STRESS AND IT'S EFFECTS ON LOG MAKER PERFORMANCE

Richard Parker & Paul Cossens
LIRO

ABSTRACT

Log making is mentally demanding work which must often be done under conditions of high noise, extremes of temperature and in close proximity to large mobile machines. Analysis indicated that boredom (measured by self assessment questionnaire) influenced log making ability. Possible methods (used in other industries) are suggested to combat logmaker boredom (stress) and so maintain log making quality and improve value recovery.

INTRODUCTION

In most logging operations in New Zealand, log making is done under arduous and potentially hazardous conditions which are not ideal for inspection and decision making tasks. The development of the AVIS (Assessment of Value by Individual Stems) single stem optimisation model (Geerts & Twaddle 1984) has enabled the study of decisions made by logmakers and estimates of financial costs associated with sub-optimal log making. The losses can occur for three reasons: errors in detection and classification of defects, the selection of log combinations that produce sub-maximal values for each stem, and the failure to manufacture and sort logs as intended by the log maker.

Performance of quality inspectors has been studied in many other industries. McCormick (1970) cites examples that confirm mental performance declines with greater noise, degree and length of exposure to extreme temperature conditions, and time allowed to perform a task. Detection of defects by inspection has also been shown to decline with increased complexity of the task (Harris & Chaney 1969). Log making is considered a "complex" inspection task with many attributes requiring inspection and assessment in order to make a grade classification. Over and above the task of classification is the need to select the combination of log grades and lengths that will maximise total stem value.

Little research has been undertaken on the human aspects of work on skid sites which process numerous log types under busy conditions. The influence of human variability in log making was first established by Landerud, Lier & Oy (1973). Work by Murphy (1987) also demonstrated individual variation in logmakers' abilities, although a very small sample size (3 men) was used.

The psychological effects of log making in the "hot deck" situation under normal operational pressures have not been investigated. This paper investigates the relationships between self-perceived boredom and value loss of six logmakers working under normal operational conditions and presents some possible strategies to reduce the mental stress of boredom.

ACKNOWLEDGEMENTS

LIRO acknowledges the co-operation of contractors Mark Cross, Brian Elmiger, Paul Olsen, Greg Rasmussen, Kevin Reweti and Alan Sinton, their crews and CHH Forests Ltd, Kinleith Region and Tasman Forestry Ltd.

STUDY METHOD

Six clearfell logging crews were studied for two days each. The crews were chosen because they comprised landing/loading machines and landing organisation representative of central North Island ground based logging operations.

Value recovery

Log making ability of the logmaker was assessed at three times during the day (first or second drag of day, last drags before meal break and last drags of day). Trees to be assessed were felled, delimbed and measured prior to extraction. The stem was assigned grades depending on branch diameter, sweep, wobble, out of roundness and defects. Stems were then extracted to be made into logs at the skid. The logmakers' cutting patterns were compared with optimal cutting patterns calculated by AVIS and expressed in terms of total value. Selection of combinations of logs that are sub-optimal will produce a sub-maximal total stem value. Errors in detection and classification of defects, or poor manufacture will result in "upgrading" of logs. Upgraded logs are identified by AVIS and penalised different amounts depending on the reason for upgrading (ie. sweep, length, diameter, or quality).

Boredom

At three times during the day, (before work, start of meal break and end of day) the logmakers self assessment of boredom was estimated by the application of a questionnaire. The questionnaire asked the logmaker to rate his level of boredom from 1 (interested) to 7 (bored). A minimum linear statistical model (using the General Linear Models procedure of SAS) reduced to incorporate only significant effects was used to partition variance. This model corrected for the effects of day of study and individual log maker effects on value loss and boredom.

RESULTS

Average ($\pm$ standard error) value recovery over all logmakers was 93.4 $\pm$ 0.49% (221 stems). There was a high random variation between individual logmakers, day of the study and time of the day (Figure 1), however there were no consistent relationships between value recovery and work rate (stems/hour), air temperature, log maker heart rate or time of day.

