small to assess.

The 0.10 level of significance was adopted to test the cross-lagged correlations. This liberal criterion was chosen because these variables had already passed a test for a third variable model, and this is, in essence, an exploratory study. Nine of the 12 variables showed statistically significant differences (Table 2, Column 13). Rozelle and Campbell (1969) and Yee and Gage (1968) have pointed out a difficulty in interpreting cross-lagged differences. Finding CII2 IIC2 is consistent either with C causing an increase in I, or with I causing a decrease in C. Finding CIIC2 >IIC2 is consistent either with I causing an increase in I, or with I causing a decrease in C. Finding CII2 <IIC2 is consistent either with I causing an increase in C, or with C causing a decrease in I. Table 3 lists, for each of the nine surviving variables, the two rival hypotheses and the authors' assessment of the plausibility of each.

Technically, it is impossible to determine which of a pair of rival hypotheses is correct, or if both are correct, from the data. It is only on a rational basis that assessments can be made. The GFA theory predicts several of the rival hypotheses. For several variables (Decision Decentralization, Innovative Flexibility, Morale, Perception of Safety Record) one of the hypotheses is unlikely or doubtful, while the other is judged likely. In such cases, the conclusion is more clear cut. For several other variables, both hypotheses are judged likely or possible

(Production Pressure, Feedback, Continued Employee Development, Consistency of Orders), indicating the possibility of a feedback loop.

These results, taken as a whole, strongly support the GFA theory of accidents advanced by Kerr 20 years ago. It appears that when decisions are seen as decentralized, when management is seen as flexible and innovative in trying new procedures and programs, and when morale is seen as high, disabling injuries decrease. Further, it appears that as disabling injuries increase, feedback to workers, continued employee development, and consistency of orders improve; this in turn appears to decrease injuries. Production pressure, on the other hand, appears to increase disabling injuries; the increase in turn, results in reductions in production pressure.

From these results, there is clear evidence that organizational climate and management practices do affect injury rates and are not simply the consequence of changes in injury rate. Changing management practices and improving morale, if the results of this study are correct, should result in lower disabling injury rates.

It is felt that this work makes a significant contribution to the study of accident causation in the underground coal mining industry and also offers empirical evidence upon which corrective actions can be taken.

TABLE 3. — Rival Hypotheses for Surviving Variables

Decision Decentralization ($p < .05$)	
1. Decentralization causes a decrease in injuries	LIKELY
2. Injuries cause an increase in decentralization	DOUBTFUL
Innovative Flexibility ($p < .10$)	
1. Innovative flexibility causes a decrease in injuries	LIKELY
2. Injuries cause an increase in innovative flexibility	DOUBTFUL
Morale ($p < .10$)	
1. Morale causes a decrease in injuries	LIKELY
2. Injuries cause an increase in morale	UNLIKELY
Perception of Safety Record ($p < .10$)	
1. Perception of a good safety record causes a decrease in injuries	POSSIBLE
2. Injuries cause an increase in the perception of the safety record	IMPOSSIBLE
Continued Employee Development ($p < .05$)	
1. Continued employee development causes a decrease in injuries	LIKELY
2. Injuries cause an increase in continued employee development	LIKELY
Feedback ($p < .10$)	
1. Feedback causes a decrease in injuries	LIKELY
2. Injuries cause an increase in feedback	LIKELY
Production Pressure ($p < .05$)	
1. Production pressure causes an increase in injuries	LIKELY
2. Injuries cause a decrease in production pressure	LIKELY
Consistency of Orders ($p < .05$)	
1. Injuries cause an increase in consistency of orders	LIKELY
2. Consistency of orders causes a decrease in injuries	LIKELY
Safety Knowledge ($p < .10$)	
1. Injuries cause a decrease in safety knowledge	UNLIKELY
2. Safety knowledge causes an increase in injuries	UNLIKELY

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