Value recovery exhibited a highly significant decrease of 6% for a 2 unit increase in boredom from 2 to 4, ($p < 0.005$, Figure 2). Most of this decrease occurred from level 2 to 3 (1 interested, 7 bored). There was a non significant trend toward increased boredom later in the day (Table 1), however this was not reflected in lower value recovery later in the day.

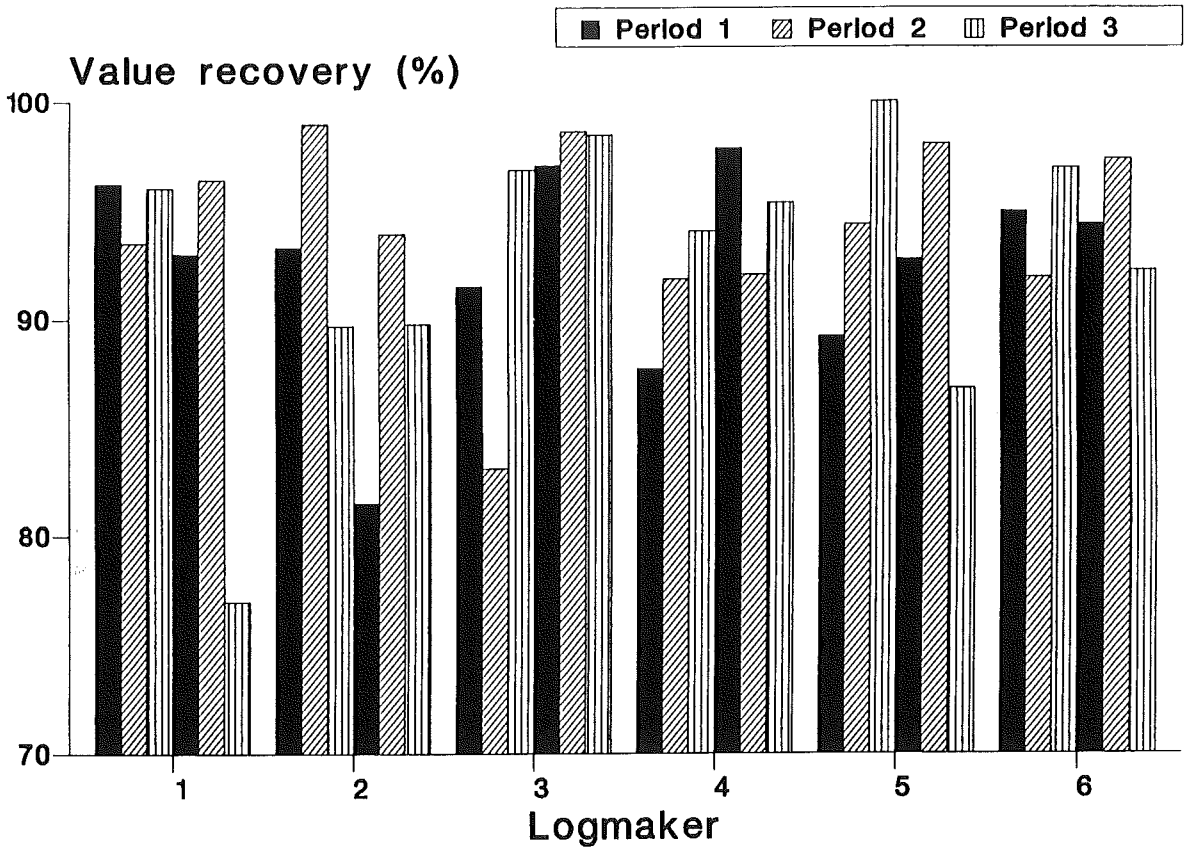

Figure 1 - Variation in value recovery of six logmakers assessed at three times each day over two days. Note the considerable variation in value recovery over the two days for some logmakers.

Table 1 - Trend of increasing logmaker boredom later in the day (average boredom score ± standard error (SE) for six logmakers over two days)

Boredom	Start of day	Before break	End of day
Average ± SE (1 interest, 7 bored)	2.4 ± 0.4 n=12	2.9 ± 0.3 n=12	3.6 ± 0.4 n=11

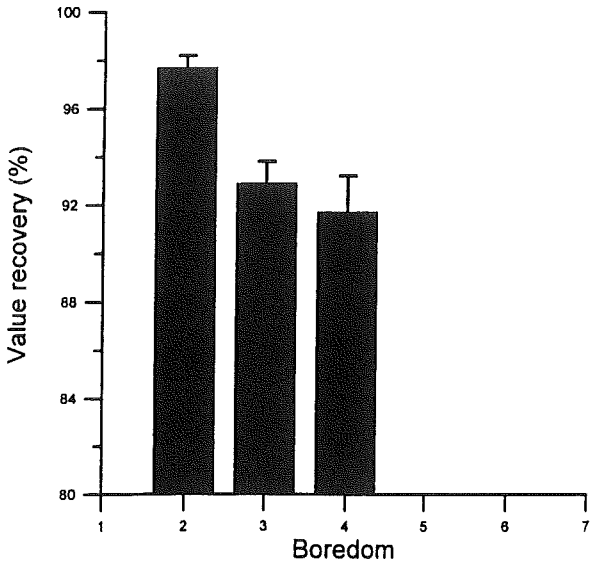

Figure 2 - Reduction in value recovery with increasing logmaker boredom. (Values separated by more than twice the height of the standard errors bars are significantly different, ie. boredom score 2 significantly different from 3 & 4).

DISCUSSION

Average value loss over six crews was similar to value loss reported by Cossens & Murphy (1988) on a simulated cold deck operation. Value loss varied with crew, day and time of day (Figure 1) and has been reported elsewhere in more detail (Strang, 1992). In the current study, boredom was shown to be related to value loss while ambient air temperature and work rate (stems/hour) were not. The effect of the number of log types made on log making ability could not be determined in this study because production constraints made it impossible to study individual logmakers making few (4) or many (12-16) log types.

Most logmakers studied felt that their job was repetitive and became monotonous later in the day. Managers, contractors and log makers need to find ways to relieve boredom in order to maintain log making performance. Possibilities are suggested in the following section.

RECOMMENDATIONS AND FUTURE WORK TO IMPROVE VALUE RECOVERY

Random variation and other factors not measured in this study influence value recovery because boredom and individual logmaker effects only explained 35% of the variance in value recovery.

The current study has identified boredom as a significant factor influencing value recovery but to obtain a better measure of the effects of other possible value recovery limiting factors (eg. air temperature, fatigue, number of log types made and type of operation (hot or cold deck)) on value recovery, more controlled studies must be undertaken. Some the methods mentioned below should be investigated under operational conditions to determine their effect on value recovery. These methods draw on literature from other industries and as yet are unproven in the New Zealand logging industry.

Training

Training should be the first and most obvious step to improve log making performance. In addition to knowledge of log specifications and practical log making skills, personnel should also have an understanding of what the customer wants. Companies that have organised visits to mills by log makers have reported improved interest in work and quality performance.

It would seem very difficult to teach someone to make complex log making decisions correctly. Education experts may be able to provide the logging industry with better ways to teach logmakers the decision making skills required.

Rest Breaks

It is well documented that in uniform repetitive tasks human ability to detect errors declines significantly after 30 to 40 minutes (Adams, 1975). Fox (1975) suggested that this decline is due to a lack of stimuli to the central nervous system.

Rest breaks are an easily implemented method to reduce boredom of the logmaker and should contribute to greater value recovery. The logmaker on a "hot deck" operation has his pace of work tied to the cycle of skidder arrival. However short rest breaks in "machine-paced" jobs do not reduce output even though less time is worked (Alluisi & Morgan, 1982 cited by Krueger, 1991). The rest break serves to provide a relief from boredom, physiological stress, muscle fatigue and cardiac strain (McCormick & Tiffin, 1974). Even on the "cold deck" operations where the logmaker has more control of his pace of work (but where monotony presumably is greater) rest breaks can reduce boredom. For example, on hot days the log maker and skid workers could rest (or do chainsaw maintenance) in the shade between drags.

Job Rotation/ Enlargement

Rest breaks need not be periods of inactivity. Several authors (Fox (1975) and Krueger (1991)) have recommended job rotation as a means to maintain worker vigilance.

In an experiment to study maintenance of inspector performance Fox (1975) tested the concept of "job enlargement". In order to reduce the uniform repetitive nature of some tasks a group of factory inspectors were given additional tasks to perform. The extra task involved going to get the items to be inspected from a store instead of having them delivered. Over a long period of time fault detection efficiency was shown to increase by 6 percent.

In logging crews this may be implemented by rotating jobs at every break. For example, make logs until first meal break, fell until second meal break and make logs again for the last run of the day.

The trend in industrial production is away from continuous production lines to small groups or teams which perform a wider variety of jobs. For instance instead of a car engine being built on a production line it will be assembled by a group of multi-skilled people. This concept acknowledges that people's performance is enhanced by working in small groups and teams. The logging crew is a "natural" team which can be encouraged to work together to ensure quality, value maximisation, productivity and safety. Contractors, foremen and supervisors could be taught the appropriate management skills that build good team morale and attitudes.

Reduction of Noise

Loud continuous noise has a detrimental effect on mental ability (McCormick, 1970). Ear muffs will attenuate most noise, however a safer alternative is the physical separation of men and machines by the use of alternate landings. Such cold deck operations also reduce machine interference delays at landings. The use of a central processing yard could give similar benefits if the logmakers were well separated from machinery.

Another alternative is the use of "active noise reduction" (ANR) earmuffs. These are sophisticated earmuffs developed by the military that produce a sound wave equal and opposite to the incoming noise thus cancelling it out. These muffs can be "tuned" to block out the low frequency throbbing noise of heavy machinery which cannot be attenuated by conventional ear muffs. The ANR muffs were designed for

military aircraft and vehicle crews who must maintain alertness and the ability to make complex decisions rapidly in a noisy environment.

External Stimuli

Several experiments show that vigilance can be maintained by provision of external stimuli after 30 minutes. Fox (1975) demonstrated that defect detection efficiency improved by 7 and 18 percent in two experiments by providing "lively" intermittent music. The music acted as a stimulus to improve vigilance. Perhaps appropriately "tuned" ANR muffs may allow the logmaker to hear the skidder, loader or other chainsaws (for safety) yet allow him/her to listen to music while working.

Reduce Task Complexity

Detection of defects in inspection tasks has also been shown to decline with complexity of the task (Harris and Chaney 1969). Log making is a complex inspection task compared with other industrial situations where quality inspection may just involve acceptance or rejection of a product according to a single specification. In log making there are many attributes that need to assessed in order to make a grade classification. In addition, the classification is not fixed as there is potential to down-grade higher value wood to lower grades. Over and above the tasks of defect detection and classification there is the need to select a combination of log grades and lengths (which have different values) that will maximise the total value of the stem. With the rapid proliferation of log types some decision support is necessary. A plasticised instruction card with preferred cutting options would reduce task complexity for the logmaker, (Twaddle, 1986 & 1987).

In 1993/94, LIRO will determine effect of the number of log grades (eg. 3 grades vs 15 grades) on log maker performance. The results will have implications for selection of products to cut in a stand and wood allocation and distribution decisions.

Ensure Feedback

Ensuring that people have feedback on their work is based on a well established theory of human work psychology called Knowledge of Results.

"Feed back of results almost invariably results in elevated performance, probably due to both the informational properties which enable self guidance, and the motivational properties which energise the will to achieve commendation and avoid criticism." (Wiener, 1975)

The most appropriate way to achieve instant feed back is ensure that loggers monitor their own quality levels. This requires that people have the suitable skills and tools to monitor quality. In a logging crew this may mean periodic sampling of log stacks and recording levels of defects on simple control charts.

Logmaker Selection

Selecting the people who have the right attributes for logmaking is a key step. There is considerable variation in individual's abilities to maximise value (Cossens & Murphy 1988). Attributes that appear to be generally important for inspector tasks are visual capability and intelligence. It should be noted that there has been found to be a poor relationship between "standard aptitude and personality tests" and inspector performance (Wiener, 1975) and such issues go beyond the scope of this paper. Common sense dictates that any selection tests for log making need to be designed to closely approximate the requirements of the logmaking task.

Motivation

Theories of industrial motivation (eg. Herzberg, 1966) suggest status, recognition, self-fulfilment and perceived importance of the work are of great significance. Contractors and managers need to have skills and knowledge to ensure their working environment and relations with their employees fulfil these needs.

Differential logging rates that reward value recovery up to (or exceeding) that expected from the preharvest assessment are common with many forestry companies in New Zealand (Duggan, 1990). However, due to the relatively low differentials between log grades paid to the contractor, achieving a "trickle down" of these financial incentives to logmakers and other logging workers has proved difficult. For financial incentives to the logmaker, to work, two issues must be resolved. Firstly, the emphasis must be shifted from production to quality. At present the rewards to contractors are based primarily on production but the emphasis from the company is on quality. Secondly, greater price differentials between log grades must be paid to share rewards for greater value recovery. Pivotal to this system working is the confidence, by all parties, in the preharvest assessment.

CONCLUSIONS

In this limited study, the level of self perceived logmaker boredom had the greatest measurable influence on value recovery. If logging companies and contractors want to improve value maximisation and quality, practices such as job enlargement or rotation and better timed rest breaks could be utilised. With the current high value of logs, improvements in value recovery by logging crews may be easier to achieve and give a far greater improvement in profitability than reducing logging costs. More work is needed to quantify the benefits of these recommendations and investigate the influence of the number of log types made, on value recovery.

Contractors and management may need to be provided with access to training in the "softer" human relations part of their business in order to improve quality and value recovery.

REFERENCES

Adams, S.K. (1975): "Decision making in quality control: some perceptual and behaviourial considerations" In C.G. Drury & J.G. Fox (Eds.), Human reliability and quality control. Taylor & Francis Ltd London. p55-69.

Cossens, P.; Murphy, G. (1988): "Human variation in optimal log-making: a pilot study" Proceedings of the International Mountain Logging and Pacific North west Skyline Symposium. p.76-81.

Duggan, M. (1990): "Incentive payment systems". In Proceedings of the LIRO Seminar "Manpower Management in Logging", Rotorua, New Zealand, June 1990.

Fox, J.G. (1975): "Vigilance and arousal: a key to maintaining inspector performance". In C.G. Drury & J.G. Fox (Eds.), Human reliability and quality control. Taylor & Francis Ltd London. p89-96.

Geerts J.M.P.; Twaddle, A.A. (1984): "A method to assess log value loss caused by cross-cutting practice on the skidsite". New Zealand Journal of Forestry 29(2):173-84.

Harris, D.H.; Chaney, F.B. (1969): "Human Factors in Quality Assurance". John Wiley & Sons New York.

Herzberg, F. (1966): "Work and the Nature of Man". New York Word Publishing Company.

Krueger, G.P. (1991): "Sustained military performance in continuous operations: combat fatigue, rest and sleep needs". In Handbook of Military Psychology, Chapter 14, John Wiley & Sons. Chichester, England. p244-277.

Landerud, I.; Lier, B.; Oy, H. (1973): "The influence of laying off log lengths on the value of logs". Norsk Skogindustri 27:375-377.

McCormick, E.J. (1970): "Human factors engineering". McGraw-Hill Book Co. New York 639p.

McCormick, E.J.; Tiffin, J. (1974): "Industrial psychology". Viking Press New York.

Murphy, G. (1987): "An economic analysis of final log manufacturing locations in the steep terrain radiata pine plantations of New Zealand". Ph.D. thesis. Oregon State University.

SAS Institute Inc. Box 8000, Cary, North Carolina 27511, USA.

Strang, M.M. (1992): "Temporal variation in value recovery from clearfell logging operations". B.For.Sci. dissertation. School of Forestry, University of Canterbury.

Twaddle, A.A. (1986): "Better log making". LIRA Technical Release Vol.8.No.5.

Twaddle, A.A. (1987): "Long log cutting in the bush for hauler extraction: cutting strategies to minimise value loss". LIRA Technical Release Vol.9.No.7.

Wiener, E.L. (1975): "Individual and group differences in inspection". In C.G. Drury & J.G. Fox (Eds.), Human reliability and quality control. Taylor & Francis Ltd London. p101-122.